УДК 630*165

Prof. Dr. Hrygoriy Krynytskyy, Roman Kuziv, Dr. Vasyl Lavnyy, Dr. Ihor Soloviy – NUFWT of Ukraine, Lviv

SWISS STONE PINE (PINUS CEMBRA L.) FORESTS IN THE UKRAINIAN CARPATHIANS: CHALLENGES FOR CONSERVATION AND REGENERATION

In the upper elevations of the Ukrainian Carpathians, Swiss stone pine (Pinus cembra L.) exibits high coenotic stability on relatively poor edaphic forest sites, so called «B»or subir edatopes (see Appendix A) as well as on sites that transition to the relatively rich edaphic forest sites, so called «C» or suhrud edatopes. On these forest sites, mixed stands of Swiss stone pine and Norway spruce (Picea alba) are characterised by considerable stratification of the stand structure. Gaps in the canopy occur relatively frequently and crown closure is usually no more than 0,25 of the optimal stocking level. This intermittent crown closure contributes to the regeneration and survival of the Swiss stone pine seedlings and advanced regeneration.

Keywords: Carpathians, interrelation, natural regeneration, Norway spruce, Swiss stone pine, uneven-aged stands.

Introduction. Over 6300 ha of forest area with components of Swiss stone pine are found in the eastern Carpathian Mountains of Western Ukraine (Smagluk, 1972). The natural sites occupied by this species is concentrated mostly in a small part of the Carpathians called Horhany massif and typified by a relatively high elevation, severe climate, and large areas with extremely poor edaphic conditions (steep slopes, rocky soils, and talus slopes). The distribution of Swiss stone pine occurs along an altitudinal gradient ranging from the lowest elevation of the natural growth -- approximately 800 meters above sea level (masl), to the highest – 1630 masl (Milkina, 1990, Smagluk, 1969, 1972). Therefore, this species grows in cool, temperately cold and boreal cold climatic zones. The majority of forest stands are concentrated at the altitudes of 1350-1450 masl. The majority of the forest stands have a Northwest aspect; 93 % of the Swiss stone pine forests area is located on the Northeast megaslopes of the Ukrainian Carpathians and only 7 % in the Southwest. This demonstrates the influence of elevation, aspect and edaphic conditions on the distribution of species in this region.

In the Ukrainian Carpathians, Swiss stone pine doesn’t form pure stands or a distinct vegetation belt. Instead, it is occurs in association with the uppermost elevational distribution of Norway spruce (Picea abies (L.)Karst.) forest belt and along upper timberline, with bush mountain pine (Pinus mugo Turra.). At the lower elevations, Norway spruce provides the strongest competition for Swiss stone pine, especially on the richer edaphic conditions, and at the higher altitude levels – bush mountain pine.

For the last two centuries, Swiss stone pine has experienced wholesale destruction as a result of human activities. The forest stands were felled for their valuable wood and intensively used as pastures, etc. (Smagluk, 1972, Stoyko S..M., et al., 1999). At the present time, Swiss stone pine is listed as a rare species in the Red Book of Ukraine and has protected status. However, for its long-term conservation, the current limited distribution of this species requires protection through active forest management practices. A considerable area of the Ukrainian Carpathians exhibits unsatisfactory natural regeneration of Swiss stone pine. This has been outlined by several literary sources (Smagluk, 1969, Stoyko S.M. et al., 1995). As mature and overmature trees fall out of the stand through natural mortality and other disturbance, the area of the natural forests of Swiss stone pine is constantly decreasing and is being replaced by Norway spruce. At the same time, insufficient study has been devoted to the process of natural regeneration of Swiss stone pine in the Ukrainian Carpathians.

Objectives and methods. The objective of the research was to determine the growth, regeneration patterns and ecological factors affecting the natural regeneration of the Swiss stone in the higher altitudinal range of the Ukrainian Carpathians. The research was conducted in the forest district of Yajko (Osmolodskyy Derzhlishosp; elevational range: 1280-1400 masl) and Kedryn (Ust`-Chornyanskyy Derzhlishosp; elevation of 1000 masl). In the first forest district, existing permanent sample Plots No. 4-7, 14-17, 20 and 30 were investigated, in the second forest district only sample Plot No. 1. The size of the sample Plots depended on ecological factor gradients and ranged between 0.04-0.24 ha in size. The forest sites evaluation was done according the classification of the P.S. Pohrebnyak (Pohrebnyak, 1955; Vorobyov 1967; Geryshynski, 1996).

In the sample plots, the forest stands were characterised according to canopy strata, species composition, growing stock, age, height, diameter at breast height (of 1.3 m) and crown projection area of each tree was used to calculate crown closure. To study the processes of natural regeneration, 100 vegetation quadrants 1×1 m were measured. These quadrants were used to determined the number, age and height of the regeneration, species composition and projected ground cover of the understory -- low brush-herbaceous layer, and ground cover (moss and lichen) for each of the sample Plots. Regeneration below two meters (2 m) in height was classified as understory vegetation.

The age of the young growth (seedlings and advanced regeneration) was estimated by whorl count. For older trees, increment cores were extracted from healthy trees at a height of 0.1-0.5 m above root collar or soil surface with corrections for the age to reach the sample height. In the case of heartrot or other defects of older specimens, the age of trees was estimated using increment borings at the same height from the healthy part of wood. Detailed study of the patterns of growth and regeneration of Swiss stone pine and Norway spruce stands were realised on the Sample Plots 14-17. Sample Plots 14-17 were characterised by what researchers determined to be a «typical form» of the stand structure and distribution of a mixed Swiss stone pine/Norway spruce forest stand (Table 1). The sample plots are situated in a narrow band across the slope gradient with increasing soil richness at lower altitude levels. The steepness gradient of the slope on Sample Plots 14-16 is 24-28° and 32° on sample Plot 17. The slope exhibits a general southerly aspect. Sample Plot 14 has different soil conditions and was, therefore, divided into two parts: Section 14a (a 5 m wide belt set aside near a talus slope) has poorer soils and Section 14b (a 15m wide belt set aside close to the talus slope) has a concavity with more fertile and more humid soil conditions.

The sample Plots represent the following forest types:

- 14a – meso-hygrophilic, poor stone pine and Norway spruce bir (A_3);
- 14b – hygrophylic, fairly poor, stone pine and Norway spruce subir (B4);
- hygrophylic, fairly poor, stone pine and Norway spruce subir (B4);
- hygrophylic, fairly poor, stone pine and Norway spruce subir (B4);
- meso-hygrophilic, fairly rich, high elevation Norway spruce suhrud (C_3).

The soils on Sample Plots 14-16 consist of an organic «soddy-peat» soil type overlaying stony parent material. Moreover, on Sample Plot 14, this soil type is still in early stages of soil formation. The understory on Sample Plots 14a and 14b is absent while on Sample Plots areas 15-17 it is represented by the single specimens of the rowan or mountain ash (Sorbus aucuparia L.) with heights up to 1,8 m, the density of the understory canopy does not exceed 0,1.

Sample Plot 30 (from Sections a, b, c, d, e) occupies a level section of southern aspect with an average slope steepness 26°. The forest site moves towards a rich subtype of the Swiss stone pine-Norway spruce subir (B_3). Sections 30a and 30b are located in the lower part of the plot and the remaining three (Sections 30c-30e) in the upper portion of the plot. The overall species composition of the stand is 14 % Swiss stone pine and 86% Norway spruce, with a growing stock volume of 392 m^3 $ha^{-1}$and crown closure of the upper canopy 0.61. The overstory is comprised of Norway spruce with age classes ranging from 180-260 years and 320-380 years and partially comprised of Swiss stone pine, with ages in two ranges: over 300 and 190-230 years. From edaphic-orographic point of view, sections of the sample Plot 30 are similar, however, in composition and structure of the stands, there are considerable differences. Consequently, on section 30c, there is a considerable part of Swiss stone pine in the stand composition while on sections 30b and 30d this species is absent (see Table 4.). The crown closure of canopy in the various sections is unequal. For section 30c, small gaps are typical, while in other sections the openings are considerably bigger and more conspicuous.

Sample Plot 31 occupies a similar position approximately 80m east on the same slope with a southern exposition and average slope steepness of 26°. The forest site is classified as a hygrophyllic subir (B_4). The composition of the stand is 30% Swiss stone pine and 70% of Norway spruce. The overstory is formed by Norway spruce with a range of ages between 190-340 years and Swiss stone pine with range of ages between 250-350 years. In the canopy of Sample Plot 31, there are substantial openings (distributed on the slope below mature Swiss stone pine trees). The same gaps were observed on the Sample Plots 14b, but on the Sample Plots 15 and 16 they are absent.

Sample Plots 4, 5, 6 and 7 occupy the same southerly slopes below the trail that bisects the sample area. The mean steepness of the slopes are 26°, 34°, 27° and 31°, respectively. The Sample Plots represent the following forest sites:

- 4 – Poor subtype of hygrophillic Swiss stone pine-Norway spruce subir (B_4);
- 5 – Meso-hygrophillic subtype of hygrophillic Swiss stone pine-Norway spruce subir (B_4);
- 6 & 7 – Rich subtype of meso-hygrophillic Swiss stone pine-Norway spruce subir (B_3).

The standing volume of these samples Plots was 198, 328, 648 and 498 m^3 ha^{-1}, respectively. A detailed study on Swiss stone pine seed production was conducted over a three year period on the sample Plot 1 in the meso-hygrophillic Swiss stone pine-Norway spruce subir (B_3) in the Kedryn forest massif of the Ust`-Chornyanskyy Lishosp. Selected cone and seed characteristics were recorded: cone size (length, width and diameter dimensions), amount of seed, seed weight, seed dimension (length and width) and seed viability. The stand under examination was uneven-aged and comprised of 50 % Swiss stone pine and 50% Norway spruce. The seed producing Swiss stone pine trees were found in the overstory. Their ages ranged from 148-169 years, height was between 17.0-24.9 m, diameter at breast height (1.3 m) was between 27-55 cm, and the mean volume per tree ranged between 0.51-2.61 m^3.

Results. Based on the data collected (table 1), we can see the distribution of species composition – Swiss stone pine was found only on Plots 14-16 and Norway spruce was well distributed throughout all the sample plots. In addition, on Sample Plot 14a, Norway spruce is absent in the overstory (this story is formed solely by Swiss stone pine). In Sample Plot 16, Swiss stone pine is absent in the understory, which consists solely of Norway spruce. The percentage of Swiss stone pine in the stand composition decreases with the movement from the poorest edatope to the richest (from

Sample Plots 14a to 17) and increases the distribution of Norway spruce until it completely dominates the stand (Sample Plot 17). In the overstory, the distribution of Swiss stone pine is decreasing slowly and the Norway spruce is rapidly increasing. In the lower strata and the understory, the process is reversed; there is a rapid decrease of Swiss stone pine and a gradual increase of Norway spruce. On Sample Plot 15, individual trees of silver fir (Abies alba, Mill.) were found scattered throughout the stand.

Table 1. Biometric Indicators of the Sample Plots

Biometric Indicators	Sample Plots				
	14a	14b	15	16	17
Total stand composition	80% Pinus cembra 20% Picea abies	66% Pinus cembra 34% Picea abies	40% Pinus cembra 60% Picea abies	18% Pinus cembra 82% Picea abies	100% Picea abies
Overstory composition	100% Pinus cembra	79% Pinus cembra 21% Picea abies	52% Pinus cembra 48% Picea abies	23% Pinus cembra 77% Picea abies	100% Picea abies
Understory composition	66% Pinus cembra 34% Picea abies	37% Pinus cembra 63% Picea abies	17% Pinus cembra 83% Picea abies	100% Picea abies	100% Picea abies
Stand volume (m^3 ha^{-1})	192	407	743	592	590
Overstory volume (m^3 ha^{-1})	80	277	497	459	534
Understory volume (m^3 ha^{-1})	112	130	246	133	56
Relation of the Picea abies overstory and understory volume	0	0,72	1,18	2,65	9,52
Relation of the Pinus cembra overstory and understory volume	1,08	4,49	5,95	-	-
Mean age of overstory (years): Pinus cembra / Picea abies	240/130	270/160	400/210	420/190	-/110

The difference in the species composition of tree species in the overstory and understory due to changes in edaphic conditions was examined in detail. The proportion for the Swiss stone pine on sample Plot 14a where it dominates is close to 1, but on sample Plots 14b and 15 where its coenotic position is weaker, the corresponding fig.s are 4.5 and 6.0. The proportion for Norway spruce in the Plots where it clearly dominates Swiss stone pine was 9.5. With the transition to the poorer edatopes and weakening of its coenotic position, this index decreases accordingly. In general, when comparing the Norway spruce to the Swiss stone pine in each sample plot where both species grew, the proportion is smaller for Norway spruce. The reason for this phenomena is based on the shade tolerance of Norway spruce which is a much more shade-tolerant species than Swiss stone pine.

There is a strong correlation observed between the density of both overstory and understory with changes in edaphic conditions. The observed minimum ratio of overstory density to understory density (0.25) was found in the poorest conditions while the maximum ratio (2,14) occurred in the best conditions (Table 2). During the transition from the sample Plot 14a to 14b, the density of the Swiss stone pine overstory increases slightly. During the next transition to sample Plots 15 and 16, it decreases sharply. In the case of the transition of Norway spruce from one sample Plot to another in the direction of increasing soil fertility, there is considerable increase of the overstory density. The following pattern is observed for age structure -- the richer the edaphic conditions, the older the age of Swiss stone pine trees. In each of the sample Plots, the oldest trees were represented by Swiss stone pine. The mean age of the Swiss stone pine trees is higher than the Norway spruce (table 1). As the edaphic conditions improve the difference between the mean ages of Swiss stone pine and Norway spruce increases: in sample Plot 14a and 14b it is about 110 years, in sample Plot 15 is approximately 190 years, in sample Plot 16 is about 230 years.

Table 2. Crown Closure of the Canopy Strata on the Sample Plots

Storeys	Species	Sample Plots				
		14a	14b	15	16	17
Overstory	Picea abies	0	0,12	0,21	0,33	0,47
	Pinus cembra	0,12	0,14	0,09	0,03	0
	Total Stand	0,12	0,26	0,30	0,36	0,47
Understory	Picea abies	0,38	0,37	0,41	0,38	0,22
	Pinus cembra	0,10	0,12	0,03	0	0
	Total Stand	0,48	0,49	0,44	0,38	0,22
Overstory and understory	Picea abies	0,38	0,49	0,62	0,71	0,69
	Pinus cembra	0,22	0,25	0,12	0,03	0
	Total Stand	0,60	0,74	0,74	0,74	0,69
Ratio of overstory and understory canopy closure	Total Stand	0,25	0,53	0,68	0,95	2,14

In terms of diameter class distribution, in each of the sample plots, the quantity of trees of the largest diameter classes are represented predominately by Swiss stone pine tree. In the smaller diameter classes, Norway spruce is more predominant as the Swiss stone pine, especially in rich soil types. With the transition from poor to rich subtypes within the subirs (B edatope), there is an observed increase in the percent of stressed trees in the stand. In stands with a high proportion of Swiss stone pine, this trend is more pronounced. In rich subirs, there is a large percentage of weakened trees which also belong to the largest diameter classes, this does not occur with Norway spruce. It is necessary to point out that there are considerable differences between the species composition and the distribution of the low shrub-herbaceous layer and ground cover species in sample plots 14a, 14b, 15, 16 and 17 (table 3).

Table 3. Projective ground cover of low shrub-herbaceous layer, moss and lichen cover on the Sample Plots (%)

Species	Sample Plots				
	14a	14b	15	16	17
Vaccinium myrtillus L.	23	23	25	10	15
Vaccinium vitis-idaea L.	11	8	3	<1	0
Lycopodium clavatum L.	0	0	0	5	<1
Dryopteris carthusiana (Vill.) H.P. Fuchs	0	0	0	<1	11
Dryopteris filix-mas (L.) Schott	0	0	0	0	1
Athyrium filix-femina (L.) Roth	0	0	0	0	1
Gymnocarpium dryopteris L.	0	0	0	0	<1
Homogyne alpina (L.) Cass.	0	0	0	0	3
Calamagrostis epigejos (L.) Roth	0	0	0	0	6
Oxalis acetosella L.	0	0	0	0	6
Carex sp.	0	0	0	0	10
Low shrub-herbaceous cover	34	31	28	16	54
Pleurozium schreberi (Willd.) Mitt.	12	13	9	2	5
Hylocomium splendens (Hedw.) Br. eur.	10	9	5	<1	<1
Dicranum sp.	10	15	36	33	9
Polytrichum commune L.	0	0	4	14	3
Sphagnum quinquefarium (Lindb.) Warnst.	0	11	<1	<1	0
Bazzania trilobata (L.) Gray	2	7	1	1	<1
Moss cover	34	55	55	51	18
Lichen cover	2	0	0	0	0
Total ground vegetation	56	72	66	57	63

On sample Plots 14a and 14b, where Swiss stone pine has a strong coenotic position, the low shrub-herbaceous cover is represented only by Vaccinium vitis-idaea L. and to a lesser extent Vaccinium myrtillus L.; the moss cover Polytrichum commune

Hedw. is entirely absent. For sample Plot 14a (where the coenotic position of Swiss stone pines is the strongest) the dominant groundcover is the lichen Cladonia rangiferina Webb. In sample Plot 15 (where the Swiss stone pine position is relatively weak), the moss cover together with other moss species is represented also by Polytrichum commune Hedw. In sample Plot 16 (where the Swiss stone pine position is very weak with intensive displacement by Norway spruce), the low shrub-herbaceous cover is represented by Vaccinium myrtillus L., Vaccinium vitis-idaea (L.) Avror., and to a lesser extent by Lycopodium clavatum L. and Dryopteris carthusiana (Vill.) H.P. Fuchs. In terms of the groundcover, the moss species Polytrichum commune Hedw. occupies the largest area, with a substantially smaller percentage of the cover of represented by the moss species Hylocomium splendens (Hedw.) B. S. q.

On Sample Plot 17, which is outside the natural boundary of the Swiss stone pine habitat, the low shrub-herbaceous cover is more abundant than on sample Plots 14a-16. However, there is a conspicuous absence of Vaccinium vitis-idaea L. In terms of groundcover, the share of the moss Hylocomium splendens (Hedw.) B. S. q. is very small. Unlike Sample Plots 14a-16, Sample Plot 17 has a noticeably larger shrub-herbaceous cover than moss cover. There exist considerable differences in ground vegetation in the sample Plots due to different edaphic conditions and the ecological position of Swiss stone pine in the forest stand. These differences could be used to identify Swiss stone pine forest sites for artificial regeneration to augment existing natural regeneration as the primary component of the species composition.

The coenotic interrelationship between Swiss stone pine and Norway spruce in dense canopies is reflected in the natural regeneration. This process of natural regeneration of Swiss stone pine in the Ukrainian Carpathians is dependent on the ecological conditions and can occur both successfully and unsuccessfully. It is important to note that the success of regeneration of Swiss stone pine depends largely on the percentage in existing stand, crown closure and structure of the canopy, including the magnitude, form and allocation of gaps and openings.

As can be seen from table 4, among five sections of sample Plot 30, the smallest proportion of Swiss stone pine regeneration is evident in section 30c. Although 30c exhibits a considerable proportion of Swiss stone pine in the stand composition, it is characterised by the highest crown closure and absence of big open places. In section 30e, there is a smaller proportion of Swiss stone pine in the forest stand but there is a larger amount of young growth due to the presence of gaps. A somewhat larger amount of regeneration occurs in sections 30a and 30b, which are characterised by low crown closure with large gaps and are situated below section 30c, which contains a large number of mature Swiss stone pine trees. Section 30d, which has the lowest crown closure and the largest amount of large gaps, does not have a lot of young growth. This is due to the absence of Swiss stone pine trees in the canopy and because the adjoining section 30c is located to the side and not below the direction of the slope and, therefore, unable to capitalize to the potential seed fall area. From sample Plot 30, it is evident, that the success of Swiss stone pine regeneration depends on the presence of openings in the canopy of mixed Norway spruce/Swiss stone pine stands, and from their location in relation to seed source of Swiss stone pine. These results can be confirmed from the sample Plots 4-7, 14-16, 20 (table 4). It can also be seen that with the same crown closure, the natural regeneration is better in stands where the structure of the canopy is more heterogeneous. The increase in openings in the canopy from small gaps (< 10 m diameter) to larger openings with a corresponding even distribution throughout the stand favors the regeneration of Swiss stone pine in quantity and growth rate.

The canopy structure of Norway spruce/Swiss stone pine stands is closely dependent on availability of soil nutrients on forest sites. In bir and poor subtypes of subir forest sites, the natural regeneration of Swiss stone pine is acceptable to assure natural propagation of the stand, however in rich subtypes of subir sites the natural regeneration of Swiss stone pine is unacceptable. From table 4, it can be seen that Swiss stone pine is much more influenced by the availability of light under the canopy than Norway spruce. Existing advanced regeneration of Swiss stone pine in Norway spruce dominated stands (Sample Plot No. 17) reveals the positive role of forest dwelling birds and wildlife in the seed dissemination of this species in the high elevation sites of the Ukrainian Carpathians.

Table 4. Distribution of understory regeneration in mixed Pinus cembra and Picea abies stands

Sample Plots	Type of forest site	Stand Composition	Crown Closure	Openings near Pinus cembra trees	Regeneration (specimens/ha)	
					Pinus cembra	Picea abies
4	B_4	55% Pinus cembra; 45% Picea abies	0,6	+	5,90	9,30
5	B_3	29% Pinus cembra; 71% Picea abies	0,6	+	2,30	11,70
6	B_3	50% Pinus cembra; 50% Picea abies	0,8-0,9	-	0	3,80
7	B_3	23% Pinus cembra; 75% Picea abies 2% Betula pendula Abies alba	0,8-0,9	-	0	4,60
14a	A_3	80% Pinus cembra; 20% Picea abies	0,56	+	2,20	2,60
14b	B_4	66% Pinus cembra; 34% Picea abies	0,69	+	1,33	1,80
15	B_4	40% Pinus cembra; 60% Picea abies	0,70	-	0,08	2,17
16	B_4	18% Pinus cembra; 82% Picea abies	0,71	-	0,06	1,10
17	C_3	100% Picea abies	0.61	-	0.03	2,53
30a	B_3	3% Pinus cembra; 97% Picea abies	0,55	-	0,18	2,45
30b	B_3	100% Picea abies	0,56	-	0,15	2,70
30c	B_3	42% Pinus cembra; 58% Picea abies	0,77	-	0,03	1,09
30d	B_3	100% Picea abies	0,47	-	0,08	1,60
30e	B_3	98% Picea abies; 2% Pinus cembra	0,65	-	0,08	1,01
31	B_4	30% Pinus cembra; 70% Picea abies	0,57	+	1,12	2,72

Based on ocular examination, the process of natural regeneration of Swiss stone pine is highly dependent on seed production. Over the course of many years of observation in the Ukrainian Carpathians, it can be shown that abundant seed harvest occurs once every 3 to 4 years. A large quantity of the seeds, especially in low seed production years, are consumed by birds, specifically by nutcracker (Nucifraga caryocatactes L.), and rodents [(Smagluk, 1969); (Stoyko S.M. et al.,1995), and (Feger Y.I., 1984)]. Generalized data based on three year's research of seed production in the Sample Plot 1 is presented in the table 5. Research into the Swiss stone pine seed production showed that the largest amount of seeds were produced by the largest trees based on diameter at breast height (1,3 m) growing in the best light and soil nutrition conditions. At the same time, distinctions in seed production between trees with different crown characteristics (based on growth characteristics and crown class) were measured. Based on the data collected and measurements of P. cembra outplantings after the first three years, there was no substantial difference in height of seedling based on crown class of trees.

Conclusions. The research demonstrates that in the higher elevations of the Ukrainian Carpathian mountains, Swiss stone pine is consistently displaced by Norway spruce on richer sites and only retains dominance of the species composition in bir sites and in poor subtypes of subir forest sites which border on talus slopes. These impoverished mountain soils are characterized early stages of soil formation, with high stone content and a mosaic pattern in soil structure development in the upper horizons. Under such growing conditions, forest stands are very uneven-aged with large differences in age class distribution. These stands are characterised by marked difference in crown closure, with the density in the overstory being far less than the lower canopies. As a rule, the overstory crown closure doesn't exceed 0.25. The overall crown closure of the canopies of the forest stand is 0.5-0.7, with frequent openings. Based on regeneration surveys, the natural regeneration of Swiss stone pine is acceptable in these stand openings. Under these conditions, the stand vigour of Norway spruce is diminished. In bir sites and in poor subtypes of subir forest sites, it is observed that Swiss stone pine dominates Norway spruce in stand composition as well as stand vigour throughout the range of crown and age classes.

Table 5. Indices of Swiss stone pine seed production on Sample Plot 1

Index	Interval size
Cones	
Range of cones/tree (no.)	0-261
Mean cone length (cm)	4.9-6.3
Mean cone diameter (cm)	3.9-5.0
Seeds	
Seed mass per tree (g)	0-1554
Mass of 1000 seeds (g)	162-299
Average seed length (mm)	9.5-11.7
Average seed width (mm)	7.0-9.1
Fullness of seeds (%)	78-100
Absolute seed viability (% germination capacity)	46-87
Sown seed viability (% germination capacity)	44-74

With the transition from poorer to richer edaphic conditions, the productivity of Swiss stone pine increases less rapidly than Norway spruce. Therefore, there is greater coenotic pressure on Swiss stone pine than on Norway spruce and in suhruds, the natural growth and distribution of the Swiss stone pine is restricted or non-existent.

Based on the research observation in rich and typical subirs, Norway spruce displaces Swiss stone pine out of the stand. Natural stands occurring on such sites are characterised by comparatively high general crown closure (0,7 and above) and high crown closure in the overstory (0,3 and above). Swiss stone pine is represented in these stands by exceptionally mature and overmature specimens. However, the natural regeneration is unacceptable to assure natural propagation of the stand. To ensure the maintenance of Swiss stone pine in rich and typical subirs in the higher elevations of the Ukrainian Carpathian mountains, intermediate treatments are recommended. These interventions will aid in the establishment of natural regeneration through the creation of artificial openings next to the seed trees and mature Swiss stone pine stands.

References

1. **Milkina, L.I.** 1990. Categorisation and principles of distribution of relict natural coniferous associations of the north-eastern macroslope of the Ukrainian Carpathians (in Ukr.). Ukrainian Botanical Journal 1. – P. 75-80.

2. **Smagluk, K.K.** 1969. Swiss stone pine (Pinus cembra L.) in the Ukrainian Carpathians (in Rus.). Lesovedenie 1. – P. 3-15.

3. **Smagluk, K.K.** 1972. Indigenous coniferous species in the forests of the Ukrainian Carpathians (in Ukr.). Carpathians Press, Uzhgorod. – 112 p.

4. **Stoyko, S.M., Nadorozhnyak, O.J., Mazur, B.A., and Kuleshko, M.P.** 1995. Ecologo-phytocoenotical characteristics of the larch-cedar pine reserve «Kedryn» in the Ukrainian Carpathians (in Ukr.). Ukrainian Botanical Journal 4. – P. 528-535.

5. **Stoyko, S.M., Tretyak, P.R., Boychuk, I.I., and Onyshko, Z.D.** 1999. Swiss stone pine (Pinus cembra L.) on timber line in Horany (in Ukr.). Collection of scientific and technical works of USUFWT 9.9. – P. 173-179.

6. **Feger, Y.I.** 1984. Restoration of Swiss stone pine natural habitat (in Ukr.). Forestry, paper and woodworking industry 2. – P. 10-11.

7. **Vorobyov, D.V.** 1967. Methods of the forest typology researches (in Rus.). Urozhay Press, Kyiv. – 388 p.

8. **Pohrebnyak, P.S.** 1955. Basics of the forest typology (in Rus.). 2nd edition. Academy of Sciences of Ukraine, Kyiv. – 456 p.

9. **Gerushinskyy, Z.Y.** 1996. Typology of the forests of Ukrainian Carpathians. Pyramida Press, Lviv. – 208 p.

Appendix A. Ukrainian Classification of Site Conditions Based on Aleksyev and Pohrebnayk

Soil humidity	Soil fertility			
	A poor (bir)	B fairly poor (subir)	C fairly rich (suhrud)	D rich (hrud)
0 – xerophile	A_0	B_0	C_0	D_0
1 – xero-mesophile	A_1	B_1	C_1	D_1
2 – mesophile	A_2	B_2	C_2	D_2
3 – meso-hygrophile	A_3	B_3	C_3	D_3
4 – hygrophile	A_4	B_4	C_4	D_4
5 – ultra hygrophile	A_5	B_5	C_5	D_5

Проф. Г.Т. Криницький д-р біол. наук; ст. наук. співроб. Р.Ф. Кузів; доц. В.В. Лавний, канд. с.-г. наук; доц. І.П. Соловій, канд. с.-г. наук – НЛТУ України

Ліси сосни кедрової європейської (pinus cembra l.) в Українських Карпатах: проблеми збереження і відтворення

Досліджено, що у високогірній частині Українських Карпат сосна кедрова європейська (Pinus cembra L.) має високу ценотичну стійкість лише у бідних типах лісорослинних умов, зокрема, у вологих і сирих борах та суборах. У цих лісорослинних умовах змішані смереково-кедрові деревостани характеризуються значною мінливістю структури. У наметі крон часто утворюються вікна і зімкнутість верхнього ярусу деревостанів зазвичай не перевищує 0,25. Розрідженість дерев сприяє появі та виживанню самосіву і підросту сосни кедрової європейської. В Українських Карпатах площа деревостанів за участю сосни кедрової європейської становить 6313 га [3]. Вони зосереджені головним чином у невеликій частині Карпат – Горганах на ділянках з екстремальними лісорослинними умовами: крутими схилами, кам'янистими ґрунтами і на кам'яних розсипах. Найчастіше кедрові ліси зустрічаються на висоті від 1350 до 1450 м над рівнем моря. Сосна кедрова європейська в Карпатах не формує окремого вертикального поясу, а росте, як домішка, у верхній смузі смерекових лісів та вздовж верхньої межі лісу серед заростей сосни гірської. Проведені нами дослідження свідчать про те, що у високогір'ї Українських Карпат високу стійкість до витіснення смерекою сосна кедрова європейська проявляє лише в борах і бідних підтипах суборів, тобто в місцях, які межують з кам'яними розсипами. З переходом від бідніших до багатших едафічних умов ріст дерев сосни кедрової покращується в меншій мірі, ніж смереки. При цьому вона зазнає дедалі більшого ценотичного тиску порівняно зі смерекою і вже в сугрудах природне поширення сосни кедрової стає неможливим. Для збереження сосни кедрової європейської у багатих і типових суборах верхнього лісового поясу Українських Карпат доцільно проводити сприяння її природному поновленню, яке полягає у створенні штучних прогалин біля дорослих дерев сосни кедрової.

Ключові слова: Українські Карпати, взаємодія деревних порід, природне поновлення, сосна кедрова європейська, ялина європейська.