Available online at www.sciencedirect.com

ScienceDirect

Procedia - Social and Behavioral Sciences 223 (2016) 758 – 763

Procedia
Social and Behavioral Sciences

2nd International Symposium "NEW METROPOLITAN PERSPECTIVES" - Strategic planning, spatial planning, economic programs and decision support tools, through the implementation of Horizon/Europe2020. ISTH2020, Reggio Calabria (Italy), 18-20 May 2016

Environmental resources conservation through sustainable forest management

Vittoria Coletta[a], Fabio Lombardi[a], Valeria Altieri[a], Giuseppe Bombino[a] Claudio Marcianò[a], Giuliano Menguzzato[a], Pasquale A. Marziliano[a,]*

[a]*Department of AGRARIA, Mediterranean University of Reggio Calabria, Loc. Feo di Vito, I-89122 Reggio Calabria, Italy*

Abstract

Between XVIII and XX centuries, the forest resources in Calabria region (southern Italy) were intensively exploited and only political strengths, relatively recent, led to a re-establishment of forest cover. Thanks to these actions, from 1957 to 1980, reforestation and forest recovery activities interested 153.000 ha and forest cover increased by 32%, with a consequent reduction of the erosion processes in mountainous areas. In the present study we analysed three monospecific conifer stands, reforested 50 years ago, in the Aspromonte National Park, dominated by calabrian pine, Monterey pine and silver fir, respectively. The long-term effects of the reforestation and the management implications were evaluatedin relation to the enhancement of the environmental resources of a modern Metropolitan city. All the reforested stands were highly productive. However, the lack of management often induced tree diseases and downfall, then loss of timber quality. Reforestation activities accomplished importance goals: (1) soil conservation; (2) timber production and (3) consequent socio-economic and employment advantages. However, in order to fulfil the long-term effects of such benefits, and to to enhance such resources within a Metropolitan city, is fundamental that forest policies should pay more attention to the management (holistic and sustainable), restoration and ecological stability of reforested stands, together with a constant monitoring of these reforested stands. Finally, reforested stands across all the Metropolitan areas play an important role in hydrological protection, water storage, but also for timber production.

Peer-review under responsibility of the organizing committee of ISTH2020

*Keywords:*Reforestation; forest management;natur conservation; conifers; aspromonte

* Corresponding author. Tel.: +3909651264256.
E-mail address: pasquale.marziliano@unirc.it

1877-0428
Peer-review under responsibility of the organizing committee of ISTH2020
doi:10.1016/j.sbspro.2016.05.264

1. Introduction

Until the first half of 1700,the Calabria Region was one of the most wooded areas in Italy. Both quantity and quality of the wood resources were so outstanding that they were often used for building ships for the Borbonic Navy (Gangemi, 2001). However, considering the continuous political, social, economical and demographical changes occurred from the mid 1700's to the mid 1900's, a great reduction in forest cover occurred. Moreover, during the world wars, calabrian forests were intensively harvested for financial requirement (Marziliano et a., 2012). Additionally, in 1951, an extreme meteorological event caused a series of landslides and flooding, which effects were worse on the pauperized soils and on the lands deprived of forest cover (Bombino et al., 2007). Particularly, in the Reggio Calabria District,economic damages were estimated around fifteen millions of Euro. In 1955, considering the strong environmental decline in the region, the Italian Government issued a special law (I Special Calabria Law 1177/55) which provided a sequence of reforestation interventions,funded by the National Italian ForestAgency (ASFD), useful to increase the forest cover in the Region, recovering the pauperized areas. Moreover, a second special law followed up in 1968 (II Special Calabria Law 438/68). The Forest Agency explicitly provided again the establishment of new forests,also recovering the degraded ones, in order to ensure favourable environmental conditions for water flows (Zema et al. 2014), but also increasing the timber supply (Pizzigallo, 1970). From 1957 to 1980,the activities related to reforestation and forest recovery affected 153.000 ha, forest cover increased by 32% and timber production significantly raised (Marziliano et al., 2015).Furthermore, other aims were achieved, such as the enhancement of landscape and soils, but also the increase of employers in the forest sector (Iovino & Menguzzato, 1999).

Conifers were the mostly used species in the reforestation, due to their faster growth rates. They quickly provide ground cover, reducing consequently the erosion processes. Moreover,conifers could supply great amounts of woody materials of small dimensions.The calabrian pine (*Pinus nigra* subsp. calabrica (Loud.) A.E. Murray) was the most usedspeciesand actually it dominatesmany stands on mountainous areas (e.g. "Aspromonte" and "Sila" National Parks). The Douglas-fir (*Pseudotsuga menziesi* (MIRB) FRANCO, var. menziesii), the white pine (*Pinus strobus* L.) and the Monterey pine (*Pinus radiata* D.DON.) were also used, but on a small extent. Silver fir (*Abies alba* Mill.) was only planted within the natural silver fir stands, with the aim to restore degraded forest stands.

In this study we focused onthe "Aspromonte" area, considering its crucial role (both for geographical and social reasons) within the Reggio Calabria Metropolitan city. We analyzed three monospecific conifer stands, reforested 50 years ago, dominated by calabrian pine, Monterey pine and silver fir, respectively.

Such reforestation activities were carried out for reducingthe erosion processes, preventing also the effects of extreme meteorological events. The main objective of this study was the evaluation of the long-term effects of the reforestation interventions, describing the dendrometric and structural characteristics of the investigated forest stands.

2. Materials and methods

2.1. Study area

The threestudy sites are locatednearby Gambarie d'Aspromonte (within the Municipality of Santo Stefano d'Aspromonte, Rc), at an altitude ranging between 1200 and 1350 m a.s.l., on a flat area. Before the reforestation interventions, they were mainly agricultural areas, surrounded by scattered oaks and beech-silver fir stands. According to the FAO classification (FAO, 1998), soils refer to *Humic and Lithic Dystrudeps* group. They have a dark epipedon, rich in organic matter, lying on rock substrates. They range from thin to very deep soils, with a coarse texture and a pH ranging from acid to sub-acid. Moreover, they are characterized by a good drainage, even if ground water reserves are scarce.

The climate is typically Mediterranean. Mean annual temperature is 10 °C, the average temperature of the coldest month is 2.3 °C, while the warmest has an average temperature of 18.3 °C. The annual rainfall is 1754 mm, with minimum precipitation in summer (31 mm). They are unevenly distributed over the year and often with a torrential characterization. According to the Pavari's phytoclimatic classification (Pavari, 1959), the stands are located between the cold sub-zones of *Castanetum* and the warm sub-zone of *Fagetum*. The reforested areas here investigated were planted after a superficial soil tillage, on small stripes drawn following contour lines. The planting space was 1 meter within the same row and 4 meters between rows (2500 trees per hectare) for calabrian pine and silver fir; whereas, for Monterey pine, the distance between trees within the row was 2 meters, due to its faster growth rates. During the first years after planting, cultural cares were carried out, through the elimination of invasive vegetation. Later, only in the pines stands, dead branches were cut in order to prevent crown fires. Later, silvicultural intervention were not realized in any stand.

2.2. Data survey and analysis

In the study area, quantitative data were collected for describing the tree living components and the stand attributes. In detail, five square plots for each forest type were sampled, with an extension of 900 m^2in the pine stands and 625 m^2in the silver fir stand,positioned through a systematic sampling design. Therefore, the diameter at breast height (DBH) of all trees and height (Ht) of the 50% of the sampled trees were measured. Standing dead trees were also sampled.

The volume of living and dead standing trees was calculated using double-entry volume models already applied in the Italian National Forest Inventory (Tabacchi et al., 2011).Basal area, mean diameters, tree density and volume per hectare were then calculated. On the data obtained, an analysis of the variance(ANOVA one-way) was carried out, in order to compare the results obtained among the three studied stands.Finally, the Tukey test was thenapplied in order to test the differences between the investigated stands.

3. Results and discussion

The calabrian pine stands were dense, with straight trees, having regular stems and crowns. Trees were distributed in one layer, and the herbaceous-shrub layer formed with ivy, fern and holly. Many trees showed defoliation due to processionary moth (*Thaumetopoea pityocampa* (Den. and Schiff)), and primary trunk bifurcation due to European pine shoot moth (*Rhyacionia buoliana* (Schiff.) (Lepidoptera: Olethreutidae). Few trees were fallen for snow weight or strong wind, often damaging also the neighbours trees. In such cases, with the formation of large gaps,the pine regeneration was evident. Moreover, where gaps were smaller, beech and holm oak regeneration was however frequent. Tree density was, on average, of 1078 trees per hectare (922÷1400, Figure1a, Table 1). The stand was characterized by a bell-shaped diameter distribution, as showed in Figure 2. The living tree volume was 673 m^3 ha^{-1}, whereas the standing dead trees were, on average, 60 per hectare witha volume of 11.67 m^3 ha^{-1}. Dead trees belonged to the 15÷25 cm diameter class and their death was maybe caused by natural disturbances, such as tree competition or meteoric events (e.g. wind or heavy snow).

Monterey pine standswere degradated, also because no silvicultural interventions were realized in the past. Moreover, dead downed trees also occurred due to natural disturbances; many trees showed also bifurcation, due to an intense infection of European pine shoot moth (*Rhyacionia buoliana* (Schiff.) (Lepidoptera: Olethreutidae). The shrubs and herbaceous layers were very dense, limiting the regeneration of tree species. All the stands were characterized by a bell-shaped diameter distribution, as showed in Figure 2. The number of trees per hectare was 387 and the volume was about 525 m^3 ha^{-1} (Table 1). Volume of dead standing trees was 7.8 m^3 ha^{-1} and the density of dead standing trees was, on average, 67 per hectare. The dead trees belonged to the smaller diameter classes.

The silver fir stands showeda precarious health condition, due to the lack of trimming and thinning interventions. Silver fir regeneration was totally absent, while beech seedlings were observed in the larger gaps, where light conditions for establishment were optimal. As consequence of illegal cuts, the tree density was low (608 per hectare) and trees showed high growth rates (Table 1). The diameter distribution was bell-shaped, slightly shifted on larger diameters. Dead standing trees were 29 per hectare, with a volume of 30 m^3 ha^{-1} and their death was caused by meteoric events (e.g. wind or heavy snow).

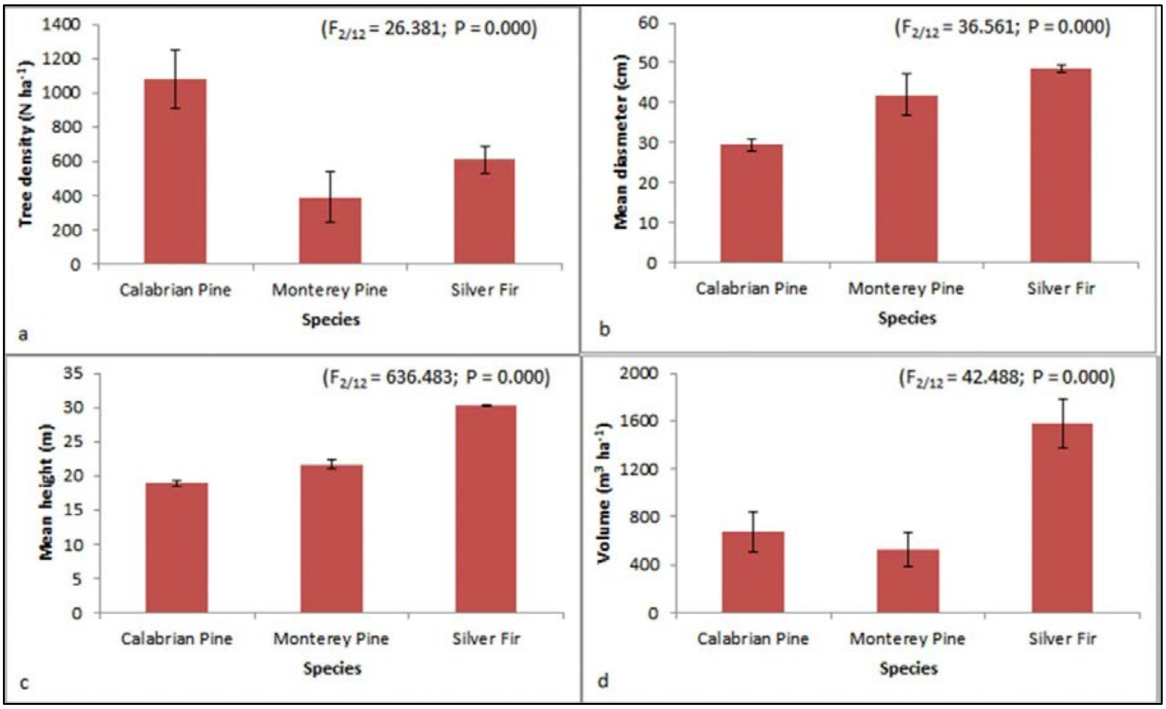

Fig. 1. Mean and Standard deviation of dendrometric data: a) Number of trees per hectare, b) mean DBH c) mean height,d) volume referred to the three studied species.

Table 1. Dendrometric data obtained for the threes studied species.

Type	Dendrometric data	Min	Max	Mean	Std.Dev
	Tree density (N ha^{-1})	922	1400	1078	191.64
	Mean diameter (cm)	27.56	31.55	29.50	1.71
Calabrian pine	Mean height (m)	18.37	19.49	18.93	0.48
	Basal area (m^2 ha^{-1})	57.69	105.82	74.45	19.42
	Volume (m^3 ha^{-1})	506.90	972.90	673.10	187.96
	Tree density (N ha^{-1})	496	720	608	84.66
	Mean diameter (cm)	47.26	49.75	48.38	1.07
Silver fir	Mean height (m)	30.15	30.45	30.29	0.13
	Basal area (m^2 ha^{-1})	87.02	129.19	112.09	16.64
	Volume (m^3 ha^{-1})	1231.10	1807.80	1578.44	229.84
	Tree density (N ha^{-1})	278	667	387	164.03
	Mean diameter (cm)	34.39	47.43	41.84	5.80
Monterey pine	Mean height (m)	20.60	22.30	21.62	0.77
	Basal area (m^2 ha^{-1})	30.84	79.67	53.07	18.54
	Volume (m^3 ha^{-1})	306.10	739.60	524.94	163.30

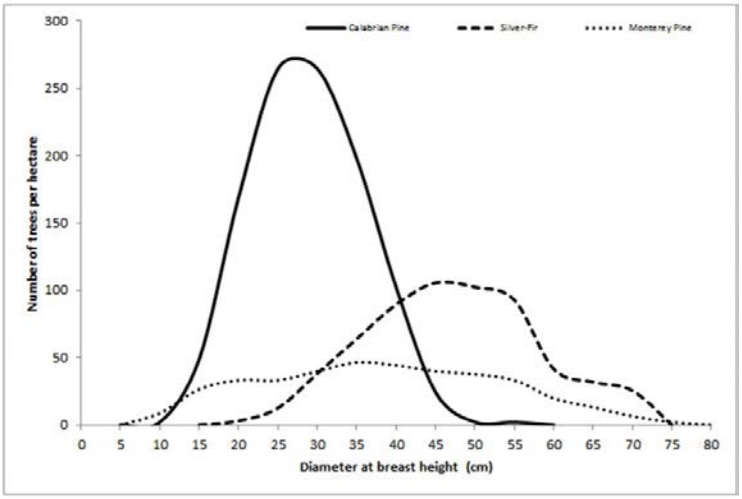

Fig. 2. Diameter classes distribution among the three studied species.

The analysis of variance showed significant differences between the three species ($p<0.001$). Pines stands differed in number of trees per hectare (Figure 1a), but had similar values of volume (Figure 1d). The average diameter for monterey pine stands were higher than calabrian pine (Figure 1b), since lower tree density led to an higher tree growth rates. Silver fir stands were more productive, probably due to the ecologic and climatic site conditions. The results showed that the use of exotic species, such as Monterey pine, can be appropriate for reforestation activities, since they are characterized by a fast growth, useful to protect steep slopes in few years, providing also large amount of timber in a short time-lapse.

Nevertheless,a regular management of the new established forests is fundamental to optimize the stand characteristics, preventing stand damages and decline (Marziliano et al., 2015). All the studied stands showed high mortality rates, due to competition and natural disturbances and, in all the investigated stands, the regeneration was almost totally absent, since thinning activities were never realized. The lack of management also led to a low quality of wood characteristics.

However, the interventions of reforestation represented an efficient and relatively fast solution forslope stabilization and hydrogeological prevention. Reforested areas surely are the less natural component of the whole forest resources in the“Aspromonte” area; however, considering the dendrometric characteristics here observed, we can underline that reforestation activities accomplished several objectives, such as (1) slopes protection and soil conservation, (2) timber production and (3) consequent socio-economic and employment advantages. Finally, in order to guarantee the long-term effects of such benefits, an active forest management is needed, together with a constant monitoring of the natural trends occurring in the reforested stands.

4. Conclusion

Forests improve the environmental quality, economic opportunity and aesthetic values, such as recreation and landscape enhancement, the so-called ecosystem services(Sanesi et al., 2007; Sanesi et al., 2013; Marziliano et al., 2013; Bottalico et al., 2016). They produce valuable goods and services that are increasingly at risk because of climate change, pests, diseases, urbanization, exploitation, and neglect. The challenges to growing and maintaining healthy forests are numerous and, by necessity, should be addressed on a long-term time horizon. After the reforestation actions in Calabria, maintenance and coherent management of forest resources were not always carried out over pre-existent and new established forests. This often led to nullifying all the strengths of environmental recovery following the Special Laws. For this reason, many reforested areas are in critical ecological conditions and, consequently, an intense hydrogeological instability often occurs. The urban environment also suffers the effects of these serious forest declines, since an increase of hydrological risk occurs mainly in the downslope areas. On the contrary, the correct management of the reforested areas could improve many ecosystem services, such as:

- Biodiversity conservation;
- Climate change mitigation and air quality improvement;
- Better management of water resources and their quality;
- Soil conservation;
- Timber and non-timber forests products;
- More occupation (especially environmental and forestry jobs);
- Recreational activities and tourism improvement;
- Easier people and materials circulation (after reduction of flooding and consequent road damages).

This study showed the importance of reforestation activities on mountainous areas. The efforts made after the special laws issue returned to Calabria region the original wood heritage; however, much more should be done to create a network between forests and society for improvingthe quality of life. The territory of Calabria is still affected by numerous landslides and, more generally, has a strong propensity to develop hydrogeological instability. Forest management is crucial for reducing such criticalities. Our results will create the prerequisites for choosing the best forest management options useful for the enhancement of environmental resources of a modern Metropolitan city located in the hydrographic basin of the Aspromonte massif.

Metropolitan territory forests are an important reservoir of timber and their management (holistic and sustainable) is inescapable to enhance such resources within a Metropolitan city. For this achievement, it is fundamental that forest policiesare addressed for the conservation and restoration of biological functions and ecological stability of reforested stands. Therefore, a proper forest management would produce economic benefits for all the Metropolitan area.

References

Bombino, G., Gurnell, A.M., Tamburino, V., Zema, D.A., Zimbone, S.M. (2007). A method for assessing channelization effects on riparian vegetation in a Mediterranean environment. *River Research Application, 23*, 613-630.

Bottalico, F., Pesola. L., Vizzarri. M., Antonello. L., Barbati. A., Chirici. G., Corona. P., Cullotta. S., Garfì. V., Giannico. V., Lafortezza. R., Lombardi. F., Marchetti. M., Nocentini. S., Riccioli. F., Travaglini. D., Sallustio. L. (2015). *Modeling the influence of alternative forest management scenarios on wood production and carbon storage: a case study in the Mediterranean region. Environmental Research, 163*, 72-87, ISSN: 0013-9351.

FAO(1998). World reference base for soil resources. Food and Agricolture Organization of the United Nations, Rome, Italy, pp. 128.

Gangemi, M. (2001). Tra strade “impervie”e boschi “inaccessibili”. Aspetti e problemi del trasporto del legname nel Mezzogiorno settecentesco, in M. Agnoletti (a cura di), *Storia e risorse forestali* (pp. 139-150), Accademia Italiana di Scienze Forestali, Firenze.

Iovino, F., Menguzzato, G. (1999). I rimboschimenti: storia e significato. Il caso della Calabria, Atti del Seminario scientifico Iaed “Rimboschimenti e piantagioni nelle trasformazioni del paesaggio”, Roma, 3 dicembre 1999.

Marziliano, P.A., Coletta, V., Menguzzato, G., Nicolaci, A., Pellicone, G., Veltri, A. (2015). Effects of planting density on the distribution of biomass in a douglas-fir plantation in southern Italy. *iForest, 8*, 368-376. URL: http://www.sisef.it/iforest/contents/?id=ifor1078-007

Marziliano, P.A., Lafortezza, R., Colangelo, G., Davies, C., Sanesi, G. (2013) – Structural diversity and height growth models in urban forest plantations: A case-study in northern Italy. *Urban Forestry & Urban Greening, 12* (2): 246-254.

Marziliano, P.A., Menguzzato, G., Scuderi, A., Corona, P. (2012). Simplified methods to inventory the current annual increment of forest standing volume.*iForest, 5,* 276-282. URL: http://www.sisef.it/iforest/contents? id=ifor0635-005.

Pavari, A. (1959). Le classificazioni fitoclimatiche ed i caratteri della stazione. Scritti di Ecologia, Selvicoltura e Botanica Forestale. Accademia Italiana di Scienza Forestali: pp 45 – 116. Firenze.

Pizzigallo, V. (1970). L’evoluzione della legislazione forestale italiana. In*L’Italia forestale nel centenario della formazione della scuola di Vallombrosa,* Accademia italiana di scienze forestali, Firenze, 311-340.

Sanesi, G., Lafortezza, R., Colangelo, G., Marziliano, P.A., Davies, C. (2013). Root system investigation in sclerophyllous vegetation: an overview. *Italian Journal of Agronomy, 8,* 121-126. doi:10.4081/ija.2013.e17

Sanesi, G., Lafortezza, R., Marziliano, P.A., Ragazzi, A., Mariani, L. (2007) - Assessing the current status of urban forest resources in the context of Parco Nord, Milan, Italy. *Landscape Ecology Engineering, 3,* 187-198.

Tabacchi, G, Di Cosmo, L, Gasparini, P. (2011). Aboveground tree volume and phytomass prediction equations for forest species in Italy. *European Journal of Forest Research, 130* (6): 911-934. - doi: 10.1007/s10342-011-0481-9

Zema, D.A., Bombino, G., Boix-Fayos, C. Tamburino, V., Zimbone, S.M., D. Fortugno (2014). Evaluation and modeling of erosion and sedimentation around check dams in a Mediterranean torrent (Calabria, Southern Italy). *Journal of Soil and Water Conservation, 69*, 316-329.