

## RELEVANCE OF SECONDARY FOREST SUCCESSIONS AND THEIR POSSIBLE MANAGEMENT

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According to FAO, a 12.9% crop land decrease was registered in Europe from 1965 to 2001 and it was particularly evident in Italy (-29.7%). Besides, FAO stated a further reduction of forest (-1.7%) and cropland (-3.1%) from 2000 to 2013. Over the same period, forest land increased of 0.7% at European level confirming the positive trend occurred over previous decades. The abandonment of marginal land became established since mid 1900 and allowed the increase of forest lands due to secondary successions and reforestation. Such an important phenomenon shows positive and negative effects, both on forest management and landscape planning. The spreading of secondary successions and, particularly, of shrubland, increases the biomass stock as well as the risk of wildfires. Rural areas abandonment and lack of maintenance of hydraulic infrastructures increase mountainside instability, but a higher forest land coverage reduces and controls erosion. The changes from cropland and rangeland to forest and shrubland reduce landscape diversity but shrublands are particularly rich in biodiversity. Other aspects are: the increased carbon sequestration capability of secondary successions and the interesting opportunity of valuable timber production, (e.g. annual increment of ash-sycamore stands can reach  $10 \text{ m}^3 \text{ ha}^{-1} \text{ yr}^{-1}$ ). An analysis of the European and Italian situation is reported, highlighting strength and weakness of these new woodlands and the role that an adequate management can play.

*Keywords:* land cover change, secondary succession, silviculture, forest management, landscape.

*Parole chiave:* cambiamenti di copertura del suolo, successioni secondarie, selvicoltura, gestione, paesaggio.

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### 1. Introduction

The abandonment of marginal lands due to heavy socio-economic changes was evident since the 1950's (Gellrich *et al.*, 2007). As such, agricultural abandonment is a consequence of the post-war trend in Western-Europe, of rural depopulation and modernization of agriculture (Mottet *et al.*, 2006). Isolated and poorer areas were most vulnerable than others (Mac Donald *et al.*, 2000). It originated the increase of forest cover due to natural secondary successions and to reforestation as well. According to FAO a 12.9% reduction of cropland occurred in Europe from 1965 to 2000. This reduction was much higher in Italy (-29.7%). On a global scale, from 2000 to 2013, FAO registered a further reduction of forest (-1.7%) and cropland (-3.1%). Nevertheless, over the same period, forest land increased of 0.7% at European level, confirming the positive trend of last decades. According to the Global Forest Resources Assessment (FAO, 2010), the trend of forest expansion from 1990 to 2010 has reached a mean increment of 1,6% in Europe.

The most relevant increment and extension in new forests was registered in Italy and Spain, with 20.5%, 31.5%, respectively (Fig. 1 and Tab. 1). Such a relevant phenomenon has positive and negative relapses on forest and landscape management. The spreading of secondary successions and, particularly, of shrubland,

can increase the biomass stock (Alberti *et al.*, 2008), but it also increases the risk of wildfires (Romero-Calcerrada and Perry, 2004). Rural areas depopulation and the lack of maintenance of hydraulic infrastructures (e.g. terraces) cause the increment of mountain side instability (Agnoletti *et al.*, 2012). On the other hand, the higher land coverage reduces erosion and runoff (Tasser *et al.*, 2003).

The changes from cropland and rangeland to forest and shrubland reduce landscape diversity with irreversible loss of interesting traditional cultivation forms (Ihse, 1995; Petretti, 1996) and past land uses (Agnoletti and Paci, 1999; Agnoletti, 2007; Agnoletti, 2014). Shrubbylands are anyway particularly rich in birds' diversity (Laiolo *et al.*, 2004; Sitzia, 2009). These aspects are strictly related to the lack of land and forest management, but they can also represent an interesting opportunity for wood production.

### 2. Patterns of settlement and colonization progress rate

The spreading of new woodlands can follow different models: *i*) frontal advancing; *ii*) spreading of shrubs clumps progressively colonized by tree species (Fig. 2); *iii*) seed dispersal (direct colonization) (Piussi, 2002; Sitzia, 2009). The rate of colonization depends on different factors: site characteristics (climate, soil ferti-

lity, etc.) surely play an important role as well as tree species characteristics (seed dispersal and/or vegetative regeneration by stem or root sprouts).

Another important factor is past land uses, which can influence the process of colonization and modify specific composition of new forests.

Particularly, in the terraced sites, the stones of walls create a suitable environment for tree regeneration and can represent a shelter protecting seedlings from mowing and other agricultural practices. In addition, trees cultivated inside or along fields' borders to produce fodder (Bargioni and Zanzi Sulli, 1998) or for traditional grape cultivation (i.e. *vite maritata*) are often a consequence of mother trees establishing the colonization of abandoned fields.

Another important factor is definitely landscape texture: small patches of agricultural land inside the forest are in fact rapidly colonized as compared with large agricultural fields, far from forests and characterized by few rows or isolated trees (Fig. 3) (Gambarino *et al.*, 2014).

Moreover, other basic factors are the periodical disturbances, such as fires (Romero-Calcerrada and Perry, 2004), cuttings, mowing etc., which can slow down the colonization process and produce a selection of tree species.

### 3. Ecosystem services and management types

Secondary forests can produce numerous ecosystem services of considerable importance to society and rural populations.

#### 3.1 Carbon sequestration

The spreading of secondary forests can also represent an interesting opportunity for carbon sequestration (Hooker and Compton, 2003; Houghton *et al.*, 1999) and it gives a relevant contribution to global forest carbon storage.

Depending on case-studies, the carbon accumulation was noticed mainly on the woody component instead than in the soil.

A comparison between organic matter storage and production in a tropical pine plantation and a paired broadleaf secondary forest showed similar total organic matter productions (19.2 and 19.4 Mg ha<sup>-1</sup>yr<sup>-1</sup>, respectively) but a significantly different structural allocation (Cuevas *et al.*, 1991).

In ash-sycamore secondary forests, stem carbon accumulation increases at a mean rate of 1.69 Mg C ha<sup>-1</sup>y<sup>-1</sup> and total storage is 1.18 Mg C ha<sup>-1</sup>y<sup>-1</sup> (Alberti *et al.*, 2008). Whilst in Mediterranean regions, a mean rate of 3.4 Mg C ha<sup>-1</sup>y<sup>-1</sup> in the soil was observed at abandoned terraces in the Pantelleria island earlier cultivated with vineyards and caper bushes (La Mantia *et al.*, 2007).

Usually, when abandoned pastures change to secondary broadleaved forests, a general reduction of soil carbon accumulation has been noticed, while an increase in carbon accumulation occurs in soils of abandoned arable land (Guo and Grifford, 2002).

#### 3.2 Management of secondary forest for wood production

The spreading of secondary forests can also represent an interesting opportunity for wood production. In the Alpine region, the progressive raising of the tree line due to the abandonment of pasture and global warming is produced by direct colonization of trees.

A few pine species, larch, spruce, birch, alder, and other broadleaved tree species colonize directly abandoned land and pasture (Motta *et al.*, 2006; Gambarino *et al.*, 2001, 2014). Sometimes, the first stages of colonization are characterized by a shrub layer (hazel, green alder, dwarf mountain Pine, Rhododendron, Juniper, etc.). The direct colonization can give rise to noticeable secondary forests because of the high productive level. In the Italian Pre-alpine region, Ash and Sycamore are able to colonize quickly abandoned agricultural land and produce new secondary forests characterized by a high productive level (Salbitano, 1998; Pelleri and Sulli, 2000; Pelleri *et al.*, 2003).

The direct colonization of these two post-pioneer species is rapid and in a few years they are able to cover the whole area of former agricultural and pasture land, reducing the chance of a further spreading of other species. A study implemented in the Vicenza Province built up a growth model for the development of unmanaged ash-sycamore secondary forests. The stems density, very high in the young stage, decreases rapidly from 30.000 trees ha<sup>-1</sup> to 600 over sixty years. At the age of sixty the total volume (stem and branches) can reach more than 450 m<sup>3</sup> ha<sup>-1</sup> (Fig. 4) with a mean increment of about 12 m<sup>3</sup> ha<sup>-1</sup>y<sup>-1</sup> at the age of eighteen (Pelleri and Ferretti to be completed).

The potential of ash-sycamore stands is very interesting also for valuable timber productions. Examples of suited management models (i.e., single-tree oriented silviculture or coppice with standard system) could allow the enhancement of a share of the more than 150.000 hectares of maple-lime and ash forests (IFNC, 2005), currently mainly managed according the coppice systems to produce firewood. Experimental trials have reached interesting results starting, in young ash-sycamore stands (aged 15-20), with a high thinning intensity and frequency (Pividori, 2002; Giulietti *et al.*, 2009; Pelleri *et al.*, 2009; Crivellaro *et al.*, 2013).

The final crop trees (100 ha<sup>-1</sup>) selected in the thinned plot and managed with three localized-selective thinning in fifteen years, showed a superior DBH (+25%) and a superior crown diameter (+69%) in comparison to the crop trees selected, with the same criteria, in the control plot.

In the Apennine and Mediterranean regions, hop-Hornbeam, flowering Ash, Elm, Black Locust, a few Oaks species and some Pines are able to colonize directly abandoned lands and produce interesting amount of wood biomass. For many secondary forests, coppice is the more suitable management system (i.e., Hornbeam, flowering Ash, Oaks, black Locust, etc.).

In these cases, a permission from local forest service is needed for coppicing, as these stands are generally considered high forest by the forest Law because mainly

regenerated from seed and unmanaged.

At the first coppicing, production can be low due to limited stools' density but it can rapidly grow at following harvestings.

### 3.3 Management of shrubs areas for cattle breeding

In the Apennine and in the Mediterranean area, secondary woods are more often characterized by a first stage dominated by a shrub layer (Fig. 5). Typical are the shrub layers characterized by Juniper, Broom, and shrub types belonging to the Rosaceae family (i.e., Bramble, Blackthorn, dog Rose, etc).

Under the shrubs coverage, tree species progressively grow using shrubs as a shelter (Pelleri *et al.*, 2005). These woods are rich in biodiversity and can be oriented in the long run towards more stable forests or can be enhanced in these transitory stages through cattle breeding. In order to improve the possibility of cattle breeding, it is important to reduce shrubs' invasion by trimming to maintain pastures free and using more rational techniques of breeding livestock (Argenti *et al.*, 2006; Sturaro *et al.*, 2009; Marini *et al.*, 2011).

Limited shrubs areas not completely closed are important, as they may be preserved as a food source and shelter for cattles in summer time and for their natural features (i.e. birds, biodiversity, etc.). Under the most suitable site conditions, where an articulate composition is present, localized low impact interventions may be carried out to favour the evolution towards mixed secondary broadleaved forests.

### 3.4 Biodiversity

The effect of land abandonment on plant and animal species richness is not unequivocal. Plieninger *et al.* (2014) discovered that land abandonment shows slightly increased plant and animal species richness and overall abundance. Results are however heterogeneous, with differences in the effect size between taxa, spatial-temporal scales, land uses, landforms, and climate. They also stated that there is no "one-size-fits-all" conservation approach that applies to the diverse contexts of land abandonment in the Mediterranean region.

### 3.5 Landscape management

In areas with high tourist and landscape value, it is basic the preservation of open spaces and traditional land uses. The progressive closure of landscape caused by the spreading of new woodlands reduces landscape diversity (Agnoletti, 2007; Foster, 1992; Foster *et al.*, 1998). In mountainous agricultural sites, characterized by a high tourist and landscape value, old traditional land uses are often present. In these situations, the abandonment can produce a loss of these traditional land uses, so important for their cultural heritage. The restorations of these old land uses (chestnut orchard, terraces, pollarding trees for forage, old grape cultivation

systems, etc.) can be maintained and managed for their historical and cultural significance and used also for tourist activities.

## 4. Conclusion

The recent FAO report (FRA, 2010) highlights a continuous increase of woodlands in Europe, especially in Spain and Italy. According to the preliminary data of new IFNC from 2005 to 2015 an increment of 600.000 hectares in forests cover was estimated in Italy. In ten years, forest coverage increased from 34.7% to 36.7% of total land area. Following the abandonment of land devoted to agriculture, secondary forests colonized wide surfaces previously oriented to agricultural and pasture activities, following different colonization patterns.

The new secondary forests are able to provide several ecosystem services (carbon sequestration, wood production, soil protection, biodiversity, etc.) but they can, at the same time, create problems connected to the abandonment, depopulation of mountain area and the lack of secondary forests management (increase of wildfire risk, loss of patterns and levels of landscape diversity, increase of land slide risk, etc).

To enhance secondary forests ecosystem services and increase the contribution that forests can provide to society, it is necessary to actively start managing these new woodlands, enhancing, case by case, their ecological and productive potentials.

In the most productive secondary forests, it is possible to improve valuable timber production (i.e., Ash-Sycamore and a few conifer secondary forests).

It seems basic the involvement of stakeholders with a participative process, to provide financial support, the cooperative management of private lands, to foster first silvicultural operations and to promote a local market as well.

In many secondary forests, the more suitable management is likely to be the coppice system (i.e., Hornbeam, flowering Ash, Oaks, etc.).

In areas with high touristic and landscape values, it is important to preserve open spaces and traditional land uses to maintain a suited landscape diversity.

In abandoned pastures dominated by shrubs, a main point is to keep pastures free, by controlling shrubs invasion, maintaining only localized shrub cover for bird diversity and manage these transitory stages through cattle breeding. In the best site conditions, where the evolution of shrubland towards mixed secondary forests is fast and evident, low impact silvicultural interventions are advisable.

It seems necessary to highlight that every type of decision on the management forms has to be based on the natural characteristics of spontaneous reforestation, and especially on social, economic and cultural contexts in which the new woodlands and landscape are inserted.

Table 1. Trends in the extension of forest from 1990 to 2010. The most relevant countries with more than 500,000 hectares of cover increment.

Tabella 1. Incremento delle foreste dal 1990 al 2010. Le nazioni più importanti con più di 500.00 ettari di incremento di superficie.

Countries	Forest area (1000 ha)			%
	1990	2010	1990-2010	
Europe	989,471	1,005,001	15,530	1.6
Spain	13,818	18,173	4,355	31.5
Italy	7,590	9,149	1,559	20.5
France	14,537	15,954	1,417	9.7
Norway	9,130	10,065	935	10.2
Sweden	27,281	28,203	922	3.4
Belarus	7,780	8,630	850	10.9
Greece	3,299	3,903	604	18.3
Bulgaria	3,327	3,927	600	18.0

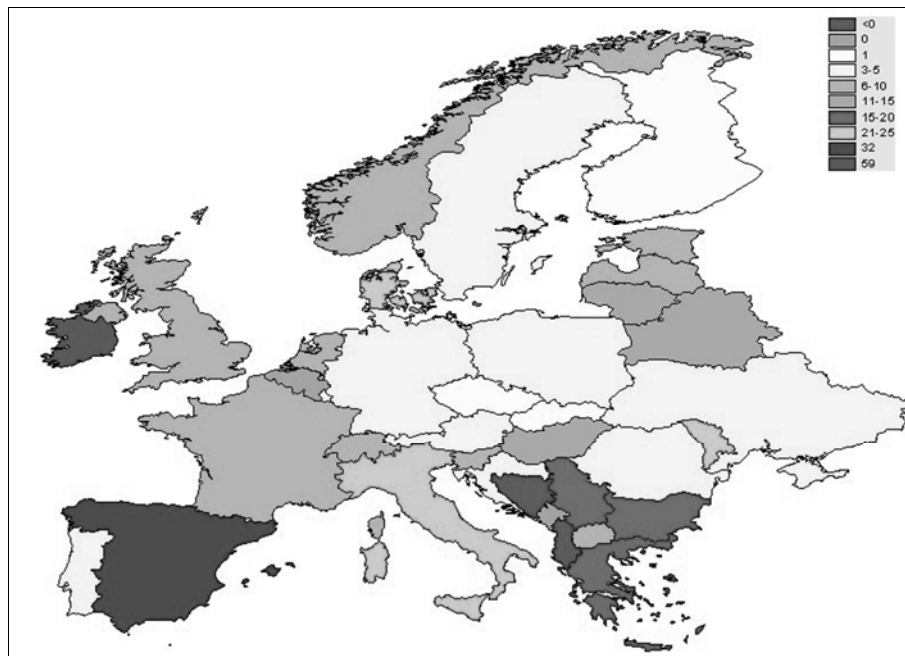


Figure 1. Trends in the extension of forest area (%) from 1990 to 2010 (FAO - FRA 2010).

Figura 1. Incremento in superficie delle foreste in Europa dal 1990 al 2010 (FAO - FRA 2010).

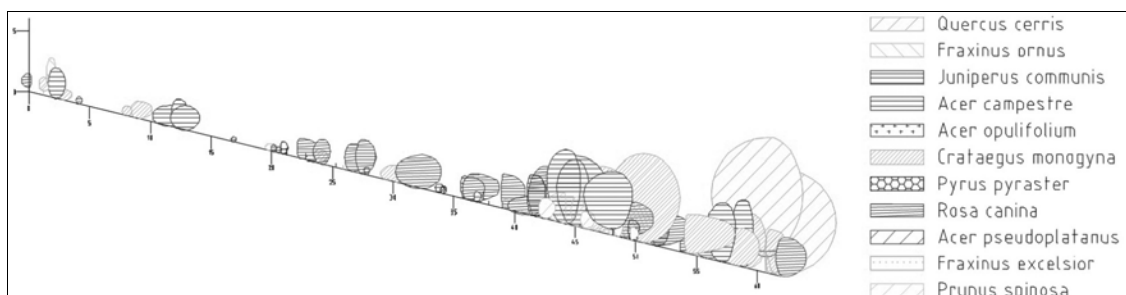


Figure 2. Secondary succession on abandoned pasture where first shrubs clumps are progressively colonized by tree species (Apennine).

Figura 2. Colonizzazione di un pascolo abbandonato dove i primi nuclei di arbusti (nucleazione) sono progressivamente colonizzati da specie arboree (Appennino).

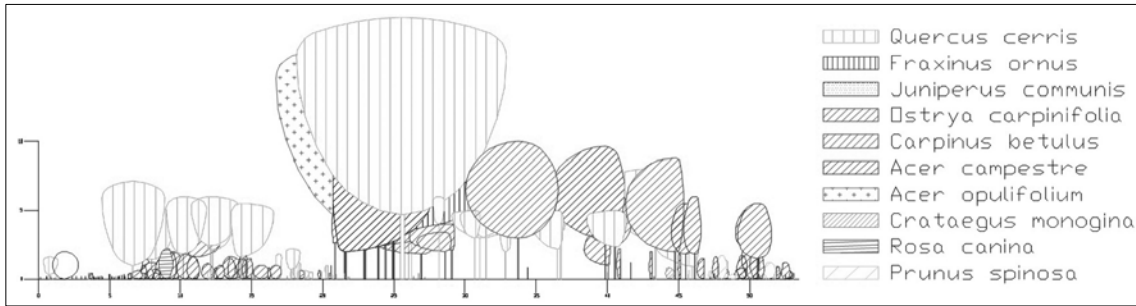


Figure 3. Secondary succession on abandoned pasture following centrifugal advancing pattern becoming established from isolated Turkey Oak and Maple trees.

Figura 3. Colonizzazione di un pascoli secondo pattern centrifugo a partire da piante isolate di cerro e acero.

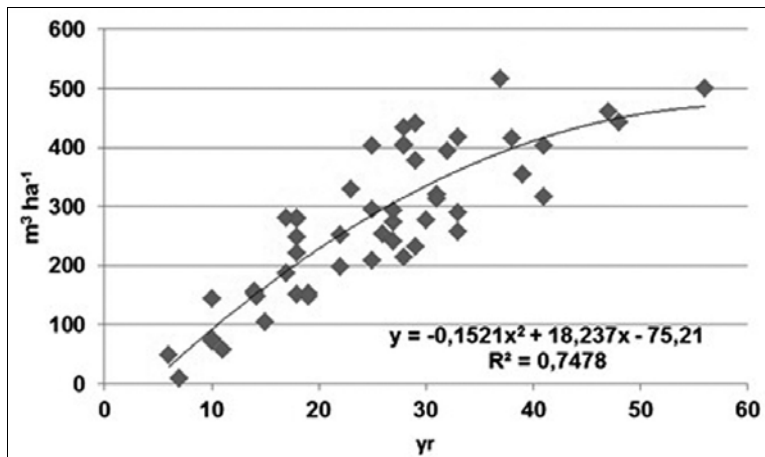


Figure 4. Total tree volume trend in unmanaged Ash-Sycamore secondary forests of Pre-alpine region.

Figura 4. Andamento del volume dendrometrico in aceri-frassineti secondari non gestiti della regione prealpina.

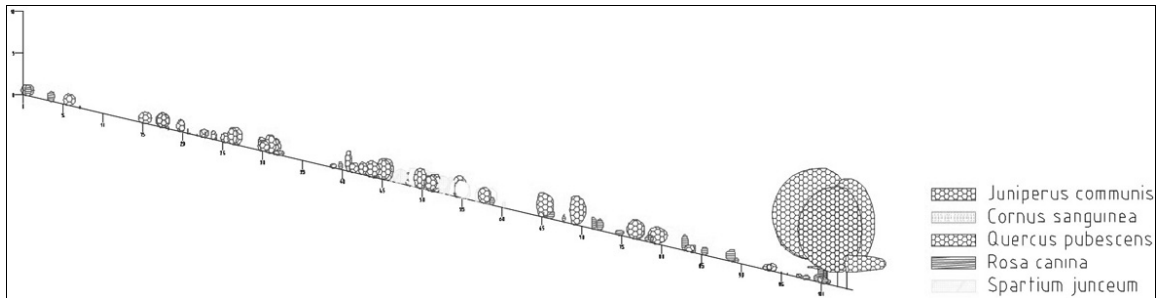


Figure 5. Juniper and Broom secondary succession on abandoned agricultural land (Apennine).

Figura 5. Colonizzazione di aree agricole abbandonate da parte del ginepro comune e la ginestra odorosa (Appennino).

## RIASSUNTO

### Rilevanza delle successioni secondarie e loro possibile gestione

Secondo FAO, dal 1965 al 2001 in Europa le superfici agricole si sono ridotte del 12,9%, particolarmente in Italia (-29,7%). Sempre secondo FAO, a livello globale, dal 2000 al 2013, la superficie forestale (-1,7%) e quella agricola (-3,1%) si sono ulteriormente ridotte; mentre in Europa quella forestale è aumentata (0,7%), concordemente con quanto avvenuto nei decenni pre-

cedenti. L'abbandono delle aree agricole marginali, originatosi a partire dagli anni '50, ha determinato il progressivo aumento delle superfici forestali dovuto all'imboschimento spontaneo e all'attività di rimboschimento. Un fenomeno così rilevante ha effetti positivi e negativi, spesso ambivalenti, sulla gestione forestale e territoriale. La diffusione delle neoformazioni forestali, in particolare di aree ad arbusteti, può aumentare il rischio di incendio, d'altra parte accresce la quantità di biomassa. La mancanza del presidio umano e l'abbandono delle sistemazioni idrauliche di aree agricole portano ad un progressivo au-

mento dell'instabilità dei versanti, viceversa la maggiore copertura del suolo riduce e controlla fenomeni erosivi. La progressiva chiusura di aree aperte porta ad una progressiva omogeneizzazione del paesaggio con perdita di diversità e di sistemi tradizionali di uso del suolo, d'altra parte le formazioni ad arbusteti sono assai ricche di biodiversità. Ulteriori aspetti sono l'aumentata capacità di stoccaggio del carbonio e le potenzialità produttive - in particolare di legname di pregio - di parte di queste neoformazioni con incrementi medi anche di 10 m<sup>3</sup>ha<sup>-1</sup>yr<sup>-1</sup>. Si analizza la situazione europea ed italiana evidenziando punti di forza e di debolezza di queste formazioni ed il ruolo che può giocare una corretta gestione.

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