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EVIDENCE FOR CLONAL GROWTH IN *FAGUS SYLVATICA* L. IN ITALY

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ABSTRACT – Based on our recent observations in Central Italy we show evidence for root sprouting and subsequent capacity of clonal growth in *Fagus sylvatica* L. The typology of resprouting in this species is still unclear according to the existing literature. We review Italian, European and global sources and discuss our finding in the light of environmental factors and genetic differences.

KEYWORDS: FAGACEAE, RESPROUTING, ROOT SUCKERS, SUCKERING, ROOT SPROUTING, ROOT SHOOTS, BEECH, FUNCTIONAL TRAITS, DISTURBANCE, PHYLOGENY

Nomenclature follows Pignatti (1982)

INTRODUCTION

In an isolated outpost of beech forest on the top of an inselberg along the coast of Middle Italy (Monti della Tolfa, Fig. 1) at 600 m a.s.l., several aged individuals of *Fagus sylvatica* L., part of a nearly monospecific old growth forest stand, produce abundant suckers from visible superficial older roots (Fig. 2), as far as 6 m from monocormic mother stems.

This unequivocal evidence is in sharp contrast with the extremely scanty and ambiguous references on the resprouting capacity of *Fagus* in the Italian sources. The latter mostly consist of assertions and anecdotes from grey literature on forest management and web-sites for commercial gardening, where it is very unclear whether basal sprouts, sprouts from the collar after severing of the stem or real root suckers are accounted for the vegetative reproduction of *F. sylvatica* in nature. This suggests unclear perception and definitions of this phenomenon. Its mistreatment can also be blamed on linguistic ambiguities in the definition of this behaviour, since current automatic, on-line technical dictionaries make no distinction between "root sucker" and "basal sprout" as well (see for example http ttp://dict.tu-chemnitz.de/). Nevertheless, explicit reference is found in Fiorucci (2009), but the author seems to report uncritically selected sources (see literature therein).

The only solid Italian reference on this topic is reported by Bernetti (1995). It deals with the capacity of producing sprouts from severed roots in case of artificial removal or devitalisation of the stool, a practice still surviving in some beech coppice, in order to enhance the growth of new vegetative sprouts in the stands. These sprouts bear fruits much earlier than trees grown from seeds and can therefore ensure new generations of seedlings. No explicit reference is made to the production of root suckers in nature without excision of the mother stem.

However, in the European literature the emission of shoots from the roots in *F. sylvatica* is clearly quoted and featured by Watt (1925) who observed this trait in populations of Southern Britain. Another prominent observation is reported by Poplawska (1928) who describes this pattern in populations of *F. sylvatica* ssp. *taurica* in Crimea, a *taxon*

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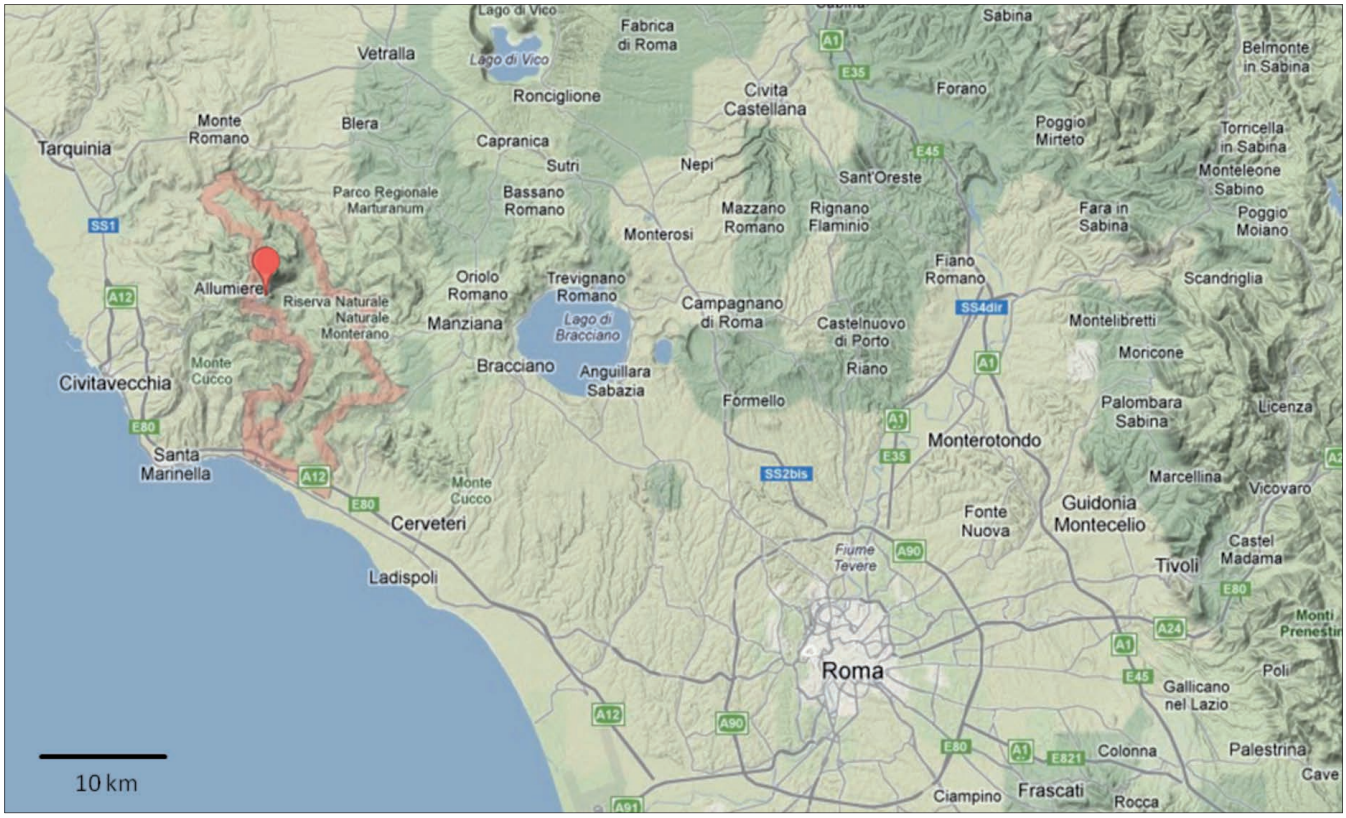

Figure 1. Location of the studied population of *Fagus sylvatica* L. North of Roma (Monti della Tolfa. M. Urbano is at the E side of the dot for the village of Allumiere) (www.maps.google.com)

supposed to be transitional between *F. sylvatica* and *F. orientalis*.

A detailed structural treatment of the topic in another species of the genus, namely *F. grandifolia*, is first offered by Jones and Raynal (1986; 1987; 1988) who report from North America the capacity of producing root suckers under natural conditions as well as by experimental manipulation. Ward (1961), Kitamura et al. (2000), and Kitamura & Kawano (2001) report extensive natural productions of root suckers in stands on shallow soils of post-glacial landscapes of North America.

Our observations provide clear evidence for vegetative reproduction by root suckers in *F. sylvatica*. In Fig. 2, a full range of sprouts is visible, from non traumatic adventitious basal shoots to real root suckers sprouting from the peculiar system of knee-like projections which reveal the progression of the roots on the soil.

Site conditions

The observed individuals are part of a population growing at 42°9’ 25’’ N and 11° 34’ 17’’ E within a patch of beech forest located at the uppermost vegetation belt at Monte Urbano (633m a.s.l.), a trachytic outcrop close to the village of Allumiere, representing the most elevated summit in Monti della Tolfa (Fig. 1), a Plio-Pleistocene ignimbritic coastal inselberg 30 km North of Roma. This beech forest is renowned due to its outstanding orometric location, ranging from 450 m a.s.l. onwards, i.e. at least 600 m beneath the lower limit of zonal beech in peninsular Italy (Anzalone, 1961; Spada, 1977; Scoppola & Caporali, 1998; Di Pietro et al., 2010).

The basically Mediterranean character of the macroclimate, with mean annual temperature of 13.9°C and two dry periods (May and August), is locally (Allumiere) mitigated by the relatively high amount of precipitation (average annual rainfall of 1048 mm), explaining the persistence of stands of mesic beech forest only 12 km from the Tyrrhenian coast.

A 20 x 20 m sample plot has been delimited around 3 aged individuals of *Fagus* with an average diameter of 40 cm at breast height, and around 18 m tall, exhibiting the most striking development of resprouting from roots (Table 1). This plot is located within a slightly convex area of a couple of hectars, corresponding to a feeble crest joining two major outcrops which represents at the same time the uppermost edge of the head of a valley.

Table 1. Characteristics of root sprouting in three old-growth individuals of *Fagus sylvatica* L. of the beech population at Tolfa.

ID of mother tree (old growth stem)	ID of kneelike projection (K) or buttress (B)	distance to mother tree [cm]	number of shoots
1	K 1	20	3
1	K 2	120	9
1	K 3	140	8
1	K 4	320	5
1	K 5	415	8
2	B 1	base of the tree	17
2	K 1	53	11
2	K 2	235	10
2	K 3	340	11
2	K 4	513	7
3	K 1	150	2
3	K 2	190	12
3	K 3	240	6
3	K 4	370	8
3	K 5	560	3

This convex morphology provides an array of topographical heterogeneities inducing enhanced soil erosion. Former trampling by cattle concentrated around a wellspring and more recent human trampling depletes the yearly deposition of litter which is blown downslope. The soil is skeletal (ranker), apparently forcing the trees to develop shallow root systems. Regeneration from seeds has not been observed within the plot. The disturbance on the forest floor is therefore intense in the plot and in the surrounding area. The bottom flora is reduced to a scanty cover (<5% of the plot) of individuals of *Luzula sieberi* and *Festuca heterophylla.* Bryophytes cover no more than 15 % of the plot and are mainly concentrated on the root protuberances. Nevertheless, the canopy is closed (75 % cover), even if somewhat lighter than on the surrounding slopes. The stand is today Nature Reserve (SCI) according to the EU Directive and no logging or gathering of wood is allowed.

Vegetative growth

The root system of the trees may be described as accommodating (sensu Watt, 1925) to the local shallow soil, with surface feeding half buried laterals. The knee-like protuberances bare intense development of callus, revealing the effect of mechanical disturbance induced by frequent trampling and exposure to wounds induced by periodical ollapse of branches.

Thick clusters of sprouts arise from them up to a distance of 6 m from the mother stem (Table 1). Each observed shoot is never longer than 20 cm, suggesting reiterated die-back, most likely induced by lack of light and predation due to browsing animals (mainly rodents).

Photographs display details on the basal sprouts on buttress (Fig. 2a), the growth of root suckers (Fig. 2b), and the habitat context including offspring distance from the mother tree (Fig. 2c, 2d).

Figure 2. Photographs of root-sprouting in *Fagus sylvatica* L. in central Italy (Tolfa, Monte Urbano). Basal sprouts on buttress (a), detail of vegetative growth of root suckers (b), habitat context and clonal offspring at a distance of 4m (c) and 6m (d) from the mother tree.

Besides collar sprouts and sprouts from roots, a third form of clonal growth is known in *F. sylvatica*, namely layering, i.e. adventitious root production in plagiotropic twigs. This phenomenon has been observed in a population of *F. sylvatica* at the timberline at 1310 m a.s.l. in the Giant Mts, Czechia, in individuals with long-lasting soil contact of plagiotropic twigs (Vacek & Hejcman, 2012). Layering has not been observed in the population at M. Urbano.

Discussion

Through field observations and experimental results, the capacity of root sprouting in populations of *Fagus* has been associated with stressful environments and/or with genetic differentiation (Watt, 1925; Poplawska, 1928; Ward, 1961; Jones & Raynal, 1988; Kitamura et al., 2000, 2001; Kitamura & Kawano, 2001).

Poplawska (1928) found in Crimea that *F. sylvatica* ssp. *taurica* exhibits a much higher capacity of producing root suckers than both *F. sylvatica* and *F. orientalis* (see also Seifriz, 1931). She also notes that root suckers in *F. sylvatica* ssp. *taurica* arise not only in gaps after clear cutting but also under the dense canopy of untouched beech forests.

The extensive development of callus on the root protuberances and its relation to the sprouting of root uckers observed in the plot in the site at M. Urbano seems to fit into the mechanism described in *F. grandifolia* by Jones & Raynal (1987, 1988). According to these authors, the tissues of callus are produced after injury and are identified as the loci of adventitious buds. The stressful conditions affecting the individuals of the Italian site and the shallow root system induced by the local edaphic assessment match the causal sequence described by the former authors. They report in detail continuous production from naturally injured or experimentally scraped roots throughout the years after injury. Apical control on the production of root suckers is relatively weak in beech; consequently, adventitious buds may expand also under a closed canopy (Jones & Raynal, 1988) as it is the case in the stand of M. Urbano. In comparison to experimentally severed roots, the higher survival of the clonal offspring on scraped roots indicates that understory sprouts must remain functionally connected to the parent for years before they are able to survive independently (Rushmore, 1961; Jones & Raynal, 1986, 1988). Del Tredici (2001) in his review reports that for many temperate trees, especially those native to mesic habitats, root suckering appears to be primarily a reparative response that only secondarily results in clonal growth.

Conclusions

In line with previous European notations (Watt, 1925: Great Britain; Poplawska, 1928: Crimea) our observation in Italy gives further support that the resprouting capacity and consequently possible clonal growth is an often overlooked phenomenon in trees. In some woody species such as *Prunus avium*, *Ulmus minor*, *Populus tremula, P. alba,* and *P. nigra* in Europe (Piccioli, 1915), *P. tremuloides* and *Robinia pseudoacaia* in N America (Del Tredici, 2001), resprouting is a highly manifested phenomenon across their

environmental range. In other tree species, however, e.g. *Tilia vulgaris (T. platyphyllos x T. cordata)*, the phenomenon is only rarely evident since it is linked to extreme environmental conditions and disturbance or, hypothetically, to genetic confinement to selected branches of their evolutionary history and phylogeny. However, resprouting might be latent, i.e. it is anchored in the phenotypic plasticity of some of the populations of a species. These species are therefore capable of a larger spectrum of functions than we can observe at present. Recent progress of knowledge in the general framework of plasticity (e.g. Nicotra et al., 2010) points out that different species characteristics, i.e. traits or trait attributes, can possibly be due to differences in the environment. This means, that when we observe differences in species traits, it cannot be deduced a priori that these differences have a genetic basis and would be the manifestation of different genotypes. We cannot even assign it a taxonomic rank at all. It is a real challenge for future research to tackle whether phenotypic plasticity lays behind the observed differences in traits or whether this is combined with genetic differences. The latter could possibly depend upon different phylogenetic lineages (e.g. Kitamura & Kawano, 2001) associated with resprouting.

The capacity of clonal growth has important implications for species survival under unfavourable conditions. Based on genetic evaluation, Kitamura et al. (2001) suggest that offshoot formation by root suckers plays a significant role in the stand structure and development in *F. grandifolia* in North America. Bums & Honkala (1990) report that frequent fires and heavy logging, are two types of disturbance that favor the spread of root-suckering species over non root-suckering ones. If sprouting occurs in a species, it can therefore originate stands which are also able to persist through climatic fluctuations.

The residual isolated outpost of beech forest at M. Urbano, as relic of a former larger spread in the surrounding region under more favorable climatic conditions, is therefore likely to owe its persistence up to present times to this detected capacity of clonal growth.

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