Analysis of the influence of the silvicultural treatments on ecosystem services in black pine (Pinus nigra J.F.Arnold) stands in Central Italy

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Ecosystem services (ES) can be defined as all the conditions and processes through which natural ecosystems sustain and fulfil human life. According to the Millennium Ecosystem Assessment (2005) ES can be classified in four main categories: provisioning, regulating, cultural, and supporting services. Their provision is influenced by site and stand characteristics and forest management practices.
Silvicultural practices can influence ES provision by modifying the horizontal and vertical stand structure, tree species composition, stand density and age. In some cases the relationship between various forest ES might be synergistic, while in other cases there is a trade-off between them. Synergies and trade-offs must be taking into account during the definition of multi-objective forest planning by forest managers. Synergies and trade-offs were analysed in two case studies in Central Italy, characterized by different site and stand features, by quantifying the effects of two different forest management practices on three categories of ES (provisioning services, regulating services and supporting services).

## STUDY AREA and FIELD MEASUREMENTS
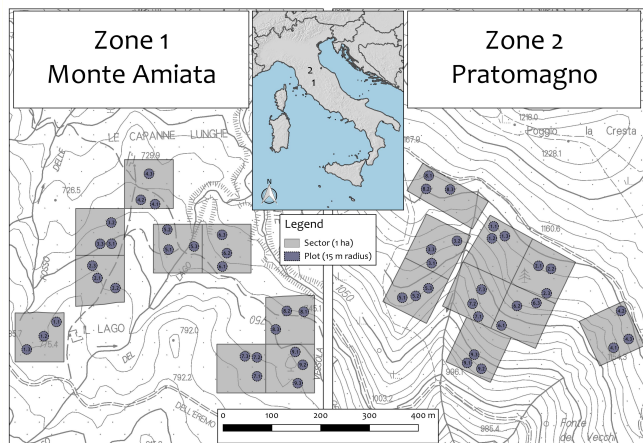
The two study area of Monte Amiata and Pratomagno are artificial pinewoods and belong to the regional Agricultural and Forestal Heritage of Toscana Region. The primary objective of such artificial stands was soil protection of bare and degradated lands as a result of intensive exploitation. The black pine represented a pioneer solution for his adaptability to harsh environments. The first one ins currently managed by the "Unione dei Comuni del Pratomagno" (UCP) while the other by "Unione dei Comuni Amiata Val d'Orcia (UCAVO). Pilot areas are located in the Pratomagno-Valdarno Forest (Arezzo) that covers a surface of 3300.14 ha and in the forest complex "Madonna delle Querce" (Siena and Grosseto) that covers a surface of 2168.60 ha. The main tree species are: Austrian black pine (*Pinus nigra* J.F.Arnold), Calabrian pine (*Pinus brutia* Ten. subsp. *brutia*), and some broadleaved species such as Turkey oak (*Quercus cerris* L.), European beech (*Fagus sylvatica* L.), Downey oak (*Quercus pubescens* L.), flowering ash (*Fraxinus ornus* L.) and hedge maple (*Acer campestre* L.).
The experimental protocol defines in each study case 9 treatment areas of 1 ha each. The forest treatments considered are: selective thinning (3 ha in total), traditional thinning (3 ha in total) and no thinning/control (3 ha in total). 3 circular sampling plots were randomly located in each treatment area. In each sampling plot, the main data were collected for mensurational and floristic analysis.

SILVICULTURAL TREATMENTS

To enhance the multifunctionality of the forests, two different silvicultural treatments were applied and compared to evaluate their effects (economical, ecological and social). While the traditional thinning consists in a classical thinning from below, the selective is a localized action performed on the most promising trees per hectare, characterized by easy applicability and replicability.
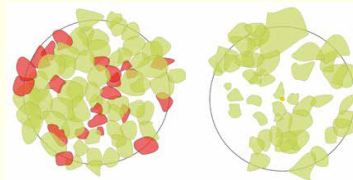
Horizontal structure of the pine forest before and after thinning from below (traditional)
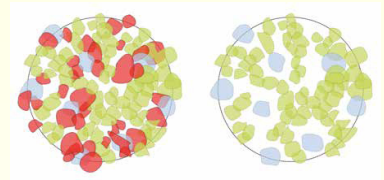
Horizontal structure of the pine forest before and after selective thinning
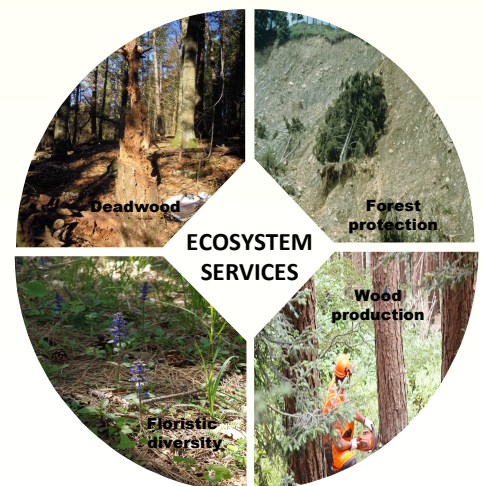
ASSESSMENT OF ECOSYSTEM SERVICES

The ecosystem services were evaluated using the data collected directly in the field and the information provided by local forest enterprises. The trade-off analysis was done using a mixed approach integrating biophysical and economic approaches. In particular, the ecosystem services with a market value were evaluated from an economic point of view, while the ecosystem services without a market value were assessed from the biophysical point of view.
In order to evaluate the effects of thinning on ES provision, three categories of ES were assessed: provisioning services (timber and woodchips production), regulating services (forest stand stability-protection), and supporting services (floristic biodiversity, quantity and quality of standing dead trees).

Trade-off between ecosystem services in the two study areas

Silvicultural treatments	Provisioning services (€ yr^{-1})	Regulating services	Supporting services	
	Timber and woodchips production	Forest stand stability (annual variation H:D ratio)	Standing dead trees / Reduction of Snag volume (%)	Floristic biodiversity / Shannon index (H')
Amiata study area				
Traditional thinning	1067	-0.969	**-53%**	**3,2**
Selective thinning	**2163**	**-1.284**	-55%	3,1
Pratomagno study area				
Traditional thinning	4211	-0.889	**-30%**	2,2
Selective thinning	**5388**	**-1.012**	-92%	**2,5**

In bold the silvicultural treatments more efficient to enhance the single ecosystem service

ECOSYSTEM SERVICES — Deadwood — Forest protection — Wood production — Floristic diversity

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