

The Red Beech at the “Montagna di Torricchio”, Marche Region, Central Italy

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Abstract

For many centuries, red beech [*Fagus sylvatica* L. var. *purpurea* (Ait.) Schneid.] was known as a botanical abnormality in botanical gardens and arboretums. Widespread artificially, red beech trees have been exploited for cultural, landscaping and botanical purposes, showing a wide horticultural, silvicultural and arboricultural interest. Over time, they may have escaped from cultivations or have been incorporated into forests by secondary successions, showing an important ecological and forestry interest. Red beeches represent a complex of phenotypes described under systematic critical taxa, showing an important floristic and taxonomic interest. Samples of red beech were found in nature, in central Adriatic Italy, in a fully protected area, namely the “Riserva Naturale Statale Montagna di Torricchio”. In order to analyse the origin of this odd shape beech variation, an interdisciplinary study was carried out integrating geography, ecology and forestry, analysing the bibliography, archival data, leaf traits, potential vegetation and the issues concerning the human-ecology relation. The results we obtained showed no evidence of artificial or accidental introduction for these specimens, suggesting treating them as a native and natural mutation in the beech forest secondary succession. The study of the natural beech forms variation could foster in some way research activities and land management actions on this issue; with some outlook on biodiversity studies, environmental policies, horticulture, forestry and ecological importance. The results allow us to propose a reflexion on the native/non-native status, and about the systematic position of beech forms; fostering reflections about the taxonomical position of the red beech and proposing the variety rank for the red beech specimens. The presence of these specimens in the study area, allows us to make some reflections in order to be more careful in negative considerations about exotic (or presumed) taxa, taking into account the repercussions on environment and biodiversity management. These red beeches can be used to strengthen the genetic pool of existing specimens that are actually used, and vegetatively propagated in nurseries.

Keywords: critical taxon; interdisciplinary study; mutation; native status; nature reserve

Introduction

There is a certain genetic variability in *Fagus sylvatica* L. (Demesure *et al.*, 1996; Leonardi and Menozzi, 1996; Gallois *et al.*, 1999; Jump and Peñuelas, 2007) that is reflecting into a phenotypical variability, often used to embellish and give a touch of originality to gardens, urban parks and avenues. The red beech [*Fagus sylvatica* L. var. *purpurea* (Ait.) Schneid.] is a specimen characterised by red coloured leaves. It belongs to a systematically critical taxon, and for that, it would deserve further systematic and floristic researches. Following “The Plant List” index database (2019), the other nomenclatures used mostly refer to species apart (*Fagus purpurea* Dum. Cours.), as a form [*Fagus sylvatica* f. *purpurea* (Aiton) Dippel], or as a synonym of the

nominal species (*F. sylvatica* L.). In any way, within each of this three nomenclature types, it is possible to consider different forms of red beeches that differ in canopy habit, tonality (and permanence) of the red colour of the leaves, or other related phenotypic characteristics (Dönig, 1994; Grossoni and Bussotti, 1999), showing a huge and wide horticultural interest. This varietal variability has been exploited for cultural, landscaping and botanical purposes (i.e.: Desfontaines, 1804). For some centuries, red beech was widespread artificially as a botanical abnormality in botanical gardens and arboretums, for decorative purposes, and sometimes it was used in plantations. Over time, red beeches may have escaped from cultivations or have been incorporated into forests by secondary successions (Gonnelli *et al.*, 2008).

In these territories, influenced by long-time human presence as it happens in Italy, it is often hard to understand the status of aliens or indigenous taxa. For that reason, often it is not possible to cast doubt and definitively answer the question, with the relative culture-environment roles, land management implications and ecological value assessment. A specimen of red beech was found in nature, on July 13, 2010 within the State Natural Reserve “Riserva Naturale Statale Montagna di Torricchio”, on the Northern slope of “Monte Fema” Mt. (NE slope) up to the “Val di Tazza” Valley, after the “Fonte Carafiume” spring (Cianfaglione, 2010). The aim of this work was to analyse the presence, status and conditions of red leaves beeches in the study area; to discuss this phenomena and to observe the originalities regarding vegetation, botany, ecology, forestry related issues; and to propose the most suitable hypotheses and explications based on our results. All this was studied to foster the development of the best practices and policies about biodiversity and land management, with some outlooks on global changes (changing environment), systematic, natural resources management (horticulture, forestry and conservation values) and finally to generate reflections about native/non-native taxa issues.

Materials and Methods

Description of the study site

The study area belongs to the Central Adriatic Apennines, in the Marche region (Fig. 1). It corresponds to the Northern portion of the “Monti Sibillini” Mountain chain *s.l.*, in the “Riserva Naturale Statale Montagna di Torricchio” State Nature Reserve. The Nature Reserve was

established in 1970 after the owner Marquis Mario Incisa della Rocchetta donation to the University of Camerino (Pedrotti, 2010). It is the oldest protected area in the Marche region and for its environmental importance the Council of Europe has elected this area as a biogenetic reserve (Pedrotti, 2010). The Nature Reserve covers about 317 ha, at an altitude from 820 to 1491 m asl. It is delimited by the slopes of “Monte Fema” (1575 m), “Monte Cetronola” (1491 m) and “Monte Torricchio” (1444 m) Mountains. The area belongs almost entirely to the municipality of Pieve Torina and for about 2 hectares to the one of Monte Cavallo. It is an isolated and uninhabited area, far from villages (i.e.: Fematre, Tazza-Capodacqua, and Riofreddo) and largest population centres (i.e.: cities of Camerino and Visso). The study area landscape consists in the typical Apennines mosaic, with environments from slopes to bottom valleys, rocky outcrops, dejection cones, meadows, etc. Over the centuries, the study area has been a source of pastures and timber for the owners and for the surrounding villages of the valley (Pedrotti, 2010). Rocks consist mainly of calcareous, calcareous-marly, and marly formations from the Lower Jurassic to the Quaternary (Deiana and Pieruccini, 1976) and the soils are related to these bedrock or ancient superficial deposits (Kwiatkowski and Venanzoni, 1994). The mean annual precipitation reaches 1250 mm and the mean annual temperature is around 11 °C (Halassy *et al.*, 2005). The area is almost dry in summer. Only a small mountain rivulet “Torrente di Tazza” and few springs are present: “Fonte della Romita”, “Fonte di Carafiume” and the “Fontanelle”. All waters belong to the “Fiume Chienti” River Basin.

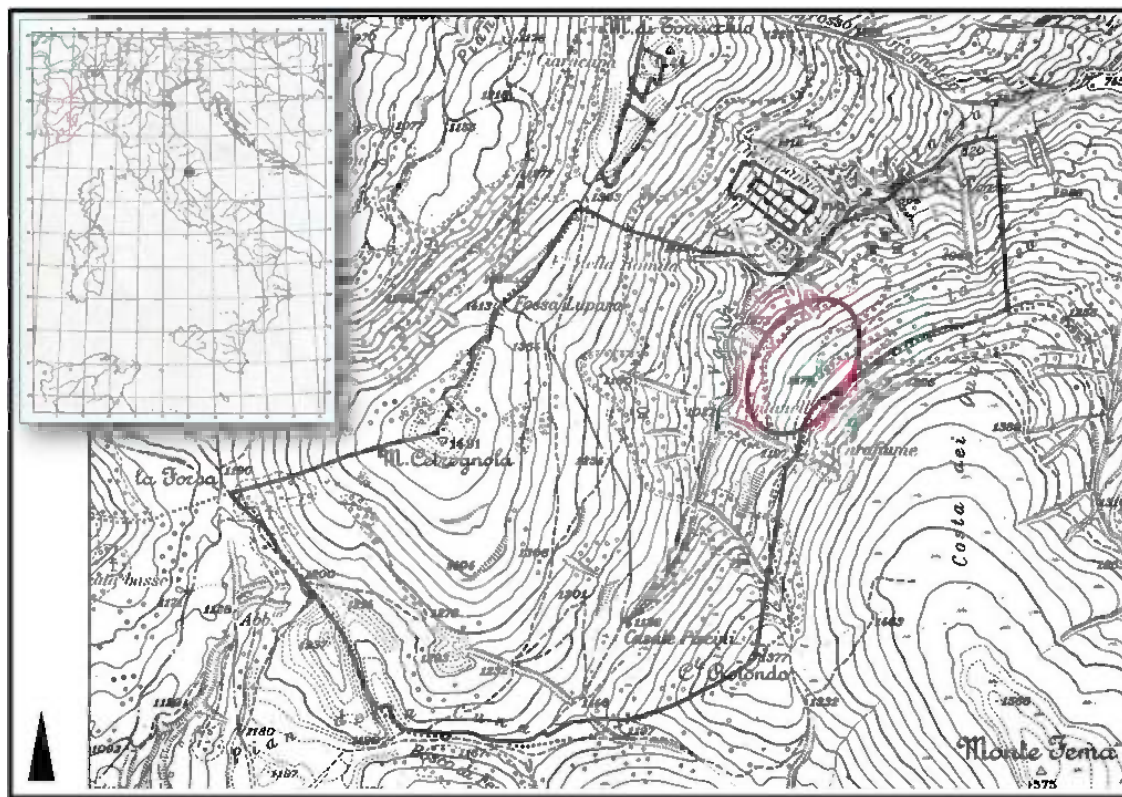


Fig. 1. Indicative maps for the identification of the study area. The blue dot in the map of Italy represents the location of the Torricchio State Nature Reserve. In the detail map, the bold black line represents the surface of the Reserve and related three small Exclaves, while the red line corresponds to the red beech trees zone (circa 200 × 300 m). The proximity of contour lines (Isopleths), denotes the “Monte Fema” slope inclination

Biological material

Samples of red leaves beeches were collected in the study area during the floristic excursions program, they were deposited at the Herbarium Universitatis Camerinensis (CAME), and they are being archived.

Bibliography and archival analysis

Reference was made to the year in which the Nature Reserve was established (1970). As from this date, considerable research and monitoring of the territory and vegetation began; since it represents a date much earlier than the age of the studied beech trees, it gives a very good safety margin (i.e.: Brillì-Cattarini and Sialm, 1973; Francalancia, 1976; Francalancia and Orsomando, 1976; Orsomando, 1976; Pedrotti, 1976, 1978, 1981, 1994; Brillì-Cattarini and Ballelli, 1979; Ballelli and Francalancia, 1982, 1987; Canullo, 1993; Canullo and Campetella, 1994; Francalancia *et al.*, 1994; Venanzoni and Kwiatkowski, 1994; Campetella and Cardona, 1998; Bartha *et al.*, 2008).

Vegetation framing

Following Pedrotti (2010), Cianfaglione and Pedrotti (2016), and the “Prodrome of Italian vegetation (‘‘Prodromo della vegetazione d’Italia’’ Ministero dell’Ambiente e della Tutela del Territorio e del Mare - MATTM, 2019) nomenclature, we provided a vegetation study via phytosociological, plant dynamic analysis, and by a forestry structure observation of the red beech samples area (Fig. 2). The zone where we found our red leaves beeches corresponds to a clearing between beech forests (*Lathyro veneti-Fagetum sylvaticae*) old coppices. This clearing is under secondary succession, mostly covered by shrub lands (*Spartio juncei-Cytisetum sessilifolii*). Meadow (mainly belonging to the *Asperulo purpureae-Brometum erecti*) patches are present, and in the most evolved condition, a pre forest (very young consisting forest stage) was remarked. All this, developing on a very steep slope, exposed to the South, with relatively thin and stony soil, under xero-thermic stress conditions, from 1100 to 1250 m asl (Fig. 1).

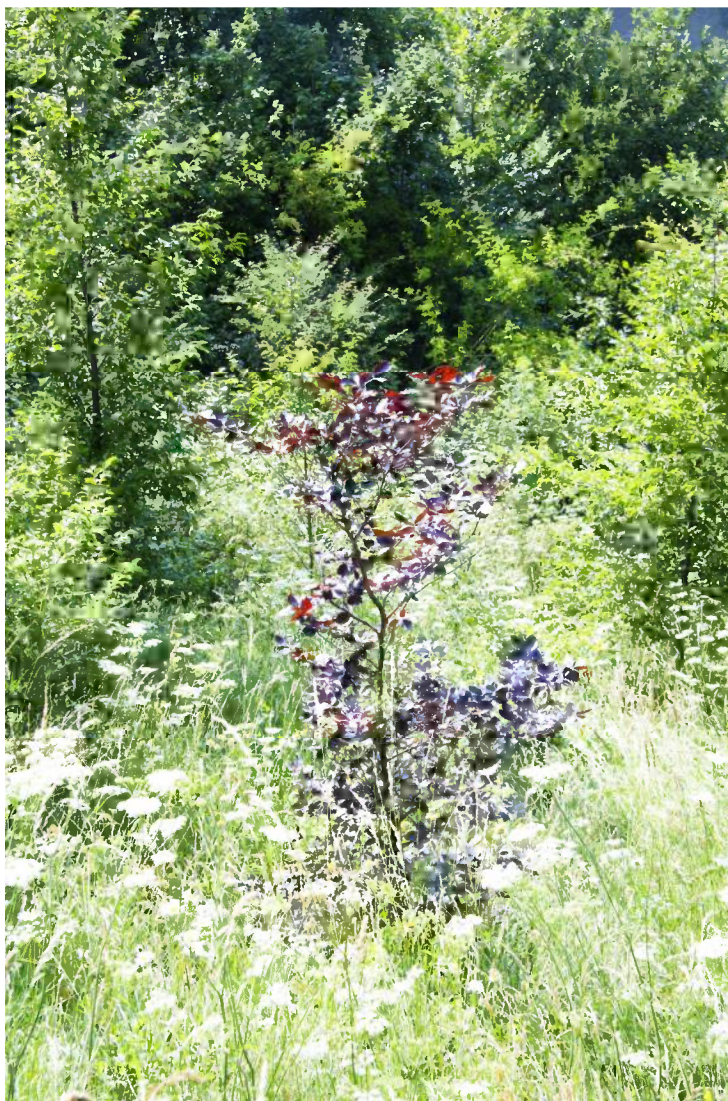


Fig. 2. A sample of red beech (*Fagus sylvatica* var. *p. f. atropurpurea*), with deep red coloured leaves, in a pre-forest stage. The pre-forest is characterised here by a Hemized and Saumized meadow herb layer. Trees mainly constitute the shrub layer (Mantle and Veil). In the picture *Fagus sylvatica* and *Ostrya carpinifolia* appear as dominant species of the pre-forest formation, *Acer campestre* and *Sorbus aria* as occasional; between the real shrubs, there is *Rosa canina* s.l. (13 July 2010)

Human ecology survey

We interviewed people (informants) who know the area well, following the snow ball technique. Consequently, informants were between the personnel who has taken continuous service in the Reserve since its establishment (1970), including retired people (professors, researchers, technicians, managers, administrators, employees and guardians). We also interviewed the pastors who worked in the zone, during the same period (between 1970 and 2010), in order to have also external opinions. Twelve people, aged from 55 to 95 were interviewed. Interviews were conducted in Italian. Prior informed consent was always verbally obtained before conducting the interviews and the researchers adhered to the ethical guidelines of the American Anthropological Association (AAA, 2012), guaranteeing the anonymous in the collected data. People were asked to answer two questions:

- Have you ever noticed or heard about red leaves beech specimens between Monte Fema, Monte Cetrognola and Monte Torricchio?
- Do you have any news about works or any human activity carried out, that could justify a possible introduction of them, in the same area?

In order to be surer about the answers, we also asked if in the study area has ever taken place any kind of intervention like ground or other material supply, plantation, reforestation or sowings.

Geography and propagation survey

We made a geographic survey to analyse the probability of natural or accidental dispersion from elsewhere, by analysing the topography, the vegetation, possible ecological barriers and corridors, and the distance as the crow flies from the known closest planted samples. It consisted in field observation and topographic map studies of the zone (IGM, Istituto Geografico Militare scale 1: 25000), in order to evaluate the related possible ecological corridors and barriers.

Experimental procedures and protocol for collecting data

Fieldworks permitted us to make environmental observations, collect biological material, make a Vegetation framing, and describe the forestry issues and to make the Human ecology survey. Then, we integrated this data with bibliographic and archival studies in order to reach our goals. Floristic surveys were carried out in the Reserve surface and strict surroundings, by a team initiative to update the "Flora of Torricchio Reserve" knowledge, under behalf of the Nature Reserve and the University of Camerino. Floristic excursions were carried out to in-depth the knowledge, and to try to understand if there were other similar Red Beech specimens, their distribution and the ecological conditions. For the same reasons we randomly explored also the surrounding areas outside the protected area. The surveys had occasional and periodical form, covering all the seasons from 2011 to 2018. We tried to find possible reasons to exclude the native status of the red beech, through bibliographic research, archival studies, targeted interviews, through a geographical analysis, and by analysing the probability of natural or accidental dispersal (gravity, wind, ballistic, waters, or by animals).

Results and Discussion*Environmental interdisciplinary analysis*

The floristic research carried out in various missions allowed to confirm the single specimen already reported, and the discovery of other red beech specimens with markedly red leaves (albeit with various shades), for a total of 6 young specimens of different ages (from a few years to twenty) signalled here for the first time. One of these specimens showed a double stem (one red and the other green) from the root-stem transition zone (Colletto). Each of the specimen trees detected are all very well developed. All the red beech trees were only found in the same zone of the first finding, which resulted among the least studied surfaces by the previous floristic, vegetation and forestry researches. From the bibliographic analyses and the interviews, results show that nobody had been aware of this red beech presence before, it has also been clear that in the area and closest surroundings have never been made any interventions or actions that can justify a possible voluntary or accidental introduction of red beech trees. From archive research and interviews, in that area were found neither traces of physical or historical reforestation, nor any type of plant introduction.

Following the geographic survey, natural or accidental introductions from elsewhere should also be excluded. The area is out of reach and inaccessible to common motorized vehicles; while the nearest known red beech trees, as cultivated in urban areas (i.e.: Camerino and Visso), located far beyond Mountains which could somehow act as a barrier against dissemination. After the geographical observations carried out by fieldworks and topographic maps, the probabilities of dispersion caused by animals and wind are largely excludable due to the long distances from the closest known planted samples and the existence of geographical barriers (i.e.: steep and high mountains and different slopes).

Hypothesis on local beech variability

The beech is not new to phenomena of exceptional phenotypic variability. Variability that is often known only on a local scale (or in local traditions) in nature, such as for the native "weeping" green beech [f. *tortuosa* (Pépin) C.K.Schneid.] from Rivodutri (Rieti) at average 1000 m asl, so-called "Faggio di San Francesco" (Bortolotti *et al.*, 1989); and the early beech so-called "Faggio Santo" also known as "Faggio di San Giovanni Gualberto" (Mercurio and Mercurio, 2013) in the "Foresta di Vallombrosa" Forest (Firenze), at average 870 m asl, a native green beech that puts its leaves before the other beeches (*F. s. var. s. f. praecox*) *forma nova hoc loco*; both trees are known as monumental trees. Other natural beech variations were reported for "Val Cervara" Valley, Villavallelonga (L'Aquila), at 1600-1850 m a.s.l., near the tree line; a forest with very old trees, almost 500 years old (*F. s. var. s. f. longaeva*) *forma nova hoc novo*, twice older than the average, considered the oldest beech trees in Europe (Piovesan *et al.*, 2005) and known because this forest is one of the last almost untouched, primary old growth forests in Western Europe. Another example of the natural forms of variability in Italy, comes from Pignatti (1982) and Paffeti *et al.* (2007) as it happens with certain

Italian beech populations, that are more similar to *Fagus orientalis* and ascribable to *Fagus* × *taurica* (= *F. moesiaca*).

Regarding the red beech, it could be hypothesized that the studied trees samples may have originated by spontaneous mutation within the secondary succession of the beech forest. These mutations are rare in nature and they can be favoured by environmental shocks known as “triggering factors”, suffered during the development of the meristem (i.e.: excessive insolation, severe drought, temperature shocks, etc.). Moreover, the same ecological factors are known to induce mutations and meristematic malformations such as the so-called “twin fruits” (Philp, 1933; Bassi *et al.*, 2007; Bargioni, 2011) on various wood species of very different families. This phenomenon can occur with a very strong frequency the year following very hot summers, with temperatures higher than average, perhaps accompanied by a period of particular drought. Under these conditions, the development of the cells that form the pistil in the bud is modified and, instead of having a normal pistil, there is a double pistil formation (Beppu and Kataoka, 1999; Beppu *et al.*, 2001). These factors can be justified, in this case, since the studied specimens’ trees are placed in a secondary succession, South-exposed; under thermic and light sun radiations, on a dry steep slope contributing to amplify the effects of drought and heat. This mutation response could have interesting outlooks on plant plasticity, epigenetics, management practices in beech ecosystems, and climatic changes studies in the scenario of a changing environment.

Taxonomical position proposal

Actually, varieties and forms tend to be neglected or placed in synonymies with higher ranks, in detriment of the intraspecific variation characterization, consequently penalizing the research activities and applications related to these differences.

Conceptually, from the four mentioned taxa, we preferred to use the taxon that recognizes the variety rank [*Fagus sylvatica* L. var. *purpurea* (Ait.) Schneid] because it differentiates sufficiently from the nominal species, giving the opportunity of grouping the various known different red forms in it and of identifying the studied specimens. This nomenclature allows highlighting the intraspecific variations, valorising the related floristic, dendrology and horticultural values. Consequently, we propose to subdivide *Fagus sylvatica* in two varietal groups: var. *sylvatica*, and var. *purpurea*, respectively depending on the dominant leaves colour (including different canopy architecture, leaves margins, and variegated in white and red forms). In the *F. s. var. purpurea* we found within our specimens the *f. purpurascens forma nova hoc novo*, with red leaved specimens turning into green, green-pale red in summer; *f. purpurea* with simple red leaves and *f. atropurpurea* with very dark red leaves.

In the study area we found also green beech specimens with normal canopy development, but yellowish-light green foliage (*F. s. var. s. f. flavescens forma nova hoc novo*).

F. s. var. sylvatica, groups as example all the previously cited green forms: *f. pendula*, *f. praecox*, *f. longaeva* and *f. flavescens*. Similarly, *F. s. var. purpurea*, groups all the

different known forms with dominant red leaves, with different canopy architecture, leave margins, and variegated in other colours.

Conclusions

Following the principle of caution, we cannot exclude a possible remote abstract possibility of non-native origins (human facilitation or artificial distribution) related to the possible human influence on the site; as it could be extended to any species in the territories influenced by a human presence. Given all the previous reasons and the environmental conditions, we propose to approximate these red beeches as endemic, avoiding exaggerations looking for alien taxa. Every observation made, together with the environmental context of the findings, allows confirming the thesis of the first report, presaging for a native status of red beech trees in the study area. Regarding the potentiality of vegetation and forestry issues in the future, when plant formation will be more structured, it presumably will make a special variant of beech forest with red samples. This could be also useful if applied to the management practices in beech ecosystems, and for climatic changes studies in the scenario of a changing environment. It could be useful to carry out a vegetative propagation of these specimens for horticulture and *ex-situ* conservation purposes, and it could be interesting to make a genetic traits analysis looking for any possible distinguishing markers and to make a long-time functional traits observation (including stress experiments) using the local germplasm, trying to in-depth this phenomena knowledge and related application in climatic stress reaction and adaptation studies in changing environments.

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Conflicts of interest

The authors declare that there are no conflicts of interest related to this article.

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