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LARCH IN APUSENI MOUNTAINS: BETWEEN PRODUCTION AND PROTECTION

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Abstract

Larch in the Apuseni mountains can be found in compositions with predominately common beech and sparce with resinous species, mainly in mixtures on average and upper slope, peaking at approximately 1200m but concentrated on the average altitude of 650m, situated on corrugated lands and occupying only 1497.5ha out of 310538ha total forested area managed by the state in Apuseni mountains. The main objectives of the paper were to analyze the distribution and stand characteristics of Larch (Larix decidua Mill.) in the Apuseni mountains. Regarded as a fast-growing tree with high quality wood, it is mainly used for producing superior timber quality, its ecological value being overseen, only 20% of area occupied by larch used for protection purposes. Predominantly in mixtures, provides shelter, acting as a support tree for other species, improving biodiversity. Larches genetic diversity provides big challenges for forest managers, a proper growth model is required to satisfy all ecosystem services.

Keywords: *Larch; Stand characteristics; Distribution; Management; Genetic diversity*

Introduction

Larch (*Larix deciduas* Mill.) is a deciduous conifer species with a wide ecological amplitude [1] which tolerates light to a high extent, many considering it a heliophile pioneer species [2, 3], the phototropism correlated to the sparce, transparent crown characteristics [4]. The diversity of Larix regional populations (ecotypes) comes in two groups based on provenances, from Alpine Larch (var. decidua) to Carpathian Larch (var. carpatica; var. polonica), native populations can be found in Slovakia, Slovenia, Austria, Poland, Romania and other countries [4-13].

The species participates in mixed percentages with evergreen conifers and hardwoods, being one of the most common species in Rusia [14] and found in mixtures in the Alps with Swiss stone pine (*Pinus cembra*) and green alder (*Alnus viridis*) at high altitudes and further down with Norway spruce (*Picea abies*) and silver fir (*Abies alba*), their limit being set in compositions with beech (*Fagus sylvatica*). Moreover, in the Carpathian Mountains it can be found in mixtures with Scot's pine (*Pinus sylvestris*) whereas in Poland the species can be found on lowlands in pine-birch or oak-birch forests [1, 9]. The forest types relevant to larch are Norway spruce stands with either *Vaccinium myrtillus* or *Oxalis acetosella* as well as beech forest stands with mull flora on different type of soils mixing with hornbeam and medium-low productivity oak in hilly regions.

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Rarely planted, larch is managed through short rotations with lower planting costs and low stems/ha (1000/ha) whereas on fertile soils, longer rotations are sought and broadleaves understory are needed to keep the soil quality. Low altitude stands giving more high quality m3/ha/yr. compared to high altitude stands near the treeline [13].

European larch is used often as a fast-growing tree with valuable timber for furniture and floors, pulp and paper and as essential oil, very rarely for music instruments [4]. Due to its high quality and wood characteristics, it is rarely used as an ecological instrument, very small patches being protected across Europe [1].

As most of the stands around the world, larch stands provide a wide range of benefits and resources as well as ecosystem services such as: wood [15, 16]; non-wood forest products [17, 18]; biodiversity through old growth forests [19, 20]; smart forests [21-23]; specific soils on which forests grow and store CO_2 [24, 25]; water provisioning [26] and necessary nutrients [27] altogether improving, enhancing and protecting the environment [28-30].

Experimental part

Materials

The analysis took place in Apuseni mountains, a massif in the Carpathian Mountains, which can be found in the center of Transylvania, with its highest peak being 1848m (Bihor) and characterized by a continental climate with local climatic differences [31] and in figure 1 it can be seen the areas occupied by the European larch in Romania according to palynological sites with Larix evidence and in red circle the area studied in this research [7]. In Romania, larch populations use to be higher but nowadays are often isolated, concentrated in 5 regions named: Ceahlău, Ciucaș, Bucegi, Lotru and Apuseni, accounted as around 4500ha across Romania, with Bucegi region having the biggest share of larch, 1570ha [4].

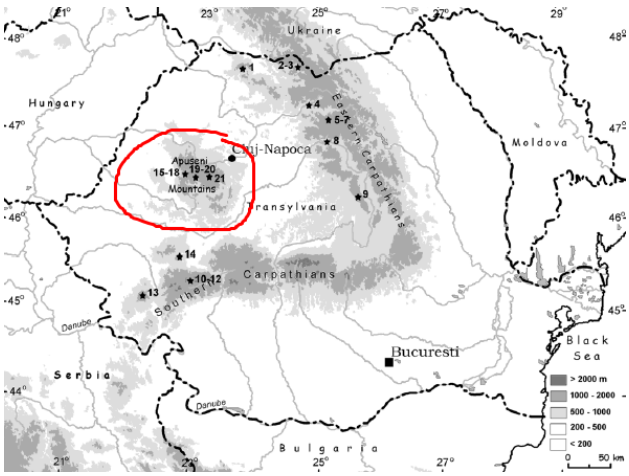

Fig.1. Larix evidence in Romania [7]

Methods

In order to conduct the present research, forest management plans from the Apuseni Mountains have been reviewed. The data from the forest management plans have been extracted from 22 state forest regional directorates in which *Larix decidua* sp. is found and managed regardless of its association with other species. The data is comprised of various forest elements such as landforms and configuration, as well as type of slopes and species participation in

compositions; stand age and current annual growth, forest type, soil type, quality classes, vitality and stand purpose.

The respective data was sorted out based on its distribution in hectares and analyzed through MS Excel in order to provide a simple and comprehensive approach and sound results. The analyze should give an overview regarding the use of larch in the study area and its related problematic situations.

Results and discussion

Distribution and site characteristics

The area occupied by larch accounts as 16% of the total mixed stands with larch in their composition and administrated by the state forest administration as see in figure 2. while the total forested area in the Apuseni mountains is 310.538 hectares and being distributed through 22 forest regional districts. Thus, larch in the Apuseni mountains occupies 0.48% of the total forested area.

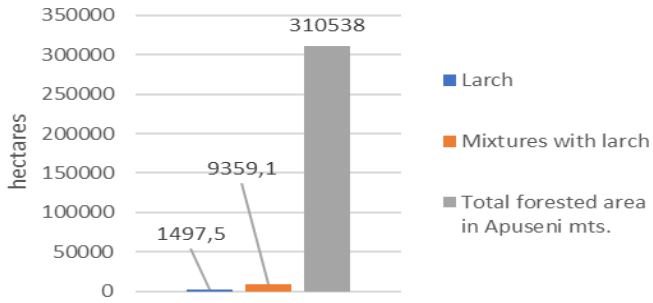

Fig. 2. Larch area in the Apuseni Mountains

Larch distribution according to ***landforms*** as illustrated in figure 3, can be accounted as on common slope with more than 50% of the stands 738.8ha, alternating between upper and middle slope, rarely seen on plateaus or high peaks, usually in low percentages in compositions, genetic variability becomes common on average slope, separated by 400m in altitude before differentiation between populations [32].

Moreover, according to figure 4, it predominates on ***corrugated land*** with more than 95% of the total stands, 1433ha out of 1497.5ha, showing its ecological importance of sustaining and stabilizing the land similar to the stands in North America on rugged mountains and narrow intermountain basins [32, 33].

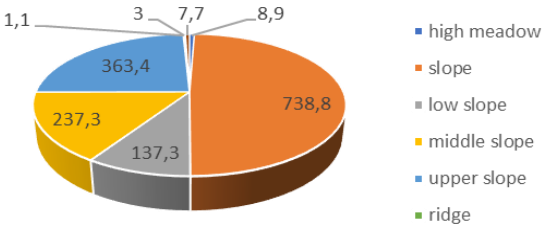

Fig. 3. Landforms distribution in hectares

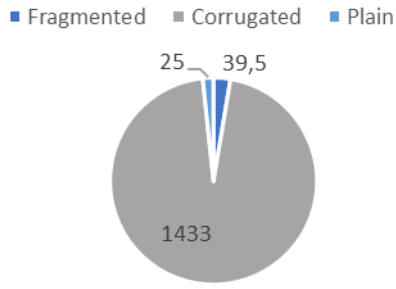

Fig. 4. Land configuration in hectares

Regarding the ***elevation*** at which larch can be found in the Apuseni mountains in forests managed by the state forest administration, the lowest altitude is around 150m with a few young stands whereas its highest point is reached around 1600m in low percentage in one stand as seen in figure 5, which comes similar to Sudeten and Tatra Mountains, with a range between 650 and 1900m [1]. The average altitude is situated around 665m.

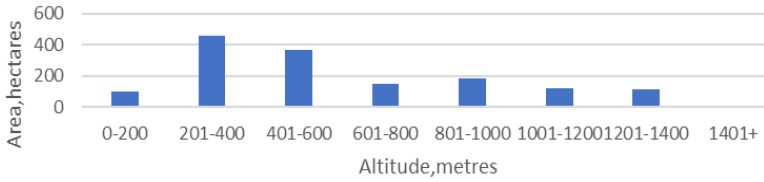

Fig. 5. Average altitude distribution

Taking into account that larch is known to thrive best on profound, rich in mineral soil, well drained with medium acidity [4], the stands in Apuseni mountains are predominantly growing on eutric dystric cambisols, reaching more than 60% of the larch area, with certain variations between luvial/alluvial soils as shown in figure 6.

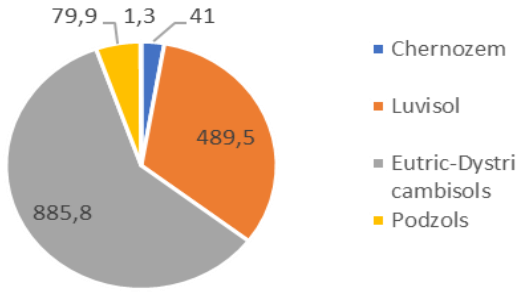

Fig. 6. Soil type classification

Stand characteristics

Being mostly known as a species that comes in mixtures, rarely in pure stands, larches in the Apuseni mountains are often scattered in the stand or rather in small or big patches, often mixed with other broadleaves or coniferous species according to the analysis in figure 7. Moreover, across the state forest administration management units, larch comes as much as 10-40% participation, extremely rare in monoculture as seen plotted in figure 8. Nevertheless, its provenances are unknown on 1441.8ha, very small areas being recognized as natural regeneration or plantation (8.2), expressing its adaptative capability for a species with a fragmented native area [34].

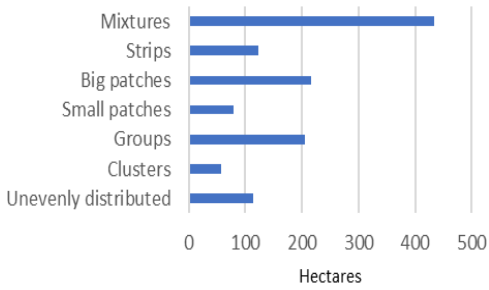

Fig. 7. Larch grouping in stands

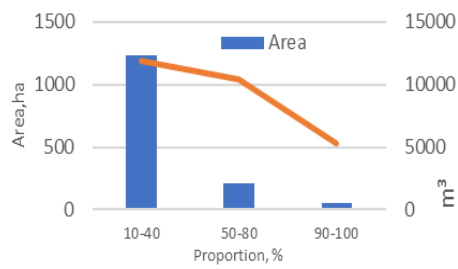

Fig. 8. Larch participation in stands

Most common stand forest types for larch in the Apuseni mountains, as seen in figure 9, are stands with hill or mountain common beech on skeleton soils with mull flora or a variation between them on similar soil types on more than 60% (approximately 800ha) of the total area occupied by larch and as the altitude rises, larch comes in composition with Norway spruce stands or beech-hornbeam stands with mull flora or *Oxalis acetosella* on approx. 280ha. Larch becomes a scarcity at lower altitudes, similar to the stands in Vistula River valley [35] consolidating stands or stripes with different species of oak such as turkey oak or pedunculate oak, forming so called tug type of forests with medium productivity most of the times.

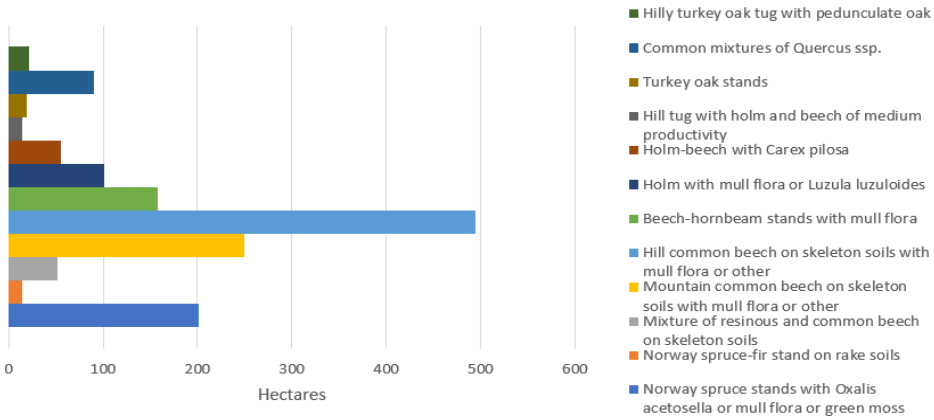

Fig. 9. Forest stand types

Stands that have larch in their compositions varies in age yet the average age is around 21 years old with peaks above 100 years in few management units, most volume concentrated around 50 years old as, average current annual growth being around 1.8 m³/year/ha, highest growth being around 40 to 50 years old.

According to the overall management purposes, 80% of the larch stands are managed mainly for common assortments, wood for timber, construction and cellulose, rarely used for conservation or land protection. By analyzing data through figure 10, forests destinated to produce thick trees prevails, which strengthens the idea of being an economically important tree in Europe [1]. Regarding the ecological role of larch in the area, as expressed in figure 11, land and soil protection predominate and the total area of larch with ecological purposes accounts for 335ha approximately.

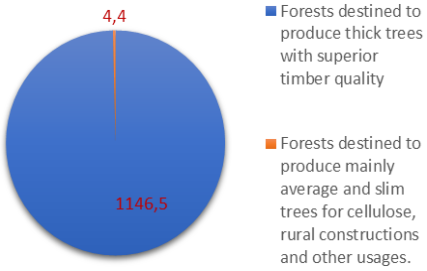

Fig. 10. Larch area destined to production

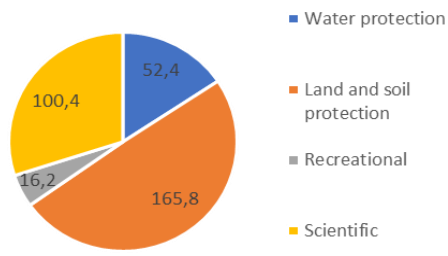

Fig. 11. Larch area destined to protection

Stands quality overall ranges from medium to high quality, most off the volume concentrated around the quality class of 2 and 3 on 1341 hectares with a volume of 12334m³.

Distribution and genetic diversity

The scarcity of larch in many areas is supposing coming as a result of intensive harvesting across the decades, the timber being valued tremendously for its quality and use [4] yet in Europe, the nowadays fragmented native distribution is believed to favor the findings of distinct genetic structures in future research [9].

Larch distribution occupies mostly the middle slope, most often on corrugated land at relative high altitude, on predominately medium and deep slopes averaging 650m, showing its adaptability and presumably mitigating landslides in mixtures with Spruce [36] and improving degraded open lands. It can often be found in stands with mull flora in mixtures with beech, rarely in mixtures with spruce and fir like different populations at high altitudes in the Alps, Carpathians and Sudets as well as Polish lowlands [9].

It's unknown provenances and high percentage in mixtures comes unsurprising based on its genetic variability and different ecotypes regarding its distribution across the globe [8]. The genetic difference between populations in Romania are rather high in the same region as compared to genetic variability between populations in separate regions. As it is shown in figure 12, larch populations in the Apuseni mountains are not studied as such from a genetics perspective [12, 31, 34, 37, 38] even though its deciduous characteristics increases the chance to find macrofossil evidence especially through needles and stomata [9].

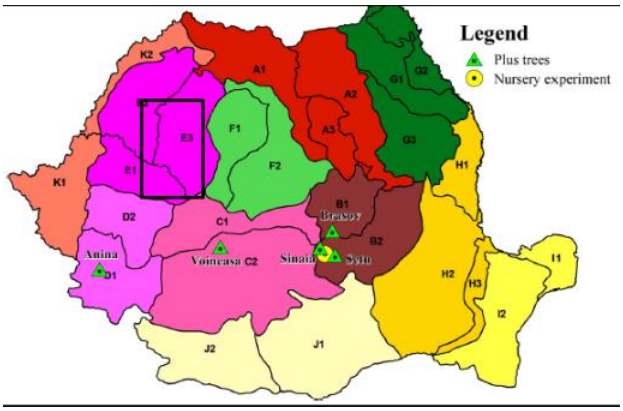

Fig. 12. Studied populations and larch nursery trials in Romania, black rectangle showing Apuseni mountains [37]

Stand characteristics and purpose

The seed dispersal and its high tolerance to light gives certain important features to land colonization by larch, often seen as one of the pioneer species in the early succession step. Larch monocultures in Romania used to occupy less than 350ha [4], now supposing being less, planted larch is quite rare seen. Thus, being present often in mixtures and very rare in monocultures, larch provides support for the main species in the stand.

Based on its participation at rather low altitude in Apuseni mountains compared with larch stands in other regions across Europe, it forms mixed stands with common beech, hornbeam and holm on mostly skeleton soils with mull flora. This shows its value on average and deep slopes, the rooting system providing resistance towards wind disturbances, being recommended in mixtures with spruce and other species with shallow roots [4, 22, 38]. Moreover, larch forms mixtures with turkey oak, complementing each other regarding water regime in the forest, the deciduous characteristic of larch improves the soil fertility through the loss of needles.

The main purpose for producing thick trees with superior quality and other assortments on approximately 80% of the area occupied by larch in the Apuseni mountains comes as a result of, larch wood being more valuable and at lower altitudes, extremely valuable compared to

other broadleaves. This shows the overexploiting of larch in Romania while the ecological status and biodiversity hot spot of native larch is shaded due to economic values.

The main volume being concentrated toward 40-50 years of age stands provides incentives towards conservation, mixed stands with pine showed higher biodiversity levels at young age when managed properly [39] while larch plantations managed accordingly with an age mosaic and proper management direct effected the productivity and biological diversity through increased leaf area index and low density of larch coupled with higher evapotranspiration, overall improving soil-water management [40].

Use and growth

Predominantly in mixtures, it shows high adaptability and based on its post-disturbance regeneration (mostly to fire disturbances), it is regarded as a long-lived pioneer species, justifying its use for protection rather than production, burnt larch stands are presumably perceived to switch in mixed stands rather than monocultures [6, 14]. Even though larch is found in mixed stands in the Apuseni mountains, 80% of the larch stands are used for production, proving the point of larch being valued for its timber [4]. Nevertheless, larch stands and larch stands with Pinus cembra are protected across Apuseni mountains under NATURA 2000 on 75943ha [7], which strengthens the idea of larch being an element of biodiversity, rather than a production focus species.

The growth of Larch in the area studied shows that it can rarely be an economically important species with 1.8m³ current annual growth at the age of 45-50 years whereas larches in high altitudes with a maximum rotation length of 100-130 years is known to provide 1.0m³/ha/year while in Alpine regions, stand growth goes between 1-3m³/ha/year [13]. However, on best site conditions larch can go up to 30m height at 55-60 years old with a stand productivity of 8-9m³/ha/year but as the stand goes older, at 100-120 years old the productivity gets lower, 5-6m³/ha/years [4].

In artificial stands establishment, based on certain genetically modified plantations (clones), the volume production, quality and fructifications seem to be improved by 10% thus providing an efficient genetic and economic future perspective for larch plantations [41]

Since the area of natural larch in Romania is below 1% [34] growing larch for production becomes tricky and implies over harvesting and unsustainable management. The quality of larch ranging between 2 and 3 on almost the entire area, coupled with the fact that it is found mainly in mixed forests, might give incentives for production services to owners, the ecological value of larch being overlooked, only approximately 20% of the stands are under protection.

Conclusions

The quantitative data analyzed have provided a good interpretation of the management of larch by the State Forest administration in the Apuseni mountains - a management based on production values rather than ecological matters, taking into account that the larch distribution and area in hectares is below 1%.

Often present in low percentages in mixtures, the ecological value and related ecosystem services are overlooked, larch seems to occupy areas with medium to deep slope, possibly mitigating landslides and wind disturbances, improving the soil fertility and water regime through its deciduous characters. Moreover, its fast growth can provide shelter for the main species in the composition, increasing species richness in the understory and biodiversity belowground. Due to its low presence in the Apuseni mountains, the management purpose of larch should be reconsidered and looked to satisfy biodiversity matters and climate change aching issue.

A thorough study is needed towards the use of Larch in mixtures and its supportive role, bringing to the surface its main characteristics of locally fast natural regeneration after

disturbances occurrence. Nevertheless, the effects of larch plantations with different schemes and proper management inside sparce stands should be researched. Moreover, since all important regions in Romania have been studied regarding its genetic variability and historical belonging, a similar study case would provide important data and connect the traceability of Larch across Europe.

Acknowledgments

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