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## Reproduction of silver fir (*Abies alba* Mill) forests in the Ukrainian Carpathians

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### ABSTRACT

Existing knowledge of the Ukrainian foresters related to the historical changes and current state of silver fir forests, as well as on the various methods of restoration of such forests in the Ukrainian Carpathians were discussed. Forest cover of fir stands in this region has been diminishing in the last two centuries. Only in the period from 1947 to 1956, the area of fir stands in Ukrainian Carpathians decreased by 38.8%. Currently, the restoration of fir stands in these areas are crucial for Ukrainian forestry. Therefore, the natural as well as artificial regeneration using seeds obtained from seed orchards are currently used. Thus, improving the forest stands' conditions mostly composed of single-spruce plantations need to be improved through changing the species compositions. However, the restoration of fir stands is time and labour-intensive, and require a long-term strategy.

### KEY WORDS

silver fir, Ukrainian Carpathians, seed production, clonal seed orchards

Ukrainian Carpathians (UC) belong to the part of Eastern Carpathians, which are located in the southwest of Ukraine, together with the Precarpathians (Eastern Carpathian Foothills), and the Zakarpattia Lowland (part of Carpathian Basin) in Ukrainian forestry are described as the natural zone of the Ukrainian Carpathians (Hensiruk 2002). This zone is located in 4 administrative regions (Lviv, Ivano-Frankivsk, Chernivtsi, and Zakarpattia). The forest cover of this zone is over 40%, while the average forest cover of Ukraine is 15.9% (Krynytskyi et al. 2017). The spruce as well as beech forests are the prevailing species for this zone. They occupy 41% and 35%, respectively, of the total

Ukrainian Carpathians forest area. Another 9% of the territory is covered by oak forests. The fir forests grow only at 4% of the forest area of the Ukrainian Carpathian region; nevertheless, it occupies an important position in the forestry of this region, both economically and ecologically.

Silver fir forests in the Carpathian zone are predominantly growing at the altitudes of 270 up to 1500 m a.s.l. While, the optimum conditions for its growth and highest productivity are at the height of 450–900 a.s.l. (after Ravlyuk 2009). The total area of the fir forests is 244,400 ha. Such stands are common in Ivano-Frankivsk administrative region – 41.8%,

slightly less in Lviv – 27.4% and Chernivtsi – 20.1%, while these are relatively rare in Zakarpattia, representing only 10.7% of the total area of fir stands in the Ukrainian Carpathian region. However, in the past, the status of the fir stands in the Ukrainian Carpathians was significantly different than today. Hensiruk (2002 p. 220) reported that in the past, the total area of the fir stands could be much larger. Reduction of forest area resulted from the development of agriculture, potash and charcoal production in the second half of the 18th century – the first half of the 19th century. As a result, forests with fir, beech and oak were replaced by spruce mono-plantations that were often damaged by wind, pests or diseases. Moreover, in the region of Ukrainian Carpathians, the significant reduction of the share of fir stands was observed up to 1965. Particularly, in the period from 1947 to 1956, the area of fir forests decreased by 38.8% (after Ravlyuk 2009). After clear cutting of the fir stands, pure spruce plantations were also created. Unfortunately, such practices had a negative impact on forestry in the region. Since the 1990s, as reported by Debryniuk (2011), a wide dieback of spruce at different ages, especially in pure plantations, were

observed. Even sanitation cutting has not revealed any positive effects. As a result, the problem of preservation and reproduction of fir forests is important for the Ukrainian forestry.

From the 1980s, the Carpathian foresters were trying to increase the proportion of the presence of fir stands in both natural and artificial regeneration (Ravlyuk 2009). It is observed, that on the majority of soil types, in the stands with the share of fir, natural regeneration of this species is satisfactory. However, the natural regeneration of fir is a quite a long process, it lasts no less than 20–25 years and requires the use of special approaches, for example, group-selection cuttings.

Another way to increase the area of fir forests is to create artificial plantations. However, in order to obtain the valuable plantations of fir, the high quality of seed selection is required. Unfortunately, the vitality of fir seeds are not stable. Thus, in the poor seed years, the vitality of seeds is quite low – 7–28% (parthenospermia effect), while in good seed years this value reaches up to 28–68%. However, in clonal seed orchard in good seed years, it is observed that the high viability of fir



**Figure 1.** Silver fir clonal seed orchard in Kolomyia Forest District

seed reaches up to above 90% (after Debryniuk 2013). So it seems to be that the establishment of seed orchards composed of clones of fir plus trees would be the most promising.

For this reason, at the end of the last century, a strategy for the establishment of a permanent forest seed base (PFSB) was proposed. According to PFSB, forest seed based units should be created on the basis of the results achieved from genetic and breeding studies. As the units of seed base were proposed to include genetic reserves, selected seed stands, plus trees, as well as clonal and seedling seed orchards created from them. In particular, the creation of such bases is proposed for every seed region. According to the current seed regionalisation, three silver fir seed regions exist in the Ukrainian Carpathians (Debryniuk et al. 1998). Carpathian forest breeders, for the most part of the region have already established a PFSB for silver fir. Currently, PFSB includes 1,269 ha of certified forest genetic reserves (24 units), 17 ha of selected seed stands, 220 plus trees and over 20 ha of clonal seed orchards.

One of the first seed orchards of silver fir were established at the end of 1980s in Kolomyia Forest District (Yatsyk et al. 2009). At the age of 18 years, the maximum seed production was about 140 kg seeds per ha on this seed orchard. However, a good seed year is observed each 2–3 years. In the low seed years, seed orchards can produce only 10–30% of the average amount seed crop. Moreover, a typical seed orchard can produce seeds up to the age of 40–45 years. According to the reports of Kolomyia Forest District (state on 2018), 4,137 kg of silver fir seeds was harvested, through all the periods of seed production on two clonal seed orchards (plantations at 33 years of age, total area 15 ha, Fig. 1). It can be concluded, that such seed orchards are profitable, and thus, can fulfil the demands for fir seeds in the Ivano-Frankivsk administrative regions and partly in the neighbouring regions.

## CONCLUSIONS

The restoration of fir forests in the Ukrainian Carpathians takes place in both natural and artificial ways. Both of these methods are time and labour-intensive, and furthermore, need a long-term strategy. Currently, in the Carpathian region, important elaborations are being done in the breeding and selection of silver fir genetic material. The new fir stands, in appropriate ecological and soil conditions, should replace the pure spruce plantations.

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