Sustainability of chestnut forest ecosystems: Is it possible?

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I. BIODIVERSITY AND SUSTAINABLE MANAGEMENT IN FOREST SYSTEMS

(O. Ciancio & S. Nocentini)

Sustainable management of natural resources is the challenge for the third millennium. It is no longer possible to ignore degradation caused by uncontrolled use that does not respect natural dynamics and equilibria. The forests are an indispensable asset for guaranteeing the continuation of life on our planet. Concern for the conservation of natural resources has become part of the international agenda. The Helsinki resolutions in 1993 on climatic changes, conservation of biodiversity, sustainable forest management and desertification comprise an ineluctable point of reference.

Some recent facts and events have brought what were long considered certainties into doubt. They concern not so much the possibility of the forest deterioration if they are not managed in a sustainable manner, as the acknowledgement that, as a result of technological developments and their growing impact on the environment, human actions are becoming increasingly powerful and destructive. This new awareness has led to the birth and growth of a common desire to pay more attention to forest management, that is the technical and economic management of the renewable forest resource.

Forest management has evolved through time, shifting from a mainly production-oriented concept that evaluated cultivation systems and techniques on the basis of wood production to the current concept where management is associated with the adjective "sustainable" that considers not only wood production but also ecological and social variables.

Systemic silviculture

Traditional forest management and silviculture consider the forest as a mere group of trees with economic significance. In reality, the forest is an autopoietic, complex adaptive and composite system that learns and evolves. It consists of adaptive agents that function like complex systems with each one adjusting to the behaviour of the others.

The concept of "system" is relatively recent in forestry. It is an innovative and revolutionary concept in some ways, and its consequences have not been entirely grasped and evaluated. Consideration of this

concept has led to both theoretical and practical changes concerning the contents, goals and limits of silviculture (Ciancio, 1998).

Sustainable forest management must be based on systemic silviculture, that is "extensive silviculture" in harmony with nature. It is a silviculture that is configurable with the actions of man in his role as an essential component of the forest system. Systemic, non-linear, extensive silviculture is based on the principle of autopoiesis. It works on behalf of the forest, that is, according to a cultivation algorithm with the aim of preserving, conserving, enhancing and promoting the system's biological complexity in a co-evolutionary continuum which *de facto* excludes the finalism typical of the linear processes that lead to the normalisation of the forest (Ciancio *et al.*, 1994a; 1994b).

Systemic silviculture favours and corroborates the system's functional efficiency. It is based on continuous, natural regeneration and low-environmental impact actions, that is, actions aimed at conserving and augmenting the system's biological diversity, promoting lack of homogeneity, and structural and composite diversification in order to increase the capacity for self-organisation and integration of all its biotic and abiotic structures. This action, furthermore, will help overcome the conflict between two extreme viewpoints: on the one hand are those who consider the forest an unavailable asset, on the other those who see the forest as a totally available asset to be exploited according to market laws.

The classic forestry system

The newly acquired knowledge in the fields of ecology, silviculture, forest management and forest economy now permit an objective comparison between the classic forestry system and what we, on other occasions, have defined as the autopoietic forestry system, that is, a system capable of self-organisation and of combining functional efficiency with a high level of biological diversity (Ciancio, 1988). The comparison reveals the salient aspects of the two systems which, for convenience, are identified as (SF₁) and (SF₂) in Table 1. These aspects concern structural features of the two systems and the repercussions in regard to management, ecological evaluation and the primary objective to pursue (Ciancio, 1998).

Classic Forestry System (SF ₁)	Autopoietic Forestry System (SF ₂)
Linear system, lacking in alternatives	Non-linear system, rich in alternatives
Uniformity and homogeneity Of the system	Lack of uniformity and homogeneity Of the system
Reduction of diversity and loss of genetic information	Diversity is a source of genetic information, it has culture and useful value
MANAGEMENT	
Cultivation uniformity demands centralised control in relation to profit and market	Cultivation diversity requires decentralised control and properly exploits "local knowledge"
Rigidly structured forest in age or diameter classes	Unstructured forest capable of "self-organisation"
Product uniformity: primarily wood (PR ₁)	Diversified products: including wood (PR ₂)
ECOLOGICAL EVALUATION	
Stable and sustainable system with input of energy, labour and capital. Productivity, yield and economic value are independent of the ecosystem	Stable, sustainable and autonomously renewable system. Productivity, yield and economic value are dependent on the ecosystem.
PRIMARY OBJECTIVE(S)	
To maximise profits through Commercial use of the forest	To increase complexity and conserve biodiversity

Table 1. Broad comparison of the Classic Forestry System (SF₁) and the Autopoietic Forestry System (SF₂). [(SF₂) is preferable to (SF₁) because the system is ecologically balanced and sustainable. PR₁ is greater than PR₂, but the scientific control rarely takes the entire range of inputs and outputs into consideration: it does not make a true ecological evaluation and therefore the comparison between PR₂ and PR₁ is distorted.]

The classic forestry system (SF₁) is a "linear system", that is a system based on the principle that the estimated results, in terms of wood production is linear. This means that, within certain limits, the yield increases proportionately to the energy used. Furthermore, it follows specific reference standards and for this reason, is lacking in alternatives.

A linear system involves a silvicultural orientation that tends towards an uniform and homogeneous forest, and hence to a reduction in biodiversity. A forest managed according to these criteria is almost monospecific or it consists of a main species and one, or at most two, secondary species. Its structure is rigidly even-aged or uneven-aged and it is arranged chronologically or according to diameter.

Forest planning is anchored to the theory of economic development which in turn is firmly based on exponential growth models. Management plans are evaluated on the basis of their ability to sustain a high rate of wood production. The rotations are relatively

short with respect to the longevity of the species. This type of management presupposes centralised control and a generic crop uniformity.

Crop uniformity simplifies control, even if, for the obligated subjects it is more costly to abide by the reference standards. To realise this phenomenon, it is sufficient to review the management plans for beech forests for example. Wherever, and in whichever station they may be, shelterwood cutting is almost always the rule. Therefore, crop uniformity is matched by product uniformity (PR₁).

The predominant, if not exclusive interest in wood production has led to a unidimensional forestry paradigm that systematically tends to maximise soil rent. Over the short and medium term, the classic forestry system (SF₁) is a stable and sustainable system.

In the classic forestry system (SF₁) productivity, yield and economic value are independent of the ecosystem while sustainability is dependent upon the

input of energy work and capital. This means that production is linked to a high level of external input. And this, since it markedly affects the ecosystem's equilibrium, leads to high vulnerability and ecological instability, significant erosion of biodiversity, lack of alternatives and few options.

The autopoietic forestry system

The autopoietic forestry system (SF₂) is a "non-linear system". It is rich in biodiversity and, since it does not follow reference standards, it varies within small spaces and adapts to different situations. A system of this type involves a silvicultural orientation that aims at conserving or increasing biodiversity and therefore less uniformity, less homogeneity, in other words, the structural complexity of the forest.

Biodiversity has cultural value and use value because it makes it possible to properly exploit "local knowledge", the property of communities that live with the forest, and to obtain products that differ from valley to valley. Wood is an important product, but it is not the sole aim of management. As Perry & Amaranthus (1997) affirm, "The protection of biodiversity is the best insurance foresters and society can buy to protect the long-term integrity of the world's forests."

Forest planning is anchored to systemic management. The silvicultural unit is the stand. Actions are based on the needs of the stand and are undertaken cautiously, continuously and in a capillary manner. Their objective is active participation in the ecosystem's evolutionary processes. Verification of feedback and reactions to the interventions is an essential aspect of management. During planning, operational decisions do not take common parameters such as rotation or diameter class into consideration. A systemic management means decentralised control and crop diversification.

Crop diversification renders control more complicated, and for this reason it is very decentralised. Foresters, however, have the non-negligible advantage of not having to abide by reference standards. The management plans follow highly flexible criteria. The study of the forest is an essential prerequisite for the selection and prescription of silvicultural interventions on a case by case basis.

Therefore, crop diversification is matched by production diversification (PR₂).

The multiple, innate interests in the autopoietic forestry system (SF₂) have led to the development of a multidimensional paradigm. (SF₂) is a system capable of satisfying society's needs and properly exploiting the wealth of experience of the local communities. Management aims at pursuing the functional efficiency of the ecosystem and orienting "silvosystems" towards environmental equilibrium.

Systemic management is highly sustainable because it enhances the potential for distributing the forest's services and products. Productivity, yield and economic value are **dependent** on the ecosystem. Sustainability is **independent** of the input of energy, labour and capital. This means that production is tied to a low level of external input. And, as this does not significantly impact the ecosystem's equilibrium, it leads to high ecological stability, the ability to conserve or augment biodiversity, a wealth of alternatives and many options.

Conclusion

In conclusion, it seems evident that if we consider the entire range of inputs and outputs, the autopoietic forestry system (SF₂) is preferable to the classic forestry system (SF₁) because, in addition to being sustainable and independently renewable, it is ecologically and economically balanced.

A forestry system of this type has benefits that extend far beyond the economic level. It enriches the soil with waste products that feed a myriad of micro-organisms, it provides protection against the wind and rain attenuating erosion, it holds the soil with its roots on slopes reducing the amounts of silt in waterways and along the coasts. It configures itself as a reservoir where carbon is collected, helping to keep atmospheric carbon dioxide levels in balance and to combat the greenhouse effect. It hosts and nourishes animals. Since it is a renewable resource it gives rise to processes of utilisation and production.

In practice it is a type of management based, on the one hand on care of the forest according to the needs of all its components beyond any possible structural prefiguration, and on the other on crop recovery. In addition, this type of management exploits the forester's professional competence and skills to the utmost. Some could raise the objection

that management based on systemic silviculture is not sustainable from the financial standpoint. This, in fact, is the argument most frequently heard against the method. At first glance it seems strong, but it is not and there are at least two reasons.

First of all: silviculture, in any case is an activity that involves high costs and low profits. Secondly: the forest is always subject to various types of restrictions. Therefore, we must remove the financial and social obstacles. It is not a matter of silviculture or forest management, but rather of forestry policy. As Hilborn *et al.* (1995) have stated, the future success of sustainable management does not depend so much on better science as it does on better institutional organisation that can control the users and create incentives for them to act in a wiser manner.

Some will ask whether it is possible to reconcile the constantly growing demand for wood with sustainable management and the conservation of biodiversity. This issue can be dealt with in several ways, for example, by reducing the consumption of wood and wood derivatives - which is sometimes so high that it is heedless waste - by recycling wood and paper, by increasing the efficiency and optimising processes in the woodworking and construction industries. And also perhaps mainly, by giving a strong impetus to tree cultivation, that is with the creation of "agrosystems" destined for the production of high quality or large quantities of wood. These "tree farms" attenuate the impact on the silvosystems.

This does not mean to say that the forest must be left to itself. On the contrary, the forest must be cultivated with discreet interventions and actions aimed at maintaining the system's equilibrium while producing wood and at the same time preventing the extinction, disappearance or temporary withdrawal of some plant and animal species which, along with the quality of the air, water and soil, are resources that are as important, if not more so than wood.

II. THE ECOSYSTEM IN A SCIENTIFIC, ECONOMIC AND SOCIAL CONTEXT. IS SUSTAINABILITY POSSIBLE?

(F. di Castri)

Hundred definitions of sustainable development have been proposed that have quite different connotations and the excessive use of this term induced a loose of its meaning. Nevertheless this

concept more often evokes an alternative, ideological model of development that is opposite and inherently contradictory to present practices (di Castri, 1998).

Some remarks could help us to delimit these concepts of ecosystems and sustainable development:

1 – The ecosystem is defined by the whole of the populations and communities of plants, animals and microorganisms, and of their non-living environment, inhabiting a given space and at a given time, and interacting as a single functional unit for the exchanges of matter, energy and information. Emphasis on elementary ecosystem units has shifted over time from atoms and calories, to genes and bits. the ecosystem is not a kind of fixed supraorganism, but a level of integration whose limits vary in space and time.

2 – The present scientific context of the ecosystem is determined by conditions of openness, permeable and fluctuating boundaries, invasive species, non-linearity, non-equilibrium, chaotic behaviour, complexity caused by multiple interactions and interfaces, hierarchical interactions between different levels of integration from the gene to the ecosystem, nested structures, fuzzy behaviour, emergence of surprises and inherent unpredictability.

3 – The present economic context is the one of globalisation of exchanges, free market a blossoming international trade, including international tourism, and the magnified foreign private direct investment world-wide. The rules of the game of economic development are radically changed, from protectionism, public investment, standardisation, centralisation and concentration on a given space, to free exchange, private investment, diversification, decentralisation and diffusion over space of productive activities. The availability of natural renewable resources, as produced by the functioning of local ecosystems, is no more the main factor of economic development. This is rather driven by the skill of human resources, their capacity of multiplying resources and, above all, their ability to adapt timely to change. The economic importance of ecosystems shifts from the production of resources any goods to the delivery and the maintenance of ecological services.

4 – The present social context is determined by the global information society, with fragile frontiers, open to flows of information, capital, people and species, with dominance of services over agricultural and

industrial activities jobs. Connectivity among societal members is provided mainly by a cultural territory, where interactions, links and networks are maintained even at the distance by electronic means and devices, now available at low cost almost everywhere. Accessibility and use of information become the main societal factor. The scales of space and time of any given ecosystem are not fixed, but are defined by societal or research choices. Most ecosystems include therefore, and according to the choices made, a variable mosaic of heterogeneous situations.

5 – With the emergence of the globalisation of economy and of the information society, the disturbance regimes acting upon ecosystems and landscapes are strongly modified. The transboundary transfer in real time of capital information and decisions across the world, over ecological, bio-geographical, genetic, administrative and political frontiers, changes scales of space and time of the impact, and the adaptative response of species and ecosystems to new disturbance regimes. Ecosystems, landscapes, territories and human-use systems become open and often virtual. Their non-linear and non-equilibrium behaviour is accentuated; unpredictability is the inherent feature. Mobility in space and time becomes the main factor of disturbance and of successive regulation, as referred to species, ecosystem boundaries, resources, peoples, jobs, capital and knowledge.

6 – These new rules, as applied to economic development and ecosystem health, are at the origin of both bright emerging opportunities and gloomy emerging risks. The winner-loser syndrome is the peculiar feature as regards the reaction of ecosystems, species, economies, societies, and countries, depending on their adaptability to change. New approaches and tools for resources management are intended to maximise opportunities and minimising risks. The four pillars to seize and expand present opportunities are openness, diversification, innovation and partnership.

7 – Environmental risks may be aggravated because of widening gaps, uncontrolled mobility, disruption of scales of time and space no more compatible with the evolutionary and ecological pace, human had-off, failure of a precautionary approach and, above all, slow reactivity and lack of societal and institutional adaptation to change, with special emphasis on university and research institutions.

According to these comments the concept of sustainable development is not and cannot be applied, because of intrinsic contradictions, and does not represent the right response to long-term trends and inherent predictability. Application is even more hazardous under present conditions of a global economy and of an open information society. This concept is rather opportunistically or ideologically taken over, because of completely different motivations, political leaders, environmentalists, businessmen and entrepreneurs. The main weakness and inconsistencies of sustainable development lie on the following six considerations: (i) there is no equilibrium between human populations, resources and environment. Both human populations and resources migrate. The concept of carrying capacity does not apply to present circumstances; (ii) Natural resources are not fixed nor predetermined. (iii) It is not possible to freeze species, ecosystems and resources, to be transmitted to future generations, at any given state of their evolution; (iiii) It is not possible to interpret needs, aspirations and value systems of future generations by simply projecting and extrapolating present trends; (v) Sustainable development is not measurable and is not accountable and (vi) The two terms, development and sustainable, are incompatible from a methodological viewpoint, when considering system dynamics, linearity, openness, stability and adaptation to change.

If we can not apply the concept of sustainable development, conversely we can use the sustainability but it is not supported by maintenance and preservation of present conditions in closed systems. It depends rather on continuous adaptation to change in open environments, through diversification and innovation.

III. SUSTAINABLE MANAGEMENT OF SWEET CHESTNUT (*CASTANEA SATIVA* MILL.) COPPICE FORESTS BY MEANS OF THE PRODUCTION OF QUALITY TIMBER

(F. Giudici, E. Amorini, M. C. Manetti, G. Chatziphilippidis, M. Pividori, E. Sevrin, A. Zingg)

Chestnut forests in Europe

Chestnut (*Castanea sativa* Mill.) is widely present in Mediterranean and central Europe. The present state of the resource is not well known. A distribution map

of European chestnut with the relevant statistical information was produced in the fifties (Morandini, 1958, 1 unpublished map) but it does not consider all European countries.

Nowadays the area of chestnut forests in Europe is estimated to be about 1 800 000 ha (Table 2). We also know that chestnut forests are spreading over the south-eastern part of the European continent (e.g., in Slovakia, Slovenia, Hungary, Bulgaria, Former Yugoslavian Republic of Macedonia, Albania, Turkey). We therefore estimate the presence of sweet chestnut in about 15 countries and that the total area covered by chestnut amounts to approximately 2.0 million ha. In chestnut forests the private ownership is generally prevalent (70-80%) even if there is also important public forest ownership.

Significance of chestnut in the past

In Europe chestnut has been present for centuries (Pitte, 1986), especially in the hilly and mountainous areas. The ownership structures, the local socio-economic organisations and the need for autarkic and economic self-sufficient systems have considerably influenced the cultivation methods.

Up to the middle of the XXth century, the main cultivation method was the orchard for fruit production. In the context of a poor and marginal economy, chestnut fruit was the staple food and an important economic income for rural communities. The decline of the rural areas, the onset of diseases (especially the chestnut blight caused by *Cryphonectria parasitica* and the ink disease due to *Phytophthora* spp.) and the demand for timber for tannin production led to the abandonment and the conversion to the coppice management of many chestnut orchards. This practice created new and wide areas of coppice stands, especially in Italy and France. Today, chestnut fruit production is dramatically reduced and is rather oriented toward high quality products in limited areas.

Origin and importance of chestnut coppices

Coppices have been a well-known management system for centuries, the technique of cultivation ("caeduo" = coppicing) having been already described by Roman authors such as Plinius and Columella

(Krebs, 1999). The easy application due to the high resprouting ability from stools, the lasting vitality of the root system and the high productivity (8-16 m³ ha⁻¹ year⁻¹ depending on site conditions) facilitated the implementation of coppice stands in many countries.

The traditional management system applied to chestnut coppices was based on short rotations (12-20 years) according to the required assortments. The main products from coppices were small and medium poles used in agriculture (fences, vineyard stakes), for transmission lines, in constructions, as fuel and for handicrafts. Very short rotations (2-6 years) were applied locally for special assortments (flower-pickets, baskets, trellis posts). This large variety of assortments preserved the coppice system economically active in large areas until the '50s - '60

During the '60s and '70s, the traditional products from chestnut coppices progressively lost their economic importance due to the labour-intensity of this kind of mass production and because of the competition from synthetic materials. Cement or impregnated wood products, considered innovative and more durable, replaced chestnut poles thus causing a production excess of these assortments and making the coppice system unsuitable to the new market demand of large sized stems. The rotation period was simply extended in order to get assortments of larger dimensions, but neither an active silviculture nor well-defined long or medium-term goals were foreseen. Moreover, the extension of the rotation was often caused by deferral or the discontinuation of treatments and was not a real silvicultural choice. The presence of many defects (ring shake) in the wood makes the use of timber for saw wood or furniture difficult. As a consequence, the local economic organisations in the rural areas were not motivated any longer to invest and to care for their chestnut forests. At present, in several European regions, many chestnut coppices are therefore aged, abandoned or improperly managed resulting in a heavy and progressive reduction of their ecological, environmental and economical value.

Moreover, in the recent past, the coppice management system was neglected because of its bad reputation: for the owners the coppice forest

Country	Coppice-timber	Orchard (fruit)	Total chestnut forests in ha	Source
France		133 759	996 834	FNI 1997
Italy	375 300	209 113	584 413	FNI 1993
Spain	92 538	40 119	132 656	FNI 1980
Portugal	6 000*	26 200*	32 100	FNI 1989
United Kingdom	19 091	9 871	28 962	FNI 1982
Switzerland	22 100	4 100	26 200	FNI 1985
Greece			17 000	Bourgeois 1992
Austria			5 000*	Regner (pers. com.)
Germany	2 000*	-	2 000	Bourgeois 1992
Netherlands	500*	-	500	Oosterbaan (pers. com.)

FNI = Forest National Inventory; *: estimation

Table 2. Chestnut forest in Europe (in ha)

symbolised the hard struggle for survival (chestnut as the "poor people's tree"), nowadays many specialists consider coppice as a brutal management system to abhor. This negative prejudice may be explained by the past overexploitation of widespread chestnut forests that were very often associated with extended and repeated clear cuts, that often provoked the exhaustion of forest soils.

Revival of chestnut coppices and chestnut timber?

Chestnut is however one of the most versatile woods of the European continent! It is highly appreciated for its technological efficiency and aesthetic qualities. The demand for sawn timber of high value assortments in sectors like joinery, furniture, flooring and internal cladding, carpentry, will also be important in the future. Moreover, for numerous outdoor facilities (e.g., in the agricultural sector and in environmental engineering), chestnut timber has advantages due to its high natural durability and the decorative aspects, especially in comparison with impregnated timber or cement/iron products, the production of which provokes a more severe environmental impact.

New silvicultural methods, alternative to the traditional management and compatible with the principles of the sustainable development, could restore a relevant part of chestnut coppices for quality timber production. The improvement of the quality and especially the reduction of ring shake risk, are the decisive steps in order to encourage owners and authorities to invest in the chestnut coppices.

The ability of the stools to produce an abundance of shoots facilitates the regeneration of chestnut coppice. This important advantage, the vitality and the responsiveness of the selected trees in the thinned areas are decisive basic requisites to reintroduce the chestnut coppices compatible with the exigencies of the modern society.

Research activities in the last 20 years

The problem of putting a value to chestnut coppices was emphasised for the first time at the end of the seventies, due to the high presence of aged coppice stands (Gambi & Amorini, 1978; Cabannes & Rolland, 1982; Bacchetta, 1984). From a technical point of view, the first alternative silvicultural concepts were proposed at the end of the eighties (Bourgeois, 1987). Some years later such models were better characterised by the same author in her important synthesis publication "*Le châtaignier : un arbre, un bois*" (Bourgeois, 1992). In the following years, the basic principles (extension of rotations up to 30 or 50 years and application of early and frequent thinning operations of moderate-heavy intensity) have progressively been better defined (Amorini *et al.* 1997a).

In this context some national and European research projects were launched in order to analyse specific themes such as the evaluation of the technological characteristics of chestnut timber (project FOREST 1990) and the estimation of stand efficiency and functionality in relation to the silvicultural system (project CAST in 1994). The first

results are promising and seem to prove the bio-ecological validity of such models, even if they are carried out in well defined and specific test conditions.

Real experimental applications or case studies were carried out in order to verify the applicability of these alternative management systems aimed to improve the quality of timber production, the stand stability and the environmental benefits (Aumasson & Guerrin, 1995; Cutini & Fabbio, 1997; Romane & Grossmann, 1997).

The state of the art

The main results of the recent research activities dedicated to improve the management and to boost the value of the products from chestnut coppices can be summarised as follows:

Silviculture

In absence of silvicultural management, a rapid and positive structural evolution takes place in aged coppices. It is possible to improve timber production by a silvicultural management which is able to increase the management choices and, at the same time, is capable of ensuring the functionality of the stands and their stability.

Some silvicultural models have already been defined and experimental trials have been established to study the effect of thinning on crown development and growth. A regular and sustained growth trend on released stems seems to be a promising silvicultural tool to decrease the risk of ring shake (Chanson *et al.* 1990; Amorini *et al.*, 1996b; Amorini *et al.*, 1997a; Amorini *et al.*, 1997b; Amorini *et al.* 1997c; Fonti *et al.*, 1997; Amorini *et al.* 1998a; Macchioni & Pividori, 1996).

Studies concerning methods to promote the natural regeneration of chestnut coppice forests were started recently. The seeding and the development in the first years is often successful but the competition of the stools still creates problems in maintaining the natural regeneration during the following years (Sevrin, 1994, Pelcé, 1994).

Technology

Chestnut timber can be processed with modern technological methods (cutting, gluing, drying) which offer possibilities for modern manufacturing or

industrial products (thick sliced veneer, laminated veneer boards, glulam, solid wood panels, finger jointed timber, *etc.*) It is also suitable for valuable furniture, carpentry products (Everard & Christie, 1995; Macchioni, 1995; Negri & Uzielli, 1997).

One of the main problems is the risk of ring shake whose presence heavily devalues the timber. The risk increases with the higher age of the trees (Chanson, 1990): in determining the rotation time of chestnut coppices this important aspect must be considered. Preliminary studies with ultrasonic measurements showed new means of using a non damaging diagnostic method that could help analyse and classify the chestnut stems qualitatively (Giudici *et al.*, 1997).

Ecology

The effects of different thinning intensities on the above ground biomass and crown characteristics were tested on young and aged coppices on good sites. The first results show that in both situations the canopy cover is re-established a few years after the thinning (Gambi & Amorini, 1978; Cutini, 1997; Cutini & Fabbio, 1997). Moreover, in aged coppice stands, the extension of rotation time allowed the branch biomass to increase progressively, contributing to the improvement of soil fertility, which had been reduced in the past by short rotations (Ranger *et al.*, 1990; Ranger & Nys, 1996). Furthermore, studies carried out in Britain show that in managed chestnut coppices the opening of tree cover at regular intervals influences the species richness of ground vegetation positively (Ford & Newbould, 1977; Barkham, 1992) and breeding birds increased (Fuller & Moreton, 1987).

Landscape ecology

The dynamics of chestnut forests is very fast. In the absence of cultivation and especially in opened structures, chestnut forests tend to evolve naturally towards mixed stands due to the invasion of pre-existing broadleaved species (Mondino, 1991, Conedera *et al.*, 1998). This trend is typical in areas where chestnut was introduced outside of its ecological optimum, whilst in good site conditions, the natural evolution often caused an homogenisation of the stand structures, with negative effects on the environmental functions (landscape architecture and ecological value).

Genetics

The silvicultural system does not significantly influence the genetic constitution and diversity of the stands (Amorini *et al.*, 1998b). The observation of a "stool effect" in the ring shake incidence suggests that the genetics could represent one of the predisposing factors in explaining the presence of this timber defect (Macchioni & Pividori, 1996; Fonti *et al.*, 1997).

Pathology

The presence and impact of diseases are strictly related to the individual vigour. For the chestnut blight (*Cryphonectria parasitica*) it seems possible to reach an ecological equilibrium host-parasite by means of an active silviculture (Amorini *et al.*, 1998b). Besides, in order to improve the biological control of the cancer, it is important to leave some shoots with hypo-virulent infections in the clear-felled and thinned areas (Conedera, 1993).

Economy

There is a significant lack of studies concerning the entire timber chain, however some analyses seem to indicate that the extension of rotation times are more advantageous both to the owners and the forest enterprises (Carbone & Ribaud, 1995).

A new management concept for multifunctional chestnut coppices

The chestnut stands in Mediterranean and sub-Mediterranean Europe, overexploited in the past, are at present not well managed if not abandoned. On the other hand, we strongly believe that the coppice system is one of the few systems able to satisfy the demand for good quality timber and at the same time also the needs for biological, economical, environmental and landscape benefits required by society.

From the social, cultural and economical points of view, the *Castanea sativa* tree is a strategic factor for the integrated development of rural and mountainous areas in Europe. In our vision the management of chestnut coppices could therefore be an exemplary model of integrated management of the living resources with multipurpose criteria (agroforestry, environment, culture, arts and crafts) of rural areas.

For the interested regions this could imply a series of advantages:

- avoid the abandonment of marginal areas by maintaining economic opportunities (jobs in environmental engineering, handicraft, enterprises in the timber chain sector, cultural education, tourism);
- offer of complementary employment opportunities to farmers and family companies (favouring especially the young generation) to be integrated into the agro-touristic and cultural activities of their native region;
- guarantee a constant presence and control of the rural territory, important to safeguard the environment;
- integration of resource exploitation, combining forest production with agricultural activities (e.g., complementary to the management of chestnut orchards).

All of these elements are substantially compatible and in line with the objectives of the new European Union policy (*i.e.*, Reg. 1257/99 from 17.5.1999 concerning the support of a multifunctional management of forests in order to improve the production and the development in rural areas). We believe that the application of our silvicultural concept of spatial and temporal differentiated treatment (or non treatment) of forest lots coupled with an increase of chestnut timber utilisation, represents a real implementation of the principles of the sustainable management of the forests!

A flexible transdisciplinary research approach

Our research activities aim to define, verify and implement alternative silvicultural concepts for the coppice forests. To avoid "one-way solutions" the new management systems should present alternative options to the following conventional means, the traditional coppicing, generally without thinning, and the simple abandonment of the coppice (giving up of any management). Our common research approach foresees the integration of silvicultural studies with ecological, technical, economic and socio-cultural elements. The most important product of silviculture is timber: hence it is very important to consider the demands/requirements and the experiences of the timber sector. In the ideal case the different actors should collaborate during the whole "chestnut forest-timber chain" to better distribute economic risks and

benefits. Ideally the results reached in different countries under different environmental, social and economic conditions should be comparable and in principle be applicable under various conditions. Moreover they should be easily transformed into decisional tools of practical use to forest managers, private owners, technicians and artisans and provide a foundation for an objective discussion at scientific and technical levels.

In our opinion, it is very important to join the efforts and co-ordinate the different research activities carried out at national level. The COST Action G4 (Multidisciplinary research on chestnut) offers a good opportunity to exchange and discuss ideas, protocols, experiences and scientific information. In the "working group silviculture" we try to collect new and better data regarding diffusion area, types and distribution of chestnut forests in Europe and further afield. Furthermore, starting from dendro-auxometrical methods, we are trying to define common indicators and criteria showing the efficiency of silvicultural and management methods (Giudici et al., 1999).

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