Journal of Maps

ISSN: (Print) 1744-5647 (Online) Journal homepage: http://www.tandfonline.com/loi/tjom20

Regions of provenance for reproductive materials of the three main forest species of Abruzzi

Maurizio Marchi, Ugo Chiavetta, Cristiano Castaldi, Daniela Di Silvestro, Francesco Contu & Fulvio Ducci

To cite this article: Maurizio Marchi, Ugo Chiavetta, Cristiano Castaldi, Daniela Di Silvestro, Francesco Contu & Fulvio Ducci (2016) Regions of provenance for reproductive materials of the three main forest species of Abruzzi, Journal of Maps, 12:sup1, 94-97, DOI: 10.1080/17445647.2016.1159886

To link to this article: http://dx.doi.org/10.1080/17445647.2016.1159886

JOURNAL OF MAPS, 2016
VOL. 12, NO. S1, 94–97
http://dx.doi.org/10.1080/17445647.2016.1159886

SCIENCE

Regions of provenance for reproductive materials of the three main forest species of Abruzzi

Maurizio Marchi[a], Ugo Chiavetta[a], Cristiano Castaldi[a], Daniela Di Silvestro[b], Francesco Contu[c] and Fulvio Ducci[a]

[a]Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA) – Forestry Research Centre, Arezzo, Italy; [b]Dipartimento politiche dello sviluppo rurale e della pesca, Ex Ufficio Razionalizzazione e Gestione Procedure Amministrative Attività Fitosanitaria, Pescara, Italy; [c]Direzione Politiche Agricole e di Sviluppo Rurale, Forestale, Caccia e Pesca, Emigrazione – Servizio Politiche forestali e demanio civico e armentizio, Pescara, Italy

ABSTRACT

Regions of provenance of reproductive materials are a mandatory tool for the management of forest genetic resources in Europe. Italian regulation (D. Lgs. 386/2003), in contrast with other European countries, gives this role to regional administrations. Here we present a map of the Regions of Provenance for Abruzzi in central Italy. Three environmental zones were identified according to climatic variability using a spatial clustering procedure and the three main forest species for the region were mapped: European beech (*Fagus sylvatica* L.), European black pine (*Pinus nigra* J.F. Arnold) and Turkey oak (*Quercus cerris* L.). The results show that the main driving factors for clustering are temperature regimes reflecting the contrast between the continental climate of the interior of the region versus the Mediterranean climate on the coast. This effect was also evident in the delineation of the Regions of Provenance for the three main species where elevation plays a key role in the selection of seed stands. The Regions of Provenance of the three species will be used for the correct management of forest reproductive materials collected from the six seed stands of the Region.

ARTICLE HISTORY
Received 29 October 2015
Revised 19 February 2016
Accepted 23 February 2016

KEYWORDS
Regions of provenance; Mediterranean area; Abruzzi; forest reproductive materials

1. Introduction

Collection of well-performing seeds for reforestation activities is a fundamental step for the bio-economy (e.g. timber production; biomass production; landscape management; and genetic resources conservation) (Orlovic, Ivankovic, Andonoski, Stojnic, & Isajev, 2014). The use of well-adapted provenances can give many advantages, from survival rate to growth rate, even outside a tree species natural range (O'Neill & Aitken, 2004).

Following the scheme of the Organization for Economic Co-operation and Development (OECD) the Region of Provenance (RoP) for a forest species is an area (or group of areas) where ecological features are homogeneous (OECD, 2007). In European countries the identification of RoPs is regulated by European Union (EU) directive 1999/105/CE and is a compulsory tool for the management of forest genetic resources. In this respect, the definition of RoPs is not only scientific, it is, first of all, a legal process (Camerano, Belletti, Ferrazzini, & Pignatti, 2012). In a RoP the reproductive forest materials and all the activities connected to the nursery process and reforestation must be certified. All basic materials (e.g. seed stand, seed orchard) must be surveyed and located in a RoP and all the Forest Basic Materials must be classified. RoPs have the same meaning and application as the 'Seed Zones' commonly used in Canada and USA where the principle is to use forest reproductive materials with the highest possibility of adaptation and climatic correspondence (Erickson et al., 2012). However, in some countries such as the UK, the RoP of a native species can be split into different Seed Zones, but they are not-statutory (Forestry Commission, 2007).

Following the EU directive 1999/105/CE, RoPs are a mandatory tool for the management of forest genetic resources. Each EU member state must create its own map of RoPs, according to the ecological variability of its environment, its administrative structure and its most valuable forest species. In Italy, in contrast to other European Countries (e.g. Belgium, France, Germany, Slovakia, UK), this role has been given to Regional administrations (law number 386/2003). Maps of the RoPs for each region are disconnected from each other, making the use of forest reproductive materials outside a region very difficult, however this approach is justified by the huge environmental variability of the Italian Peninsula.

The Abruzzi is a geographic and administrative area in central Italy and, in contrast with any other Italian region, is divided into two different ecological zones by the Apennines chain which runs parallel to the coast line. The climate of the internal part is

CONTACT Ugo Chiavetta ugo.chiavetta@crea.gov.it

continental and very different from coastal regions, which are fully Mediterranean with hot and dry summers. Here the Apennines chain has the highest peak of the whole Italian range, the 'Gran Sasso d'Italia' reaches a maximum elevation of 2912 m and is just 40 km form the Adriatic sea. Abruzzi is also one of the most forested regions of Italy. About 40% of the total regional area is covered by forests, which represent 4.2% of the national forest area. The climatic variability is reflected by the forest composition and distribution. Beech (*Fagus sylvatica* L.) and Turkey oak (*Quercus cerris* L.) are the main hardwoods of the internal area and are often mixed with black pine (*Pinus nigra* J. F. Arnold) which was the main species used for reforestation programmes after the Second World War. Beech covers the higher parts of the mountains while Turkey oak is in more continental zones. In addition, many northern species are distributed across this area at higher elevations. Among them are the Black pine of Villetta Barrea (*P. nigra* ssp. *nigra* var. *italica*), and marginal populations of Silver birch (*Betula pendula* Roth) and mugo pine (*Pinus mugo* Turra, 1764). The eastern part of the region is much less forested and covered mainly by Mediterranean Oaks (*Querucs ilex* L. and *Quercus pubescens* Willd., 1805). The Abruzzi region is noted for three main characteristics: (a) it has rare Alpine climatic conditions in the middle of the Apennines; (b) it has the only naturally regenerated population of Black pine of Villetta Barrea; and (c) it presents a large continental area where the Turkey oak finds its best environment in the peninsula.

In this paper, the methods and the resulting (Main Map) of the Abruzzi region in the central part of Italy are described. Three ecological RoPs were mapped for the whole region and for each of the three main forest species (Beech, European black pine, and Turkey oak).

2. Methods

To establish a common criteria for the management of forest genetic resources, the EU directive 1999/105/CE defines the RoP for a species or sub-species as '[…] the area or group of areas subject to sufficiently uniform ecological conditions in which stands or seed sources showing similar phenotypic or genetic characters are found, taking into account altitudinal boundaries where appropriate'. To achieve this goal, two different methods are generally used: associative and partitive. The first is used when genetic data are available and takes into account the genetic variability of populations, grouping stands when a similar genetic structure is demonstrated. The second method is based on ecological and climatic features and is used to divide the administrative environment (region or a state) into climatic zones (Ducci, 2015; Pignatti & Ducci, 2003). In this study the second approach was applied due to the absence of updated genetic information and the availability of a robust regional climatic database. The climatic data were obtained from the meteorological network of the Abruzzi region and were georeferenced to the WGS84/UTM 33 N reference system (EPSG 32633). A cluster analysis was initially performed on raw data to assess the climatic variability of the region and to define the correct number of RoPs to be determined. Twenty-one climatic maps were then created by interpolating the main climatic parameters using geostatistical methods with 100 m spatial resolution and according to the most important limiting factors of the Abruzzi region (primarily temperature). Those variables included monthly temperature (12 maps), annual and summer precipitation (2), average, minimum and maximum annual temperature (3), absolute minimum and maximum annual temperature (2), and maximum temperature of the hottest month and minimum temperature of the coldest month (2). The interpolation method used a comparative method based on the Root Mean Squared Error, obtained with a cross-validation process. Methods tested were linear regression, regularized spline with tension, K-nearest neighbour, kriging (ordinary universal and regressive) and cokriging (ordinary and universal). The cross validation was performed on the database extracted from the regional climatic network (57 meteorological stations for temperature, 137 for precipitation) using a leave-one-out approach as used in similar studies (Attorre, Alfo, De Sanctis, & Bruno, 2007; Brunetti, Maugeri, Nanni, Simolo, & Spinoni, 2014).

The raster maps were then used to perform a spatial principal component analysis (sPCA) scaling the rasters and centring the sPCA. The standardization procedure is a very important step in this process because it uses different scales for different climatic factors (in this case degrees Celsius versus millimetres). The derived components with eigenvalues higher than 1.0 were then used as input data for an unsupervised classification procedure. The clustering procedure (Hastie, Tibshirani, & Friedman, 2001) was performed calculating the Euclidean distance between pixels and aggregating them into three spatial clusters (environmental zone, see Table 1). The optimal number of clusters was previously acertained by analysing the raw data obtained from meteorological stations. The maximum number of iterations was set to 30 while the convergence value (the points at which cluster means become stable) was set to 98%. These two

Table 1. Official definitions of the environmental RoP of Abruzzi.

RoP	Official name
1	Adriatic zone
2	Low mountain and hilly zone
3	High mountain zone and continental lands

Table 2. Seed stands of Abruzzi region.

Regional code	Species	Local (Italian) name	Area (ha)	RoP
ABR01	*Abies Alba Mill.*	Abetina di Rosello	35	2
ABR02	*F. sylvatica L.*	Cappadocia – Campo Ceraso	271	2
ABR03	*Fraxinus excelsior L.*	Riserva statale di Feudozzo	185	3
ABR04	*P. nigra* Arn. var. *italica*	Pineta Zappini	105	3
ABR05	*Pinus mugo* Turra	Feudo d'Ugni e Blockhaus	856	2
ABR06	*Q. cerris* L.	Scodanibbio	81	3

values were used to stop the classification process because clustering procedures are never totally static (means always change during the iterative process). The map was then validated using statistical procedures and field surveys. Finally the RoPs of the three main forest species of the Abruzzi (Main Map) were obtained by clipping the spatial distribution of each target species obtained from the forest category maps of the region (Corona, Marchetti, & Filesi, 1999) with the map of the RoP. Those species were the European beech, the European Black pine (*P. nigra* J.F. Arnold) and the Turkey oak. A more detailed article about the procedure, results, characterization of the environmental RoP, and seed zones of Abruzzi was published in 2013 (Marchi et al., 2013).

3. Conclusions

A specific RoP describes and divides a geographic environment following ecological rules and including different forest species that can be moved with a certain degree of freedom. However the same species can be distributed across more than one Region and this issue will play a key role in tackling the effects of climate change. For instance, moving seeds from a dryer region to a more humid one could improve the resistance and resilience of the populations to climate change. In the same way, altitudinal gradients can be seen as a way to take into account adaptation to frost. In this view the map of RoPs of Abruzzi will guide the future administration of regional forest nursery and forest management. As each Italian administrative region develops its own map, further connections will allow proper management of forest genetic resources (Camerano et al., 2012). In fact, Abruzzi includes many marginal populations and six seed stands (Table 2) and is one of the most important zones in Italy for the conservation of biodiversity and endemic species. This zone can be seen as a source of seeds to be transferred into northern regions or countries to tackle the effects of climate change (e.g. Silver birch, Black pine, and Mugo pine).

The partitive approach, often used in other Italian regions, for example, Campania (Ducci et al., 2008) has been demonstrated to be an appropriate method in the absence of genetic data, which is often connected to climatic variability (Provan & Maggs, 2012). Results also showed that High mountain and Continental RoPs contain almost the total distribution of the three main species. In contrast, the Mediterranean RoP contains only marginal populations of European black pine and Turkey oak. A deeper analysis of the genetic structure of populations should be encouraged to check and improve the knowledge obtained with this study. Southern Europe is a hotspot of biodiversity and Abruzzi represents just a part of the work that has been undertaken for the southern Mediterranean area. Italy is divided into 20 Administrative Regions and, consequently, efforts will have to be made to create a unique map for the whole Country to align Italy to other European countries.

Software

The Main Map was compiled using only open-source software. R CoreTeam (2015) and GRASS GIS 7.0 (GRASS Development Team, 2015) were used for the statistical analysis (sPCA and clustering) while QGIS Lisboa 2.8.3 (QGIS Development Team, 2015) was used to create the print layout. The operating system was Ubuntu 14.04 LTS.

ORCID

Maurizio Marchi http://orcid.org/0000-0002-6134-1744
Ugo Chiavetta http://orcid.org/0000-0002-8404-7927
Fulvio Ducci http://orcid.org/0000-0003-2686-9540

Acknowledgements

The Main Map was compiled for the ABRFORGEN project coordinated by Dr. Fulvio Ducci ('Implementation of forest nursery chain and organization of a modern management of forest genetic resources in Abruzzi'), a partnership between CREA-SEL of Arezzo and the Abruzzi Regional Government. The authors wish to thank the Regional Agro-meteorological Centre of Scerni (Province of Chieti) for the climatic data and scientific support as well as the reviewers and the editor for their valuable comments that helped improve the manuscript.

Funding

This work was supported by Regione Abruzzo ABRFORGEN project coordinated by Dr Fulvio Ducci.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Attorre, F., Alfo, M., De Sanctis, M., & Bruno, F. (2007). Comparison of interpolation methods for mapping climatic and bioclimatic variables at regional scale. *International Journal of Climatology*, *1843*(March), 1825–1843. doi:10.1002/joc

Brunetti, M., Maugeri, M., Nanni, T., Simolo, C., & Spinoni, J. (2014). High-resolution temperature climatology for Italy: Interpolation method intercomparison. *International Journal of Climatology*, *34*(4), 1278–1296. doi:10.1002/joc.3764

Camerano, P., Belletti, P., Ferrazzini, D., & Pignatti, G. (2012). Definizione di Regioni di Provenienza. *Sherwood*, *179*, 23–27. Retrieved from http://www.rivistasherwood.it/filevari/filenotizie/2015/ValorizzazioneRisorseGenetiche/0-Sherwood179-Articolointroduttivo.pdf

Corona, P., Marchetti, M., & Filesi, L. (1999). Mappatura in scala 1:10000 di tipi forestali in Abruzzo. *Documenti Del Territorio*, *42*, 31–34.

Ducci, F. (2015). Genetic resources and forestry in the Mediterranean region in relation to global change. *Annals of Silvicultural Research*, *39*(2), 70–93. doi:10.12899/ASR-779

Ducci, F., Vannuccini, M., Carone, G., Vedele, S., Cilli, S., & Apuzzo, S. (2008). Delimitazione di Regioni di Provenienza per la gestione dei Materiali, *Annali C.R.A.-SEL*, *35*, 133–142.

Erickson, V., Aubry, C., Berrang, P., Blush, T., Bower, A., Crane, B., … St. Clair, B. (2012). *Genetic resource management and climate change: Genetic options for adapting national forests to climate change*. Washington, DC: USDA Forest Service, Forest Management.

Forestry Commission. (2007). *Forest reproductive material. Regulations controlling seed, cuttings and planting stock for forestry in Great Britain*. Edinburgh: Forestry Commissione. doi:10.1051/forest:19930752

GRASS Development Team. (2015). *Geographic resources analysis support system* (GRASS). Open Source Geospatial Foundation. Retrieved from http://grass.osgeo.org

Hastie, T., Tibshirani, R., & Friedman, J. (2001). 14.3.12 hierarchical clustering. In J. Friedman, T. Hastie, & R. Tibshirani (Eds.), *The elements of statistical learning* (pp. 272–280). New York, NY: Springer Open.

Marchi, M., Chiavetta, U., Castaldi, C., Contu, F., Di Silvestro, D., & Ducci, F. (2013). Definition of regions of provenance and seed zones for forest basic and moltiplication materials of Abruzzo region. *Forest@ – Rivista Di Selvicoltura Ed Ecologia Forestale*, *10*(4), 103–112. doi:10.3832/efor1085-010

OECD. (2007). *EOCD scheme for the control of forest reproductive material moving in international trade*. Retrieved from http://www.oecd.org/

O'Neill, G. A., & Aitken, S. N. (2004). Area-based breeding zones to minimize maladaptation. *Canadian Journal of Forest Research*, *34*, 695–704. doi:10.1139/X03-227

Orlovic, S., Ivankovic, M., Andonoski, V., Stojnic, S., & Isajev, V. (2014). Forest genetic resources to support global bioeconomy. *Annals of Silvicultural Research*, *38*(2), 51–61.

Pignatti, G., & Ducci, F. (2003). La definizione delle Regioni di Provenienza. Criteri generali. Parametri fisici. In D. Fulvio (Ed.), *Linee guida per il reperimento e l'impiego dei materiali foresta-li di base* (pp. 84–87). Arezzo: Istituto Sperimentale per la Selvicoltura.

Provan, J., & Maggs, C. A. (2012). Unique genetic variation at a species' rear edge is under threat from global climate change. *Proceedings. Biological Sciences/The Royal Society*, *279*(1726), 39–47. doi:10.1098/rspb.2011.0536

QGIS Development Team. (2015). *QGIS geographic information system*. Open Source Geospatial Foundation Project. Retrieved from http://qgis.osgeo.org

R CoreTeam. (2015). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria: Retrieved from https://www.R-project.org/. Retrieved from https://www.r-project.org/