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Dataset Paper

A multi-temporal dataset of forest mensuration of reforestations: a case study in peri-urban Rome, Italy

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Abstract - The dataset supplied in this article provides data from continuous forest inventory carried out in the Castel di Guido estate, located in the Italian Tyrrhenian coast. The reforestation project started over 30 years ago using native and non-native species: 29 forested plot areas have been surveyed in 1997, 2000, 2003, 2006, 2011, 2013 and 2017 where information about species and stem diameters have been collected for a total of 2'215 tree stems. The dataset also contains height-diameter curves modelled for 1997, 2006 and 2017 years to let the user to estimate growing stock and total biomass easily. These data can be exploited to assess net primary productivity, pollutant uptake, and as comparisons with other European artificial reforestations programs with similar species. The database is finalized to narrow the knowledge gap on long-term growth pattern of urban and peri-urban reforestations, providing comparative data on different species performances, grown in pure and mixed stands. Dataset and metadata here presented are available at https://doi.org/10.5281/zenodo.2633972.

Keywords - Continuous Forest Inventory; Castel di Guido estate; urban forestry; peri-urban forests.

Introduction

Continuous Forest Inventory (CFI, *sensu* Köhl et al. 2006) is considered a well-suited observational approach to investigate growth patterns of urban and peri-urban reforestation over decades. In these cases, reforestation plans are increasing in municipalities areas to improve the environmental and aesthetic quality of urban landscapes (Christopoulou et al. 2007, Capotorti et al. 2015, Tomao et al. 2018).

Understanding how species interact with each other and with their environment is essential to obtain success in reforestation programs (Oldfield et al. 2015), especially under the uncertainties of the effects of climate change on forest ecosystems (Escobedo et al. 2011, Nowak et al. 2013, Jacobs et al. 2015). According to this perspective, forest monitoring represents a crucial precondition to support decision-making to preserve multiple forest functions in the long term (Corona et al. 2011, Marquardt et al. 2018, Puletti et al. 2019). For example, it is possible to estimate aboveground biomass and carbon absorption over time using satellite imagery, such as Landsat and Sentinel-2, in combination with long-term (10-25 years) forest inventories (Torres et al. 2013). Moreover, a few studies exist regarding the long-term survival and growth rate in urban and peri-urban plantations (e.g. Hotta et al. 2015, Ferrari et al. 2017, Sasaki et al. 2018).

The lack of maintenance, and the increasing occurrence of other disturbances like wildfires, pests and disease, can negatively affect the reforestation success (MacKay et al. 2011). Therefore, it is crucial to implement permanent monitoring activities at city and municipal levels in order to assess the plantation success (Ruiz-Jaén and Aide 2006).

From this point of view, in this paper, CFI monitoring the growth of forest plantations located in the suburbs of Rome in Castel di Guido (Italy) and established between the years 1987 and 1994 is presented. The plantations are extended over 300 hectares of former agricultural land in the farming estate of Castel di Guido. The main goal of the reforestation was to restore the forest cover and to prevent building speculation due to urban sprawl, that in less than twenty years (1990-2008) has taken a huge amount of agricultural land (11'000 hectares) in the municipality of Rome (Quatrini 2015, Gasparella et al. 2017, Salvati et al. 2017).

The database has been finalized to narrow the

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knowledge gap on long-term growth pattern of urban and peri-urban reforestations, providing comparative data on different species performances, grown in pure and mixed stands.

Methods

Study area

The Castel di Guido estate is located within the territory of Rome Municipality (41°54'3.3" N, 12°17'14.4" E) and covers around 3673 hectares along the Tyrrhenian coast. Its elevation ranges from 10 to 80 m a.s.l.

The climate of the area is mainly Mediterranean (i.e. Xerotheric Bioclimatic Region of Latium, Thermo-Mediterranean/Meso-Mediterranean Climate Subregion: Blasi 1994). Such climate may potentially support various forest types (Barbati et al. 2014, Ferrari et al. 2017) dominated by mesophytic and thermophilous broadleaved tree species including *Quercus suber* L., *Quercus pubescens* Willd., *Quercus cerris* L. and *Fraxinus angustifolia* Vahl. The predominant soil types of the reforested areas are calcic cambisols (Chirici et al. 2001). The area is included in the "Litorale Romano" State Natural Reserve and incorporates a Natura 2000 Special Area of Conservation (SAC), the Macchiagrande di Galeria IT6030025 site, and an Important Bird Area (IBA), the "Oasi Castel di Guido".

The reforestation project, implemented in the 1984-1994 period, aimed to obtain fast soil coverage in high visual impacts areas and to limit urban expansion in that area using both native (mainly *Quercus* spp.) and non-native (mainly *Pinus* spp. and *Cedrus* spp.) species which have been planted in large monospecific stands up to 8 ha. Other broadleaved species, such as *Acer campestre* L., *Celtis australis* L. and *Fraxinus ornus* L., have been planted on smaller areas (down to 60 m^2) in monospecific or multi-species patches in order to increase structural and compositional diversity of the reforestations. The spatial pattern of forest stands is shown in Fig. 1.

Sampling scheme and data collection

A network of 40 permanent plots has been localized in the reforested area since 1997 (Chirici et al. 2001) and extended up to 70 in 2003, in order to sample most widespread combinations of species

Species		1997	2006	2017
Acer campestre L. *Alnus cordata* (Loisel.) Duby *Celtis australis* L. *Fraxinus ornus* L.		y = 11.229 + 2.11 * ln (DBH)	y = 18.73 + 4.29 * ln (DBH)	y = 22.028 + 5.025 * ln (DBH)
	R^2	0.68	0.55	0.48
	N	180	174	154
Cedrus atlantica (Endl.) Manetti ex Carrière		y = 9.432 + 1.837 * ln (DBH)	y = 27.775 + 10.039 * ln (DBH)	y = -12.736 + 8.616 * ln (DBH)
	R^2	0.90	0.48	0.72
	N	52	49	56
Pinus eldarica Medw. *Pinus pinaster* Aiton		y = 13.194 + 3.263 * ln (DBH)	y = 20.984 + 5.81 * ln (DBH)	y = 22.908 + 5.438 * ln (DBH)
	R^2	0.82	0.42	0.36
	N	92	88	56
Pinus pinea L.		y = 8.576 + 1.844 * ln (DBH)	y = 19.18 + 6.202 * ln (DBH)	y = 32.178 + 12.834 * ln (DBH)
	R^2	0.94	0.30	0.55
	N	64	56	64
Quercus cerris L.		y = 9.415 + 1.727 * ln (DBH)	y = 19.253 + 4.626 * ln (DBH)	y = 26.404 + 6.329 * ln (DBH)
	R^2	0.73	0.59	0.60
	N	174	168	164
Quercus ilex L.		y = 10.594 + 2.161 * ln (DBH)	y = 19.997 + 5.203 * ln (DBH)	y = 19.494 + 4.177 * ln (DBH)
	R^2	0.76	0.71	0.54
	N	120	90	112
Quercus pubescens Willd.		y = 9.337 + 1.836 * ln (DBH)	y = 16.595 + 3.91 * ln (DBH)	y = 22.926 + 6.071 * ln (DBH)
	R^2	0.80	0.64	0.69
	N	112	122	104
Quercus suber L.		y = 9.029 + 1.677 * ln (DBH)	y = 18.345 + 5.15 * ln (DBH)	y = 16.673 + 4.232 * ln (DBH)
	R^2	0.86	0.73	0.79
	N	40	52	56

Table 1 - Height-diameter curves modelled in 1997, 2006 and 2017. Diameters at breast height must be expressed in meters.

groups and environmental factors. The plots were located according to a stratified random sampling design, with strata defined by species groups and sample size in each stratum approximately proportional to the variability of the profile curvature

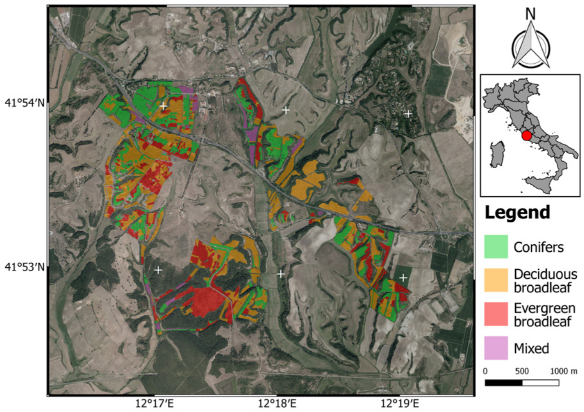

Figure 1 - Castel di Guido forest map, classified by main four species groups (conifers, evergreen and deciduous broadleaves, mixed forests). The red dot on the right side indicates the study area position.

(landform curvature parallel to the direction of maximum slope was also quantified processing a 25-m resolution Digital Elevation Model; Ferrari et al. 2017), one of the main site factors that empirically seems to affect plantation growth in the examined environment.

The permanent plots contain at least 36 planted trees. The centre of each plot was geo-referenced by GPS positioning, with post-processing sub-meter accuracy. However, due to natural disturbs (i.e. wildfires and windstorms) it was not possible to survey all the plots during the last two decades. In this data paper, we present data collected in 29 permanent plots, i.e. those plots where CFI was carried out along the entire period. Field data were collected during the winter in 1997, 2000, 2003, 2006, 2011, 2013 and 2017. The diameter at breast height (dbh) has been measured on standing living trees according to the scheme reported in Fig. 2. Tree heights have been measured using the central trees of each plot (16) and, when it could be necessary to increase this number to improve the height-diameter curve for a species, border trees of the plot have been used too. These curves have been modelled for 1997, 2006 and 2017 as shown in Table 1. Planting density, dead trees and failures have been also assessed for each plot and year.

Dataset content

To describe the characteristics of each stand, the dataset was compiled with the following variables: identifying number of record (ID_prog), plot area (ID_Plot), tree (ID_Tree) and stem (ID_Stem), genus (Genus), species (Species), scientific name of the tree (SN), EPPO code for the scientific name (EPPO; EPPO 2019), dbh measured in each inventory (DBH_1997, DBH_2000, DBH_2003, DBH_2006, DBH_2011, DBH_2013, DBH_2017) and, if present, notes (Note_1997, Note_2000, Note_2003, Note_2006, Note_2011, Note_2013, Note_2017).

Data access and metadata description

The dataset can be download using the following reference. Grotti M., Mattioli W., Ferrari B., Tomao A. & Corona P. (2019). Reforested areas of the Castel di Guido estate (Italy): field plots dataset [Data set]. Zenodo. http://doi.org/10.5281/zenodo.2633973. An exhaustive description can be found on the metadata file at the same DOI link.

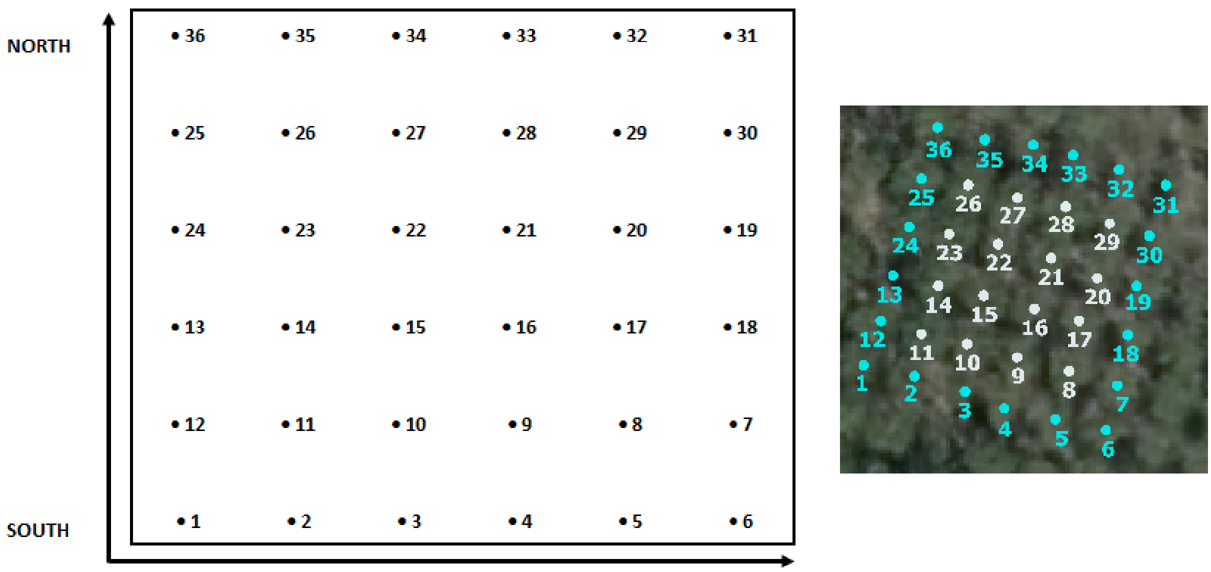

Figure 2 - Scheme used for numbering living trees in each plot. The white central trees are the ones where heights have been measured.

Technical validation

The dataset includes a total of 2'215 trees stems measured in 1997, 2000, 2003, 2006, 2011, 2013 and 2017. Accurate field checks have also been carried out from 2013 to 2019. Finally, the data of each tree have been carefully verified before the publication, avoiding misspelling or error among data collected by different operators in different periods.

Reuse potential and limits

Even if characterized by small plots, the sampling design and the high number of repetitions across the twenty years of the CFI allow the calculation of all the parameters related to diameter at different ages. Growing stock volumes could be easily calculated for trees, using equations with dbh and height as explanatory variables, developed with data from the last Italian National Forest Inventory (Tabacchi et al. 2011) implemented by the *ForIT* package (Puletti et al. 2014) in R software (R Core Team 2019). Annual mean annual increment of diameter or volume can be also easily calculated. Given the diachronic nature of the survey, this database can be also used to build yield tables, especially for young stands of the species here considered. The main limit of this dataset is the availability of height measurements only for three inventory dates. On the other hand, several models able to assess the net primary productivity and standing woody biomass (e.g. 3D-CMCC, Collalti et al. 2018) or pollutant uptake (e.g. Urban Forest Effects i-Tree, USDA) can be also applied.

The Castel di Guido's reforestation case study provides data about species growth in a Mediterranean peri-urban context, which can be used with respect to other reforestation projects under comparable environmental conditions or under the choice of species in reforestation programs across Europe. All information derived from this dataset and its implementation and use can be the basis of guidelines for other reforestation and afforestation initiatives in Mediterranean cities. The dataset offers scientific support to urban planners and policy makers encouraging reforestation plans that can limit the urban sprawl and the negative effects of climate due to greenhouse gasses emissions (FAO 2016).

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