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AGROFORESTRY SYSTEMS IN MEDITERRANEAN AREAS PRONE TO DESERTIFICATION

Agroforestry systems are typical of Mediterranean traditional rural landscapes and they are frequently localized in areas sensitive to desertification risk. The preservation and restoration of the existing systems or the establishment of new ones may be suitable alternative options to reforestation under many semiarid environments, ensuring environmental and social benefits and allowing the recovery of the biological and economic productivity of degraded land. Linear tree and shrub systems such as windbreaks, hedgerows and buffer strips may furtherly counteract the negative effects of fragmentation and soil degradation from intensive land use, and sometimes from the abandonment of rural areas too. This note outlines the main characteristics of agroforestry and tree linear systems, by assessing their limits and potential especially as means to combat desertification. The note also provides guidelines for the protection and realization of these systems in semiarid areas.

Key words: agroforestry systems; woodlots; windbreaks; hedgerows; buffer tree strips; desertification.
Parole chiave: sistemi agroforestali; boschetti; alberature frangivento; siepi; fasce arboree tampone; desertificazione.

1. INTRODUCTION

Afforestation and reforestation, i.e. the establishment of forest stands through plantation of tree and shrub species on bare, degraded or uncultivated soils, is recognized as one of the most incisive direct measures to combat desertification. The reconstitution of forest coverage allows the

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rehabilitation of ecological functionality of degraded regions in relatively short time (CORONA *et al.*, 2009a). However, such land use change is not feasible in all territorial contexts. Indeed, it is difficult to find lands available for reforestation where the profitability of intensive agriculture is relatively high. In these cases agroforestry systems may be a more viable option to counteract the risk of ecological landscape fragmentation and soil degradation.

Indeed, agroforestry systems characterize rural traditional landscapes of Mediterranean areas at risk of desertification. Topical examples are: cork oak stands and holm oak forests which constitute the so-called *dehesas* and *montados* of the Iberic peninsula, the systems dominated by *Argania spinosa* in Morocco and by *Acacia tortilis* in Tunisia, the carob stands and manna ash forests in Sicily.

In Italy, agroforestry systems localized in areas at risk of desertification are mostly *sylvopastoral systems* and sometimes *agrosylvopastoral*, with the prevalence of oak species. Tree crops for production of timber (PARIS *et al.*, 2003; PARIS *et al.*, 2005) are usually not exploited for agroforestry systems in Mediterranean areas since these require combinations of species and functions different from those traditionally applied. For instance, RÜHL *et al.* (2010) describe many different types of cultivated agroforestry systems in South-Eastern Sicily employing olive trees in association with Mediterranean forest tree species, in particular for the production of firewood (downy oak, holm oak, cork oak) in association with forage or grazed species (e.g., oat, barley, vetch) and cereals.

In the latest years, the increasing abandonment of rural areas has caused a significant decline of the agroforestry practices. Besides anthropogenic factors, also increasing drought can be considered as a cause of land degradation, as observed in Spain (LOURO and SEQUEIRA, 1988; CEBALLOS *et al.*, 2004) and in Sicily: e.g. in the latter region a high mortality of downy oak and almond trees has been observed in agroforestry systems in dry years associated with climate dominated by south-east winds. Also cattle breeding, a fundamental component of Mediterranean agroforestry, has locally become a relevant degradation factor, due to overgrazing (ENNE *et al.*, 2004).

Protection and restoration of existing agroforestry systems and the realization of new ones can lead to considerable environmental benefits, distinctively: habitat diversification and associated potential increase of biodiversity; significant sequestration of atmospheric carbon (CORONA *et al.*, 2009b); conservation, requalification and valorisation of traditional landscapes.

2. Measures to protect traditional agroforestry systems

Agroforestry systems restoration may often lead to environmental and economical benefits higher than those supplied by the so-called forestry systems (Stainback and Alavalapati, 2004). For instance, Rosalino *et al.* (2009) evidence that in south-western Portugal areas where there are inclusions of orchards/olive yards and riparian vegetation in the cork oak woodland a significantly higher number of mammalian species are present.

However, European agroforestry policies have so far fostered actions of relatively poor environmental value and weak connection with territory, as the establishment of woody buffer strips, rather than concrete strategies to preserve already existing agroforestry systems. This policy has often proved to be ineffective in Mediterranean countries (Carvalho *et al.*, 2002). The case of cork stands in Italy and Portugal is emblematic: despite their economic and environmental values, they have suffered deterioration (e.g., Acacio *et al.*, 2009) and even a significant decrease in land area (Barbati and Corona, 2006; Corona *et al.*, 2006).

Agricultural abandonment favours re-naturalization of agroforestry systems notably where they are colonized by tree species naturally occurring in forest (e.g., ash, cork oak, holm oak). However, the benefits may be only apparent. For instance, in many burned olive tree groves after the loss of above ground biomass and the variety of grafting, the resprouting of the wild olive tree contributes to create a more natural appearance, but implies a decrease of biodiversity and a loss of the identity characters of the traditional landscape. Moreover, where degradation becomes more intense it can lead to the loss of soil and the acceleration of the desertification processes: e.g., see the effects of traditional agroforestry system abandoment in Sicily described by La Mantia (2002).

For these reasons, the protection of agroforestry systems should be focused on:

– increasing agricultural subsidies for their conservation and management, thus stimulating farmers to the continuation of these traditional activities;
– the adoption of sustainable and ecologically compatible management techniques;
– setting up an integrated strategy for agroforestry product commercialization (e.g., cork, manna, hazelnuts);
– the funding to research to support the maintenance of these systems.

Just considering the case of cork oak stands – for this agroforestry system well-established practices of sustainable management are available (e.g., Dettori *et al.*, 2001) – key actions for their preservation may be:

– a rational exploitation of financial incentives: sometimes these formations were replaced by unsuccessful artificial reforestations; an economic support for their protection would probably have allowed to preserve an ecosystem with an outstanding landscape value and a well appreciated commercial product (the cork);
– the compulsory application of *minimal* management techniques (e.g. clearing of shrubs to reduce fire hazard);
– the respect of sustainable management standards in areas at risk of desertification (for technical details, see CORONA *et al*., 2006);
– the integration between production and product transformation, to establish a quality chain through the constitution of networks on regional and international scales;
– to train specialized staff, especially for barking;
– the set up of shared rules for the evaluation of cork product quality;
– the valorisation of the species and of the commercial sector through the integration with other productive chains (e.g. wine and food) and tourism marketing in the same territory.

What just mentioned for cork oak can be extended and generalized to other Mediterranean agroforestry systems.

3. BENEFITS AND GUIDANCE OF AGROFORESTRY SYSTEM ESTABLISHMENT

Diversity is usually reduced in agroecosystems because of simplification and human disturbance. Nevertheless it is possible to increase diversity by creating undisturbed "islands" within the agroecosystem able to reduce the ecological distance between fields and natural ecosystems. These "islands" can be represented by hedgerows, scattered shrubs and trees and small woodlots, along with restoration/establishment of traditional Mediterranean practices like dry stone walls and heaps of stones.

Distinctively, the realization of new agroforestry systems is a possible alternative to the reforestation *sensu strictu* for the rehabilitation of the biological and economical productivity of degraded lands in semiarid zones. New systems should be low density woody stands, with a number of trees variable between 10 to 100 per hectare.

There is a measure in the frame of Italian national programme for Rural Development 2007-2013 (First establishment of agroforestry systems on agricultural lands) which provides financial support to farmers who combine integrated systems of sylviculture and extensive agriculture on the same land.

General technical guidance to establish these systems can be summarized as follows:
– the choice of species must be ecologically coherent with the environmental characteristics of the area and it is strictly recommended to choose

genotype of local origin; moreover, it is convenient to preserve typical components of traditional agricultural landscape; many examples in Italy show unexpected unsuccessful results when these suggestions were not pursued: for instance, on the Ibleo plateau the carob stands have been replaced by Mediterranean pines; as a result, these are now forest areas not coherent with traditional landscape and more vulnerable to fire; similar situations have been observed in Sardinia after the introduction of maritime pines in areas with cork oaks;

– soil cultivation techniques should not compromise its conservation (CORONA *et al.*, 2009a);
– to protect seedlings from grazing by shelters and young stands by fences, as usually practiced for cork oaks in Sardinia; moreover, in summer it could be necessary to hoe and irrigate in order to ensure seedlings high survival rate (thus high initial densities could be avoided); it is also possible to establish initial mixed plantings with broadleaves that will build the agroforestry system (cork oak and other oak species, carrob, etc.) intermingled with conifer such as pines, provided that thinnings are subsequently carried out to avoid competition by the latter (e.g., ABELTINO *et al.*, 2000);
– grazing is an essential component of agroforestry systems in the Mediterranean areas, but at the same time it could be one of the causes of their degradation, due to the common practice to eliminate inedible species by burning; in order to prevent the risk of uncontrolled fires it is advisable to introduce rules for the enhancement of pasture lands (e.g., mowing down and eradication of inedible species).

Distinctive awareness for agroforestry system planning should be devoted to establish the new agroforestry systems without causing fragmentation of the remaining traditional herbaceous crops which can be better complemented by windbreaks, buffer tree strips along the watercourses and hedgerows, wherever needed and possible.

Windbreaks are barriers conceived to protect agricultural lands – in Italy these lands historically result from reclamation of coastal wetlands – from the action of wind (wind erosion, transport and deposit of sand from coastal areas, marine aerosol). These systems are composed by one or more rows of trees placed orthogonally to the dominant winds direction: they protect a lee side area up to ten times the tree row height, also as a function of the permeability of the row structure. The decrease of wind velocity entails generally a reduction of daily and seasonal thermo-hygrometric range and a decrease of evapotranspiration with a water saving up to 25% in open countryside (ROOSE, 1994).

The climatic mitigation produced by hedgerows has positive effects on crop productivity, especially in climatic zones susceptible to desertification

(PACUCCI *et al.*, 2002). SANCHEZ *et al.* (2010) reports that the levels of soil water content and organic carbon are higher where hedgerow are in place in comparison with places where they are removed. Another important function, albeit often neglected, is the protection of seedlings in young forest stands. Additional important positive effects on ecological functionality of the territory is provided by the potential of hedgerows and tree rows to act as ecological corridors and habitat for fauna (MASSA and LA MANTIA, 1997; LO VERDE *et al.*, 2002).

Unfortunately, hedgerows and tree rows have suffered from a strong decline especially in areas characterized by modern intensive agriculture, favoured in some cases by the land rearrangement activities (MARCHETTI *et al.*, 2002). For an effective improvement of these systems adequate information is primarily needed: sometimes the disadvantages, such as the competion with the adjoining crops, are more acknowledged than their benefits (AGRIMI and PORTOGHESI, 2002), as e.g. the shelter to fauna precious for controlling dangerous arthropods (e.g. LA MANTIA and MASSA, 1995). The choice of the species to be established requires particular attention. For instance, eucalypts have historically played a relevant role for land reclamation in Italy, but today their use is not advisable anymore (BARBERA and LA MANTIA, 1991).

A peculiar, modern example of reforestation is the establishment of riparian buffer strips, i.e. tree rows between cultivated zones and water-courses. This option has an added value for its potential of phytoremediation, i.e. as soil-vegetation filtering system for water depuration, distinctively relevant in areas with intensive agriculture, e.g. low flatland or valley bottoms. The reconstitution of tree and shrub strips interposed between crops and watercourses allows the interception and reduction of polluted flows coming from intensive agricultural areas. Their potential to absorb dusts, aerosol and different kinds of waste (e.g., particulate) is also of high interest in agricultural areas crossed by high traffic road facilities. Of course, such buffer strips may play an important function as ecological corridors and permanent habitats for many micro-mammals, nest and stopover sites for several species of standing and migratory birds; they influence positively the presence of predatory insects and therefore they are useful for biological control of phytophagy insects. The performances depend on the structure of the buffer strip (tree and shrub species, width, age); buffer strips with mixed structure and minimum width of 30 metres (green belt with forest vegetation next to watercourse and herbaceous vegetation next to cultivated field) can optimize the effect of interception and abatement of the main pollutants of agricultural origin (BORIN, 2003).

The protection of superficial and deep water resources is one of the

main objectives of the National Strategic Plan for rural development and it is applied on a regional scale in a perspective of multifunctional use of woodlands. In Southern Italy the edges of the big artificial water storages can be assigned to this purpose. This would also contribute to decrease the serious widespread phenomenon of landfill and to increase biodiversity: for instance, these woodlots, where present, have played an important role in the diffusion of Ardeides in Southern Italy.

For the realization of buffers strips FRANCO *et al.* (2001) suggest to:

– evaluate the available spaces, taking into consideration possible disturbances (for example, summer fires) and related control measures;
– choose tree and shrub species coherent with the environmental features of the site and the main target of the buffer strip (production, environmental protection, fauna habitat);
– consider tree and shrub species requirements (for example, resprouting species need frequent maintenance interventions) avoiding to build shelters for invasive tree species dangerous for crops;
– define, as far as possible, a planting design favouring the development of multilayered vertical vegetation profile.

Along with the constitution of buffer strips it is convenient to preserve the spontaneous riparian vegetation. For example, in the latest years in Sicily many natural buffer strips, constituted by several woody and shrub species such as poplar and willow, have declined because of the fire in the adjacent agricultural areas cultivated with wheat. In the past, the correct agronomic practices required to plough strips around the single plots of land to avoid fire propagation during stubble burning. This precaution is carried out even more occasionally, so that fires tend to spread over dozen of hectares usually considered of low environmental value (grasslands, garrigues, bushy formations), contributing to foster desertification processes on a large scale. The degradation of riparian formations is poorly contrasted by the establishment of buffer strips composed by the broom of Spain and other species extraneous to the Sicilian flora, which are of low environmental value (LA MANTIA and BARBERA, 2007). The financial support should instead be redirect at rewarding those farmers that apply ecologically suitable practices for the realization of buffers strips and/or preserve the existing natural formations.

4. FINAL REMARK

Agroforestry systems are deliberate consociations of woody (trees and shrubs) and herbaceous species, often associated with cattle raising. This

kind of systems is based on a positive ecological and economical synergy between sylviculture and agriculture and allows to combine agricultural activities with the supply of forest products through a spatio-temporal crop combination.

The synergic exploitation of these systems may allow: (i) the valorisation and requalification of agricultural landscape; (ii) the reintroduction of islands of biodiversity improving the capability to host plant and animal species and supporting their mobility and dispersion; (iii) the mitigation of urban sprawl constraining the transformation of agricultural land; (iv) the provision of multiple products (e.g. wood, cork, carob, honey, fodder, olive oil, cereals, grazing) suitable for integrating farmer income, even in consideration of the potential for their agri-tourism exploitation.

In the light of this, protection and restoration of existing agroforestry systems and the realization of new ones should even more become a concrete target of sustainable rural development guidance and European Union agricultural policies.

RIASSUNTO

Sistemi agroforestali in aree mediterranee a rischio di desertificazione

I sistemi agroforestali, che caratterizzano i paesaggi rurali tradizionali delle zone aride mediterranee, ricadono frequentemente in aree a rischio di desertificazione. La salvaguardia e il ripristino dei sistemi esistenti o la realizzazione di nuovi impianti agroforestali possono rappresentare opzioni alternative al rimboschimento in molte zone semiaride, garantendo significativi benefici sotto il profilo ambientale e sociale e consentendo il recupero della produttività biologica ed economica di terreni degradati. I sistemi arborei e arbustivi lineari quali alberature frangivento, siepi e fasce arboree tampone possono contribuire ulteriormente a contrastare gli effetti negativi della frammentazione e il degrado dei suoli conseguente a pratiche agricole intensive improprie, e talora anche all'abbandono colturale delle aree rurali. La presente nota inquadra i principali caratteri dei sistemi agroforestali e dei sistemi arborei lineari, valutandone limiti e potenzialità soprattutto ai fini della lotta alla desertificazione, e fornisce alcuni orientamenti per la salvaguardia e realizzazione di questi sistemi in zone semiaride.

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