Composition, Structure and Regeneration Dynamics of *Olea ferruginea* Royle Forests from Hindukush Range of Pakistan

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**Abstract:** The abundance of *Olea ferruginea* in Malakand Division has been significantly reduced across its distribution range due to anthropogenic pressure in the recent past. A number of initiatives were taken for grafting this species to obtain better seeds for oil production, without the basic information on their ecology and management. To address this knowledge gap, we quantified the composition, structure and regeneration dynamics of *Olea ferruginea* forests in Malakand Division, Hindukush range of Pakistan. In the present study, five communities dominated by *Olea ferruginea* were identified using Ward’s agglomerative cluster analysis. Total tree density ranged from 153-2602 plants/ha, and basal area from 19.55 to 2353 m² ha⁻¹ with *Olea* having a relative density of 51% to 87% and basal area of 48% to 93%, respectively. The density of juveniles of the dominant and subordinate tree species were generally low which reflect their narrow distribution in the study area. Size-class distributions of *Olea ferruginea* disclosed a bell-shaped pattern, indicating that forests were heavily exploited by local inhabitants in previous periods and recently by armed forces owing to security risks in the study area. The age (mean max. 300±34 years) and annual increment (3.2±1.2 years/cm) indicates that the species is long lived and generally slow growing among the different broad leaved species studied so far. However, the oldest trees can be found by the exploration of large diameter trees in the area. In addition, we found a stable linear relationship between the age and diameter ($r² = 0.779$), indicating that diameter is a good predictor of age for this broad leaved species. In view of its relatively slow growth, longevity and positive ring-width characteristics *O. ferruginea* seems to be a suitable choice for dendroecological and dendrochronological studies in lesser Himalayan and Hindukush ranges of Pakistan. The results obtained from this study may help in understanding the composition, structure and regeneration dynamics of other subtropical broad leaved species.

**Keywords:** *Olea ferruginea*; Species composition; Ward’s agglomerative cluster analysis; Seedling; Dendroecology

**Introduction**

Pakistan is broadly divided into 9 ecological regions with about 6000 plant species (Sher et al.
Among all these eco-regions located in northern areas are hubs of biodiversity with about 2500 plant species among which *Olea ferruginea*, *Quercus*, *Acacia* and *Monotheca* are common representatives, native trees in the foothills and lower slopes of the Himalaya and Hindukush ranges (Champion et al. 1965; Sher and Hussain 2009). *Olea* occupy 25%-40% stem density of the total natural broadleaved forests by area and comprise of 27% of the total standing stock volume in northern areas of Pakistan (Sheikh 1993). *Olea ferruginea* is an evergreen broadleaved tree species that grows throughout the Himalaya, Hindukush, Salt range, Kalachitta hills and the Suleiman ranges in Pakistan (Ahmed et al. 2006). The species is also distributed in Afghanistan and Kashmir (Abbas et al. 2011). This species grows from 500 m to 2000 m above the sea level, but is most abundant at altitudes near 750 m above the sea level in the graveyards (Yousifzai et al. 2010). These forests constitute important natural communities and provide a wide variety of ecological and economic services to local human populations over the centuries (Khan 2012). *Olea ferruginea* supplies food, firewood, construction wood and medicinal products to different ethnic groups from prehistoric times to the present (Ibrar et al. 2007). *Olea* seeds have a high content of fat (41%) and protein (37%) (Bianco et al. 2013).

Wood is very resilient, heavy and used for turning, plough axes, digger, furniture, firewood and other household needs (Ibrar et al. 2007). The wood quality of *Olea ferruginea* in Pakistan is generally poor because of short clear bole lengths and frequent occurrence of crooked stems (personal observation). However, the same species growing in some part of Malakand division shows straight-upward growth with long and clear boles particularly in graveyards. *Olea* species are also grown commercially in different countries of the world and recently in China, Nepal, India, Pakistan and producing large quantity of olive oil which is one of their major sources of income (Paudel 2010). *Olea* cultivation has the potential to ease, together with other crops, the extreme burden of the bill for edible oil import in Pakistan (Government of Pakistan 2007).

A number of initiatives were attempted in the past in order to introduce Olives (*Olea europaea*) in some areas of Pakistan, regrettably without any proper basic research or studies. According to Pakistan Oilseed Development Board (PODB), around 44 million wild olives are still growing in natural forests of Pakistan and a substantial number were logged adversely affecting the ecosystem typical of mountainous regions. These facts indicate that *Olea ferruginea* growing in Pakistan has a potential to grow well like those species in other countries, if adequate silvicultural treatments are applied. Silvicultural treatments are needed for producing trees with long and clear boles for timber wood and attempts to graft better varieties could increase the fruit and oil production. Before the application of silvicultural treatments to reproduce *Olea ferruginea* can be prescribed, the silvicultural and environmental factors that affect the distribution, establishment and growth of various types of *Olea* reproduction must be understood. The objectives of this study were (1) to analyze the structure of *Olea* forests in northern Pakistan and (2) to understand the population dynamics and regeneration potential of the species and (3) to estimate the age and examine the population size class distributions to understand the replacement dynamics.

1 Materials and Methods

The vegetation structure and regeneration processes of *Olea ferruginea* forests were studied at different locations in Malakand division i.e. Malakand hills, Buner, Swat and district Dir after the army takeover during the period from 2011 to 2012. These areas lies in the northern part of Pakistan spanning between 36.50° N latitude and 72.73° E longitudes (Figure 1), characterized by rugged terrain and vales with elevation ranging from 700-7708 m (Hazrat et al. 2008; Khan et al. 2013). *Olea ferruginea* forests were sampled between altitudes ranging from 700 m to 1900 m above sea level. Climatic data was obtained from Swat, Dir lower and Dir upper meteorological stations for the period 1990-2012. The data for all the stations were tested and found to be homogenous for the entire period following Heinrich (2004) and Mitchell and Jones (2005). Temperature and precipitation for the stations were found to be strongly correlated (r=0.860, p<0.001) using Pearson, product moment