

MANIAVA

Excursion guide
on the close to nature
silviculture sample plot



Hungary-Slovakia-Romania-Ukraine
ENPI Cross-border Cooperation Programme



The Programme is co-financed by the
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NAME: MANIAVA,
Excursion guide for the close to nature silviculture site

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INTRODUCTION

Close to nature silviculture object MANIAVA is located near Maniava village in Bohorodchany rayon of Ivano-Frankivsk region in the area "Skyt Maniavskiy". The object is located at the slope, which borders right bank of Maniavka river, which is a tributary to Bystrytsya Solotvynska river.

This locality is a part of the Outer Carpathians and of the mountainous forest management area and is characterized by unevenness of the terrain and distinctive alteration of middle high mountain ridges and hollows with slight slopes of various steepness and expositions and relatively flat areas, cut by ravines, valleys and also slight lowlands and dens. Tops of the mountains, as a rule, are covered with forest and natural field areas.

Except forest resources, this locality is rich with other natural resources. There are deposits of oil, gas, salt, mineral wax, lignum fossil, and also construction materials (gravel, stone).

Forest stands of the object area are represented by mixed (2-3 species) beech (43.3%), spruce (25.6%) and fir (21.1%) stands. Besides main forest species here are pine, larch, birch, sycamore maple, and elder.

Forests of this region from long ago were intensively used by local people. Already at the end of 19th – beginning of 20th century territory around Maniava village was covered with mixed fir-broadleaved forests. However, as a result of intensive harvesting of forest resources at the end of 30s of previous century, and especially in second half of 40s and until the end of 60s share of beech in the composition of the forests has increased. Valuable species were cut in order to satisfy needs of local people in construction materials, household products and for firewood. Significant amount of timber was used by operating at that time extracting and processing industries. Also forests were harvested with purpose to expand pastures and agricultural lands.

Forest management was done according to the age classes method, which was based on establishment of management units formed by



homogenous by the composition and productivity forests stands, united by the same age and type of harvesting. Initial accounting unit is taxation subcompartment, and initial planning unit – management section. All calculations are done based on results of area and growing stock of management sections by age classes. This method foresees clear cutting. At the clear cut areas single specie stands were established, mainly by fast growing spruce, grown from seeds brought from other areas. Areas after last cut of gradual cuts and after clear cuts, which were left for the natural growth, were reforested mainly by even-age natural regeneration with significant part of pioneer species. Particularly spruce and softwood – birch and aspen, regenerated intensively.

That is why, as a result of such management system, currently in forest area we have significant part of secondary, dominantly one-layer, even-age, and single specie stands. They consist of trees with more or less similar diameters with modest crowns, which is a result of high density of the stand canopy. Forest stands have certain level of stability only to the time, when they are closed and not being challenged by hazardous factors. Rapid damage of the canopy by wind, snow or exceeding selection during harvesting, results in weakening of trees, which impacts stability and allows disintegration of the forest stand.

Taking into account natural climatic conditions, wide variety of species in the stands, its perfect capability for successful regeneration in natural way, different biological features, there are practical need in use of close to nature silviculture at this area. At the selected object there are all needed preconditions for conversion of present forest stands in order to form stands with values, which describe close to natural forest. Finally it will be possible to get stable natural forest ecosystem with differentiated special construction, uneven aged structure, high productivity, and value, profitable in economic, environmental, and social dimension.



CHARACTERISTIC OF THE AREA

Location and geographic position

Educational object of close to nature silviculture MANIAVA is located in compartment #34 of Maniava forest range of State Enterprise "Solotvyn forest management" of Ivano-Frankivsk regional department of forest and hunting management, subordinated to State Agency of Forest Resources of Ukraine. The plot has area of 11.2 hectares.

Geographic coordinates of the educational sample plot are: from 48°39'13" to 48°39'26" N and from 24°23'08" to 24°23'40" E.

Range of altitudes varies within 500-595 m a.s.l. Area is hilly, with slopes of north-eastern exposition mainly, inclination from 10° to 20°. Slopes which border Maniavka river, have inclination of up to 45°.

Climate, geological basis, and soil

Climate in the locality of the area is moderate continental, humid with cool summers and mild winters. Average July temperature in plain area +18°C, in mountain – from +12 to +16°C, annual January temperature is respectively -4 – -6°C. Average annual air temperature is +7,1°C, minimal -28°C. Average duration of the frostless period is 176 days, vegetation period - 180 days, ice stops in first decade of May and starts in third decade of October. Average annual precipitation at the area is 760 – 1060 mm, where during warm period there are around 460 – 600 mm, which makes 60% from the annual amount. In summer here are frequent rains in form of shower rains and also rains which have lasting character. During winter snow cover is not stable.

Winds are primary of north-western and north-eastern directions. River valleys have significant impact on the wind direction. In most of cases winds blow along the valleys.

This area obtains mainly mulchy deep gley, gleic and non-gleic light clay-bearing soil, brownfield sod pod, brown mountain forest surface-gleic light clay-bearing soil, brown mountain forest and mulchy-brownfield



deep break stone light clay-bearing soil. As a basis and soil-formation layers are deluvial clay, eluvium-deluvium of Carpathian flysch, ancient eluvium and today eluvium deposits.

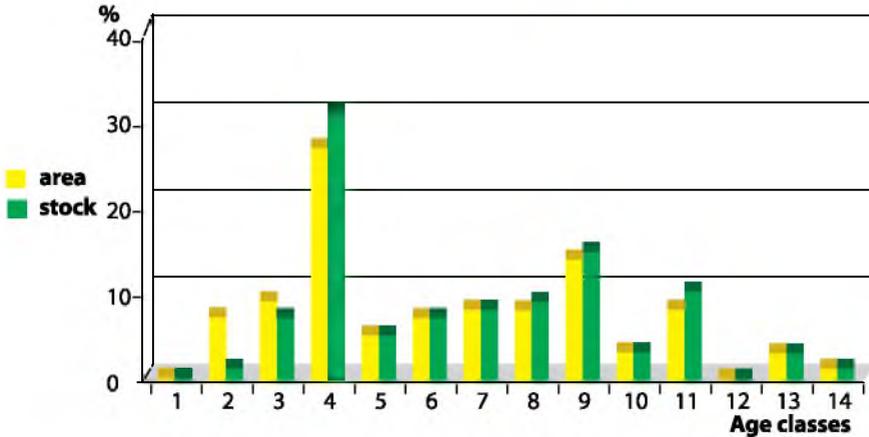
Natural situation

Forest areas of the object are related to marginal low-hill terrains of subregion of Outer Carpathians, forest vegetation area of beech-fir mountain forests of northern megaslope of marginal ridges.

Forest stands are mainly in fir forest types group (183.3 ha), where they form humid beech-spruce semi-fir forests and beech forest types group (96.4 ha), where they form humid spruce-fir semi-beech forests.

Locality, where the educational plot is situated, belongs to the nature protection fund of Ukraine. In compartment #34 and neighbouring compartment ##32, 33, 35, 36, 37 in year 1982 with purpose to disseminate ecological knowledge, preservation of landscape with fir and spruce-beech-fir forests, "Area "Skyt Maniavskyi" forest reserve of national value was established at the area of 356 ha. Besides this, these forest areas fulfill recreation functions, as they are located close to the frequently visited religious center Skyt Maniavskyi. Also they ensure fulfillment of soil protection, water protection and water regulation functions due to situation near Maniavka river.

In this area most of the stands are coniferous, and cover 200.4 ha (69.3%), a little less land is covered with broadleaf stands – 88.8 ha (30.7%). Total growing stock of the stand makes 85.83 thousand m³, average stock – 297 m³/ha, stock in mature and overmature trees – 302 m³/ha. Young stands make 11.1%, premature – 15.0%, mature – 19.8%, overmature – 2.7%. Average age of the stand – 71 year. Distribution of the area and growing stock by classes of age is shown at the chart in picture 1:



Picture 1. Chart of distribution of area and stock by classes of age.

As it is clearly visible at the chart, area and stock of the stand is represented almost in all age groups, although age structure of the stand is uneven: more than a half of the area (51.4%) is covered by middle age stands, as a result of intensive pre-war (1939-1941) and post-war (1945-1967) forest utilization. Figures of the stands of older age, by its area and stock per 1 hectare would have to be higher as well. Such stands, first of all, require intervention by conversion of even-aged forest stands into uneven-aged.



FOREST MANAGEMENT IN THE PAST

In previous audit period forest inventory of the forests of educational sample plot was done using method of age classes and forest management there was carried out based on clear cut system.

Taking into account natural protection status of the forests of educational sample plot, forest inventory, starting from 1978 and until 2013, didn't prescribe any forest management activities, except thinning with up to 15% intensity at the plot #5. Because condition of this stand didn't require any immediate interventions, planned harvesting was not carried out. Besides this, in 1991 this stand entered another age group, which was not an object for thinning anymore, and another types of cuts are forbidden in the reserve in accordance with the statutory document of "Area "Skyt Maniavskiy".

From 1984 to 1996 in stands of educational sample plot only unplanned cleaning of forest stands were carried out, which usually are done after windfalls and harvesting of drying trees, affected by root rot, particularly cleaning of forest and selection of freshly affected by bark beetle trees of European spruce with intensity of selection at the level of 4-6 m³/ha.

Starting in year 1996 damage of the stand by root rot and, as a result, drying of trees, continued to expand and the enterprise was forced to carry out unplanned sanitary harvesting with annual intensity 5-15 m³/ha.

Due to intense drying of spruce and damage of the stand by wind and related above mentioned harvesting and natural drain of spruce along with intensive growth of fir, the stand moved from spruce management section to fir management section.

Technology of the above harvesting was the same in all years: felling of affected trees and wind fallen trees was done with the chainsaw, cutting of branches manually with axes, cutting of trunk into pieces with chainsaws at the loading sites, skidding with caterpillar tractors (harvesting in 2008 and 2013 – with wheel tractors) with horse hauling-in.



Creation in recent years of artificial forest stands without necessary attention to the issue of biological stability and ecological aspects of applied methods of reforestation and conduction of cuts and loss of natural stability due to anthropogenic influence and climatic changes, became a reason of significant degradation of sanitary and pathology condition of forests, decrease of efficiency of fulfillment of environmental, melioration, social and resource functions by forests.

LONG-TERM CONCEPT OF FOREST MANAGEMENT

With the goal to increase stability of stands and not allowing degradation of its condition in future, it is important to reform current priorities and forest regeneration and nursing methods towards close to nature silviculture approaches. When designing and implementation of forest management operations it is important to base on principles of close to nature silviculture, which will ensure formation of high productive mixed, rich by specie composition and complicated by structure forest stands with domination of fir, which is a long-term final goal of planned economic activities. Leading principles of close to nature silviculture in forest stand of educational object are based on selective and group-selective types of cuts in combination with conversion cuts. Special feature of fir forests is its specific character of the forest regeneration process. Biological peculiarity of fir cause successful initial regeneration in groups and biogroups, therefore require conduction of gradual formation of uneven-aged stands. Construction of such complicated uneven-aged stand, where second layer is formed by fir with adding of accompanying species of beech and sycamore maple, requires long time.

Selection for harvesting of separate trees and small groups and biogroups in upper and middle layers will serve as a tool not only for gradual decrease of first layer canopy density and provision of light to the lower layers for growth of young trees of natural regeneration, but also will serve as an activity, which will provide possibility for each separate tree in the stand to reach its optimum. Freeing out the crown by taking out of surrounding, damaged and weakened and more or less economic trees, will allow



increase of increment of the rest of trees and its diameters towards target, which will improve also economic efficiency of the whole stand.

In the stands of the educational object it is needed to conduct integrated nursing harvesting and conversion cuts. In order to reach the goal it is important, by means of selective and group-selective cuts, to lighten (where necessary) undergrowth and regulate microclimate. Taking into account the fact, that broadleaf species are completely absent in the upper layer, it is important to preserve them as much as possible in the lower layer and do all possible for appearance of these species in the undergrowth (especially in subcompartment #5).

For provision of target specie composition, if needed, to conduct introduction of absent species by means of complementary seeding or planting of seedlings or young plants. Artificial regeneration should be only complementary activity in formation of target specie composition, because at the educational object there is enough of uneven-age natural regeneration of fir and spruce.

Tending in young forests is done to create better light conditions around target trees and biogroups by cutting out single undesired species and undergrowth, which suppress development of target trees, and also taking out overgrown multi-collar young trees of main species with bad quality. Tending in undergrowth of lacking species is done to support and protect from possible damage by animals or during harvesting by building of simple fence.

Taking into account absence or small number of undergrowth in separate places and further drying of spruce, in dense biogroups it is important to conduct cutting of drying and weak spruce trees, and also damaged fir trees, by means of single tree or small group harvesting and to create opening for emerging of desired natural regeneration. With purpose to prevent in the newly created openings intensive growing of blackberry, soil sod formation, provocation of windfalls and windbreaks, it is important to form small openings with the size 15x15-20 m. During harvesting it is possible to take out 20-25 m³ of timber, mainly spruce. Cuts should be repeated depending on intensity of drying of spruce. At the same time it is important to assist to natural regeneration and nurse the undergrowth.



In the part of the stand, where it is thinned and where there is a need in good quality undergrowth it is important to cut out dry trees of spruce and damaged trees of fir. Intensity of interventions will depend from volume of drying spruce. Tending in the undergrowth will be the main task in coming years and in future. It is important to form undergrowth in dense biogroups, if needed – to conduct cut of single trees, which prevent growth and development of better target trees, but at the same time it is important to maintain high density of undergrowth in the biogroup. This will ensure high vitality and environmental stability of the biogroups of undergrowth against impact of biotic, abiotic and anthropogenic factors. In next decade biogroups of undergrowth, if needed, would be thinned and converted, defining target trees for further growth in the stand.

Finally, in the process of carrying out economic activities at the educational object, sustainable high productive uneven-age mixed and rich by specie forest stands with the domination of fir in upper layer, well defined second layer also with dominating fir with admixture of spruce, beech, and sycamore maple and undergrowth layer should be formed. The stand should be made out of trees with optimal development of the crown in each of the layer (length of crown more than 2/3 of the height of tree in more than 40% of trees), dense natural regeneration, uneven special location at the area, and with trees of different age. In the stand there should be trees of all growth and development classes.

Economic activities on restoration of forest coens within educational object should be close to natural processes, which are present in natural stands; it is important to carry out economic activities taking into account natural protection status of the area. The first priority is the increase of biological stability of forest stands and its quality of fulfillment of the ecological environmental balance regulation, securing its vitality and qualities, which are especially important in context of climate change, industrial pollution and other negative natural phenomena of the modern age. In the same forest stands of other categories of forests there are even more wide possibilities for use of close to nature silviculture principles.





EXCURSION ROUTE

For the preparation of forestry practitioners to the target-oriented silviculture through the close to nature silviculture approaches, and in order to deliver professional theoretical and practical knowledge on close to nature silviculture, typical for this area forest stands were selected and assigned as educational sample plot MANIAVA, which consists of three educational sites. Forest stands in subcompartments ## 4, 5, 7, 8 and 10 in compartment # 34 were selected for the educational object (see picture 2).



Picture 2. Map of the educational sample plot MANIAVA.

The stand was selected in a way that it will meet main goals and motives of its establishment, - possibility to compare condition of the forest stand before and after harvesting operations done in accordance with close to nature silviculture principles. Educational sites established in subcompartment ##5 and 7. First educational site in subcompartment #7 represents forest stand after harvesting, done in previous decades in order to improve its health conditions and based on close to nature silviculture. Educational site #2 in subcompartment #7 illustrates forest stand before harvesting with trees marked for harvesting, and educational site #3 in



subcompartment #5 is aimed for the practical trainings, there participants of field trainings will have possibility to mark trees for harvesting themselves. Forest stand in this subcompartment is simple by structure and even-age, therefore in order to meet target parameters they need the whole set of activities regarding change of composition and structure.

960 m long educational trail was designed in a way, that visitors will go from one educational site to another. Along the trail there are 6 information boards, which contain all needed information about each site, plot and area in general.

FOREST MANAGEMENT IN STANDS AT THE EXCURSION ROUTE

Stand in subcompartment #7

Located at the altitude 520-595 m a.s.l. at the north-east exposition slope with steepness from 10° to 25°. The forest stand of 4.9 ha belongs to the forest type of humid beech-spruce semi-fir and has a status of "Forests of nature protection, scientific, historic and cultural purpose" – reserve, economic part – forests of nature protection purpose with limited regime of use in mountains. The subcompartment is under regime of limited forest use – special protection forest area at the especially protected parts of reserves. Terrain of the site is uneven.

The stand is of artificial origin, established by planting of forest cultures in 1912. Main specie at the time of establishment was European spruce, not indigenous, but brought from other climatic conditions. Average composition: 80% of European spruce, 20% of white fir. The stand, due to its close proximity to the settlement and relatively easy access, from time to time was affected by human activities. Besides this, spruce was damaged by root rot and drying out. All this brought to the situation, when forest stand became low dense and with domination of fir in the specie composition.

Description of the stand from the previous Forest Management Plan (FMP) for 1998-2008:

Area 5.4 ha, age 97 years, density 0.6, specie composition: White fir 60%,



European spruce 40%, one-layer, average figures: height 27 m, diameter 44 cm, total growing stock 2322 m³, or 430 m³/ha, growth class 1.

Description of the stand from the materials of actual inspection and inventory in 2013:

Area 4.9 ha, age 102 years, density 0.6, specie composition: White fir 80%, European spruce 20%, single beech and sycamore maple of natural origin, about 20% of fir also of natural origin. Average height of fir - 30 m, spruce - 27 m, average diameter of fir - 40 cm, of spruce - 32 cm. Stand density - 0.5, uneven, canopy density - 0.5, growing stock 2430 m³, or 450 m³/ha.

Along the open sites (subcompartments ##49 and 51) and in southern part of the subcompartment, second layer starts to shape in fragments, and is represented mainly by fir with complementary spruce, beech and sycamore maple. At these plots, earlier than in main part of the subcompartment, thinning of the canopy has happened and well-developing undergrowth has emerged. Nowadays natural process of conversion from even-aged simple by shape stand into close to natural forest has started (see picture 3).

Picture 3. Start of formation of second layer.





Undergrowth in the stand is well developed, its composition: fir 50%, spruce 20%, beech 20% and sycamore maple 10%, rarely oak. Average undergrowth age – 10 years. Average height of fir – 1.0 m, other species – 1.5 m; maximal height of undergrowth – 4.5 m, some examples reach 7-8 m. Number of trees – 40 thousand pieces per 1 ha, in more thinned parts number is higher, in more dense – respectively lower; where canopy was thinned long ago undergrowth is of older age and higher.

In northern part of the subcompartment, at the border with subcompartment #5 there is a biogroup with area around 0.1 ha, where all trees were cut due to drying, undergrowth is the densest. In general at the area natural regeneration is successfully developing, undergrowth is reliable.

Undergrowth is not dense, composition: whitebeam - 50%, hazelnut - 20%, raspberry - 20%, blackberry - 10%, rarely honeysuckle and currant. Average age of the undergrowth – 5 years. Average height: whitebeam – 1.5 m, hazelnut – 2.0 m, raspberry – 0.5 m, blackberry – 0.3 m. Density - 0.4.

Continuous drying of spruce is observed, around 5% of spruce trees have signs of drying. As a result of mechanical damages, received during harvesting, about 1% of trees in the stand have trunk rots and fungi. A lot of trees have double or even triple collar due to break of the collar by wind, some trees have broken collar, there is littering with volume of 10 m³/ha present in the stand.

Plan and implementation of economic activities

Forest inventory of 1978 for the period 1978-1988 didn't prescribe any economic activities in the stand. Out of plan, in 1984 forest enterprise has conducted selective sanitary cut with volume of 28 m³ at the area 4.9 ha, - spruce, fallen by wind, was taken out of the stand.

In coming short-term period 1989-1991 forest inventory didn't prescribe any activities, although, due to windfalls, which took place in December 1989 and February 1990, enterprise had carried out number of out-of-plan activities: in 1989 selective sanitary cut, 7 m³ of spruce at the area of 4.9 ha was harvested, in 1990 cleaning from litter with volume of 49 m³ of spruce



timber at the area of 4.9 ha, in 1991 selective sanitary cut, 27 m³ of spruce timber at the area of 4.9 ha was harvested (incl.: 20 m³ – selection of freshly inhabited by trunk invaders spruce trees, 7 m³ – harvesting after windfall).

Unscheduled forest inventory in 1991 didn't prescribe any economic activities as well. In 1993 enterprise has conducted unplanned cleaning from litter with the volume of 30 m³ at the area 4.9 ha, spruce tree, fallen by wind, was taken out of the stand.

In 1996 forest inventory has recorded affect of 8% of the growing forest with root rot, but no activities were prescribed. In coming years root rot affection and, as a result, drying of trees, continued.

During the period 1996-2008 enterprise has carried out number of out-of-plan activities for improvement of health condition of the stand, particularly in years 1997-2003 selective sanitary cuts with intensity 3.5-15 m³ were annually carried out, in total during mentioned years 283 m³ of affected spruce timber was taken out of the stand, and in 2003, 2006-2008 as cleaning from litter, 45 m³ of affected European spruce timber was taken from the stand.

Forest inventory of 2008 for the period 2009-2018 prescribed activities, aimed at cleaning of forest from litter with volume 39 m³. As a result of intensive drying of spruce and damage of the stand by wind, in 2010 enterprise has carried out selective sanitary cut of 20 m³ at the area of 4.9 ha, and in 2011 – also selective sanitary cut of 24 m³ at the area of 4.9 ha. 41 spruce trees and 19 fir trees were prescribed for harvesting in 2011. In total during 1984-2013 selective sanitary cuts and cleaning cuts take out of the stand 513 m³ of affected by wind and invaders timber, primarily of spruce.

As a result of the above mentioned cuts, natural loss of growing spruce and intensive growth of fir, the stand has moved from spruce management section to fir management section.

Technology of the above harvesting was the same in all years: felling of affected trees and wind fallen trees was done with the chainsaw, cutting



of branches manually with axes (during harvesting in 2008 and 2013 – partially with chainsaw), cutting of trunk into pieces with chainsaws at the loading sites, skidding with caterpillar tractors (harvesting in 2008 and 2013 – with wheel tractors) with horse hauling-in.

Comment: As the stand is located at the wind break slope and periodically is damaged by heavy winds and snow breaks, main purpose of the activities, conducted in recent 30 years was to reach needed health conditions with maximal preservation of vitality and functionality of the stand. The stand is rather thin with enough quantity of uneven-age undergrowth of fir, but not enough presence of undergrowth of beech and other valuable species. As intensity of the mentioned harvesting was moderate, it is expected that increment will increase, especially at the fir trees, which grow in more free position and overall stock of the stand, including due to better increment of the trees in lower layer. It is recommended to direct silvicultural activities in future towards harvesting of mature fir and spruce trees, under which there is rather developed lower layer of undergrowth, where process of differentiation and self-thinning takes place.

In the stand there are two educational sites established (two out of three sites of educational sample plot) with the area of 0.49 ha each (square with the sides 70x70 m), where all trees with diameter more than 8 cm and more were recorded with the help of field geoinformation system Field-Map including such data as coordinates of each tree, its diameter, height, volume, horizontal crown projection and its spatial situation. At the educational site, which was divided into squares 10x10 m each, in each squares for trees with diameter more than 8 cm and undergrowth which forms lower layer, species of trees, which are located there, its average height and coverage share was surveyed and recorded.

Established educational sites are aimed at demonstration of forest management activities, including harvesting, based on principles of close to nature silviculture.

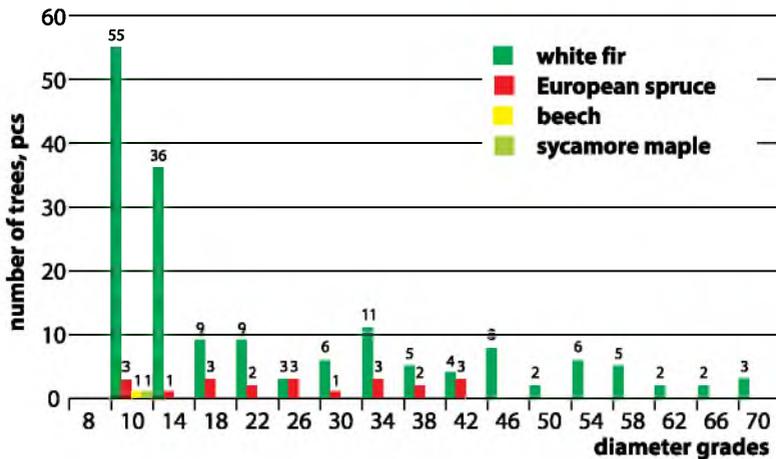
Silvicultural-taxation characteristic of the stand in educational site #1:

At the site 189 growing trees of total volume of 147.2 m³ were measured, out of them 166 trees of white fir (88% of the total number of trees and



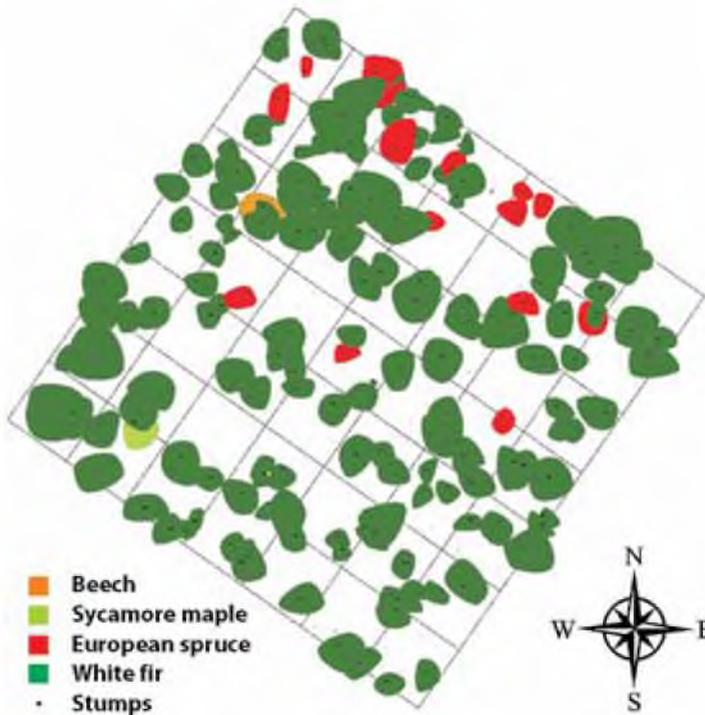
91% of the total volume), 21 tree of European spruce (11% of the total number of trees and 9% of the total volume) and two beech and sycamore maple trees (1% from the total number of trees). Total volume of the growing trees per 1 ha is 300.5 m³. Average trunk volume of growing trees – 0.78 m³, fir 0.8 m³ and spruce 0.64 m³. Growing trees of 10th and 14th diameter grade make 51%, trees of 18-30 diameter grades - 19% and trees of 34-70 diameter grades - 23%. Trees of beech and sycamore maple are present only in 10th diameter grade.

Graphic distribution of the number of trees by tree species and diameter grades is shown in picture 4.



Picture 4. Distribution of trees by species and diameter grades

Spatial situation of trees at the educational site #1 in Field Map Data Collector environment is shown at picture 5.



Picture 5. Spatial situation of trees at the educational site #1.

At the site there is not enough presence of spruce trees in 46th and higher diameter grades due to its intensive drying, also beech, and sycamore maple trees, because earlier forest management system was not aimed at formation of target specie composition and desired structure of the stand. Spruce trees after conducted sanitary cuts stay mainly in lower part of educational site, which borders forest road.

Also with the help of Field-Map special situation of 50 harvested trees was surveyed and recorded. Total volume of harvested trees is 87.6 m³, or 178.7 m³ per 1 ha, out of 50 trees 44 are spruce trees with volume of 62.6 m³ (71.6%) and 6 fir trees with volume of 24.9 m³ (28.4%).



Spatial situation of harvested trees at the educational site #1 in Field Map Data Collector environment is shown at picture 6.



Picture 6. Spatial situation of harvested trees at the educational site #1.

Among harvested trees are: drying, fallen or broken by wind, European spruce and fir trees, mainly growing in the middle part of the educational site. Most of the harvested spruce trees (66%) are within 30-50 diameter grades, and fir trees (12%) in 58-66 diameter grades. Total intensity of harvesting at the site is rather high and makes 37.3%, which is almost 2 times higher from the average intensity of cuts at the whole area of subcompartment. Such intensity in future will directly influence general condition of the stand, number and development of natural regeneration in thinned stand.

General distribution of all trees at the site before harvesting, also of harvested trees, trunk volume and intervention intensity by diameter grades is shown in table 1.



Table 1.

Diameter grade, cm	Total number of trees, pcs.	Number of harvested trees, pcs.	Number of harvested trees, pcs.	Volume of harvested trunks, m ³	Intervention intensity, %
10	60	-	1.321	-	-
14	38	1	3.115	0.082	2.6
18	14	2	2.452	0.352	14.4
22	13	2	4.067	0.626	15.4
26	12	6	5.892	2.988	50.7
30	11	4	7.657	2.792	36.5
34	15	1	14.484	0.972	6.7
38	14	7	18.24	9.17	50.3
42	11	4	18.21	6.72	36.9
46	18	10	37.62	20.9	55.6
50	9	7	23.22	18.06	77.8
54	6	-	18.66	-	-
58	8	3	29.68	11.13	37.5
62	4	2	17.4	8.7	50.0
66	3	1	15.18	5.06	33.3
70	3	-	17.58	-	-
At the area 0.49 ha	239	50	234.78	87.55	37.3
Per 1 ha	488	102	479.14	178.7	37.3

Based on taxation measurements and calculations the following characteristics of the stand of educational site were identified: specie composition: 9 White fir 1 European spruce, rare beech, sycamore maple; average diameter – 29.0 cm; average height – 20.9 m; density – 0.6, thickness – 386 pcs/ha.

At the educational site natural regeneration was counted. Share of coverage by squares is different. In one square, or at 2% of the area of site, natural regeneration is absent. In 5 squares, or at 10% of the site, regeneration of spruce and fir with height up to 130 cm and in one up to 400 cm is present, in 30 squares or at 61% of the site natural regeneration



of fir with height up to 130 and 400 cm is present, and in 9 squares or 18% of the site – regeneration of fir with height up to 130 cm. At 6% of the counted squares regeneration of fir with height up to 400 cm.

Review of the distribution of regeneration by height and share of coverage is shown in table 2.

Table 2.

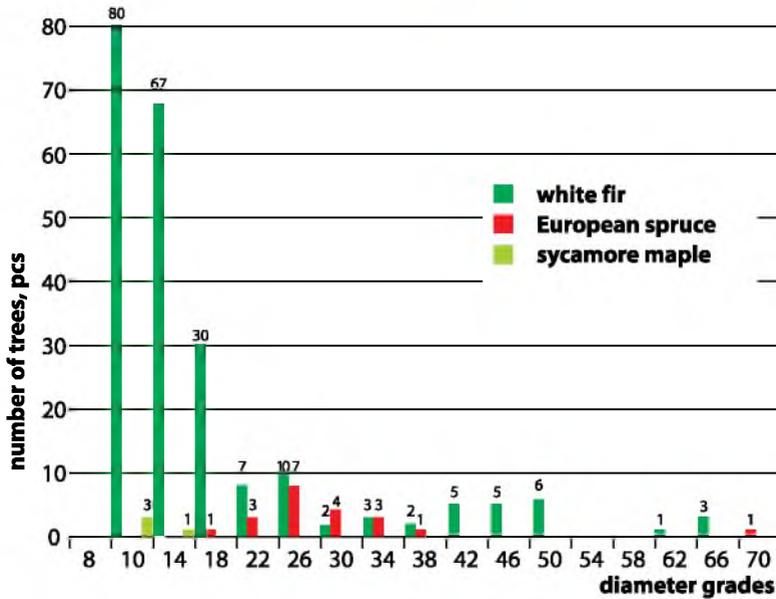
Regeneration height (cm)	Specie	Number of squares	Share in total area (%)	Coverage in squares (%)
Up to 20 cm	White fir, Eur Spruce	6	20	5
Up to 130 cm	White fir, Eur Spruce	44	25	16
Up to 400 cm	White fir, Eur Spruce	36	56	18

Natural regeneration of spruce with height up to 20 cm is present in only one square together with regeneration of fir with height up to 130 and 400 cm, total coverage in the square less than 5%.

Silvicultural-taxation characteristic of the stand in educational site #2:

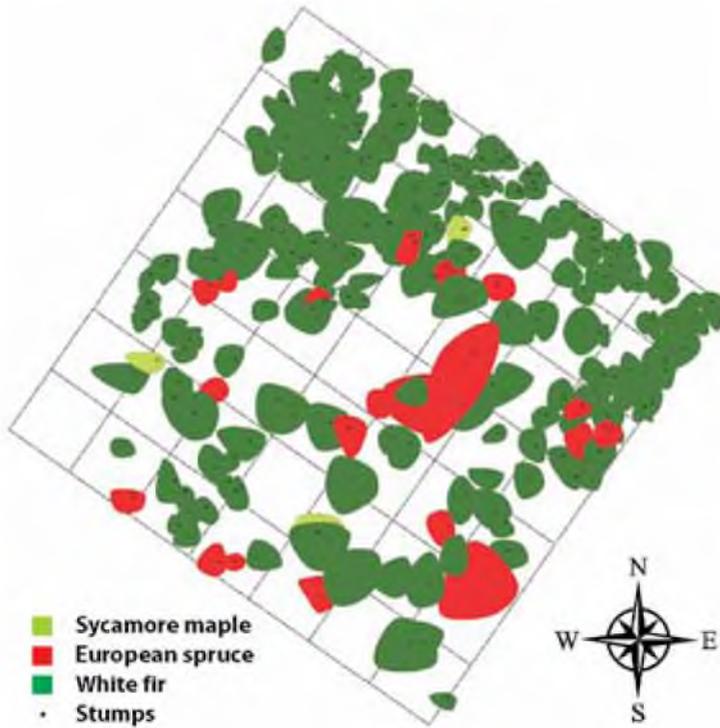
At the site 245 growing trees of total volume of 104.2 m³ were measured, out of them 221 trees of white fir (90.2% of the total number of trees and 80.2% of the total volume), 20 trees of European spruce (8.2% of the total number of trees and 19.6% of the total volume) and 4 sycamore maple trees (1.6% from the total number of trees and 0.2% of the total volume). Total volume of the growing trees per 1 ha is 212.7 m³. Average trunk volume of growing trees – 0.42 m³, fir 0.38 m³ and spruce 1.02 m³. Growing trees of 10th and 14th diameter grade make 62%, trees of 18-30 diameter grades - 26% and trees of 34-70 diameter grades - 12%. Trees of sycamore maple are present only in 10th (3 trees) and 14th (1 tree) diameter grades.

Graphic distribution of the number of trees by tree species and diameter grades is shown in the picture 7.



Picture 7. Distribution of trees by species and diameter grades
at the educational site #2.

Spatial situation of trees at the educational site #2 in Field Map Data Collector environment is shown at picture 8.



Picture 8. Spatial situation of trees at the educational site #2.

At the site there is not enough presence of spruce trees in 10th, 14th and 42nd and higher diameter grades, besides 70th diameter grade, which is presented by one tree. These diameter grades are represented mainly by white fir due to harvesting of intensive drying spruce of higher diameter grades and successful natural regeneration of fir of different age under thinned canopy of the stand and in openings, where spruce was growing before. At this site, the same as at the previous one, earlier forest management system was not aimed at formation of target specie composition and desired structure of the stand. Spruce trees after conducted sanitary cuts are distributed unevenly mainly in central and upper parts of educational site.



Also with the help of Field-Map special situation of 7 trees, marked for harvesting, was surveyed and recorded. Total volume of these trees is 29.34 m³, or 59.9 m³ per 1 ha, 5 out of 7 trees are fir trees with volume of 19.84 m³ (67.6%) and 2 spruce trees with volume of 9.5 m³ (32.4%).

Characteristics of trees, marked for harvesting, are described in table 3.

Table 3.

#	Tree number	Tree specie	Tree diameter, cm	Tree height, m	Comments
1	60	White fir	66.7	38.3	Mature for harvesting
2	72	European spruce	33.0	23.8	Affected
3	79	White fir	68.0	33.7	Mature for harvesting, affected
4	90	European spruce	72.0	34.4	Mature for harvesting
5	143	White fir	61.5	32.3	Mature for harvesting
6	155	White fir	16.0	13.8	Fallen
7	163	White fir	66.3	33.3	Mature for harvesting

Trees, marked for harvesting are affected or stunted trees and mature trees with target diameters. Intervention at the site is set with intensity 29.6%, which is 8% lower comparing to harvesting intensity at the educational site #1, as this stand doesn't require stronger intervention, and slightly dense young trees under the canopy of the stand will thin itself without assistance from the side of foresters.

General distribution of all trees at the site, trees marked for harvesting, trunk volume and intervention intensity by diameter grades is described in table 4.



Table 4.

Diameter grade, cm	Total number of trees, pcs.	Number of harvested trees, pcs.	Volume of all trunks, m ³	Volume of harvested trunks, m ³	Intervention intensity, %
10	83		1.776		
14	68	1	6.456	0.095	1.5
18	31		5.97		
22	10		3.303		
26	17		8.77		
30	6		4.44		
34	6	1	6.06	0.97	16.0
38	3		4.02		
42	5		8.45		
46	5		10.8		
50	6		15.9		
62	1	1	4.3	4.30	100.0
66	3	3	15.45	15.45	100.0
70	1	1	8.53	8.53	100.0
At the area 0.49 ha	245	7	104.2	29.34	29.6
Per 1 ha	500	14	212.7	59.88	29.6

Based on taxation measurements and calculations the following characteristics of the stand of educational site were identified: specie composition: 8 White fir 2 European spruce, rare sycamore maple; average diameter – 22.2 cm; average height – 18.3 m; density – 0.5, stock – 104.2 m³ or 212.7 m³/ha; thickness – 500 pcs/ha.

At the educational site natural regeneration was counted. Share of coverage by squares is different. In one square, or at 2% of the area of site, natural regeneration is absent. In 8 squares, or at 16% of the site, regeneration of spruce and fir with height up to 130 cm and in 7 squares or at 14% of the site - with height up to 400 cm is present. In 36 squares or 73% of the site regeneration of fir with height up to 400 cm is present, and in 28 squares or at 57% of the site regeneration of fir up to 130 cm. At



4% of the counted squares regeneration of fir with height up to 20 cm is present.

Review of the distribution of regeneration by height and share of coverage is shown in table 5.

Table 5.

Regeneration height (cm)	Specie	Number of squares	Share in total area (%)	Coverage in squares (%)
Up to 20 cm	White fir	2	4	5
Up to 130 cm	White fir	28	57	5-15
Up to 400 cm	White fir	36	73	5-35
Up to 130 cm	White fir, Eur Spruce	8	16	5-35
Up to 400 cm	White fir, Eur Spruce	7	14	15-40

At the educational site natural regeneration is present, but it is located unevenly. Particularly natural regeneration of spruce up to 20 cm high is completely absent at the site, and is present only in separate squares only together with regeneration of fir up to 130 cm and 400 cm high. Instead of this regeneration of white fir is present in all height grades. In the dominating number of squares with white fir regeneration height of regeneration is up to 400 cm.

Stand in subcompartment #5

Located at the altitude 520-575 m a.s.l. at the north-east exposition slope with steepness from 10° to 18°. The forest stand of 3.0 ha belongs to the forest type of humid beech-spruce semi-fir and has a status of "Forests of nature protection, scientific, historic and cultural purpose" – reserve, economic part – forests of nature protection purpose with limited regime of use in mountains. The subcompartment is under regime of limited forest use – special protection forest area at the especially protected parts of reserves. Terrain of the site is uneven.

In the northern part of the subcompartment there is very steep slope (up



to 45°) which borders Maniavka river – here one can observe landslides and erosion processes: in two places there were landslides of 0.1 and 0.2 ha of size.

The stand is of artificial origin, established by planting of forest cultures in 1951. Main specie at the time of its establishment, as in the subcompartment #7, was European spruce, not indigenous, but brought from other climatic conditions. Forest cultures were created with the following specie composition: 80% of European spruce, 20% of white fir. As a result of natural processes and human economic activity now fir dominates in the composition of the stand (see picture 9).



Picture 9. Structure of the stand.



Description of the stand from the previous FMP for 1998-2008:

Area 3.4 ha, age 58 years, density 0.7, specie composition: European spruce 80%, White fir 20%, one-layer, average figures: height of spruce - 24 m, diameter - 26 cm, height of fir - 23 m, diameter - 30 cm, total growing stock 1428 m³ or 420 m³/ha, growth class 1a.

Description of the stand from the materials of actual inspection and inventory in 2013:

Area 3.0 ha, average age 63 years, specie composition: White fir 80%, European spruce 20%, roughly 30% of fir is of natural origin. Average height of fir - 26 m, spruce - 24 m, average diameter of fir - 32 cm, spruce - 28 cm. Stand density - 0.6, more or less even, canopy density - 0.7, growing stock 1320 m³ or 440 m³/ha.

Layer of the undergrowth just started to shape, because optimal density of the stand has appeared only recently. Fir dominates in the undergrowth, rarely appears spruce, beech, sycamore maple, and birch.

Average age of the undergrowth is 3 years. Average height of fir - 0.2 m, other special - 0.5 m; maximal height of undergrowth (along the forest line) - 3 m. Number of trees in undergrowth - 30 thousand pieces per 1 ha, satisfactory condition, undergrowth reliable. In the nearest future there is possible emerging of larger number of undergrowth in thinned parts of the stand.

Among undergrowth species there are whitebeam (90%) and raspberry (10%) 3 year old, 0.5 m high, maximal height - 1.5 m. Distribution uneven, density - 0.3.

In the stand, similar to the subcompartment #7, drying of spruce is observed. Dry trees at the subcompartment make about 10 m³, weakened and drying trees - 15 m³, dead timber - up to 15 m³. There are few trees with trunk rot and multi-collarity. The stand fulfills important soil protection and anti-erosion function.

Plan and implementation of economic activities.

Forest inventory of 1978 and 1988 for the periods 1978-1988 and 1989-



1991 prescribed thinning in 2 stages with intensity of selection of 15%. Due to the fact, that prescribed cut was not urgent, and condition of the stand didn't require intervention, enterprise didn't conduct the cut; out-of-plan activities were not carried out as well. In 1991 age for the thinning has ended, and other kinds of cuts were not allowed by the statutory documents of the "Area "Skyt Maniavskyi".

Of out-of-plan activities in period 1991-1996 2 cuts were carried out: in 1992 cleaning of forest from litter at the area 3.0 ha with volume of 23 m³ and in 1995 selection of freshly inhabited by trunk invaders trees at the area of 3.0 ha with volume of 18 m³. Out-of-plan cuts were conducted with purpose to improve health condition of forest stands after windfalls, which took place in December 1989 and February 1990 by means of harvesting spruce trees, fallen by wind and affected by root rot.

In 1996 forest inventory has recorded affection by root rot in 10% of the growing forest, but didn't prescribe any activities. In following years affection by root rot has expanded, and as a result of it, trees continue to dry out. That is why, in order to improve health condition of the forest, in period 1996-2008 enterprise almost annually carried out unplanned selective sanitary cuts with intensity 4-17 m³/ha, in total during these years 260 m³ or 86.6 m³/ha of damaged timber was taken out of the stand.

As a result of sanitary cuts and natural drain of spruce and intensive growth of fir, the stand has moved from spruce management section to fir management section.

Forest inventory of 2008 for the period 2009-2018 due to the condition of the stand, didn't prescribe any economic activities. In 2010 enterprise has carried out unplanned selective sanitary cut with volume of 23 m³ at the area of 3.0 ha. 61 trees of spruce were assigned for harvesting, information on its quantity, diameter, technical value and volume of timber is described in table 6.

In total during 1992-2010 at the stand by means of selective sanitary cuts and cleaning cuts 324 m³ of damaged by wind, invaders and drying spruce trees were harvested, which makes 22% of the timber stock at this plot.



Table 6.

Diameter grade, cm	Specie	Commercial trunks, pcs.	Firewood trunks, pcs.	Total, pcs.
12	European spruce		7	7
16	- " -		11	11
20	- " -	8	17	25
24	- " -	1	4	5
28	- " -	4	3	7
32	- " -	3	2	5
36	- " -			
40	- " -		1	1
Total, pcs.	-	16	45	61
Total volume of timber, m³	-	6	17	23
Average volume of timber, m³	-	0.38	0.29	0.31

Harvesting intensity, which was defined by the level of damage of the stand, was low and made around 2-4%. As a result of the above mentioned cuts, natural drain of spruce and intensive growth of fir, the stand has moved from spruce management section to fir management section.

Technology of the above cuts was the same in all years: felling of grown trees and wind fallen trees was done with the chainsaw, cutting of branches manually with axes and partially with chainsaws, cutting of trunk into pieces with chainsaws at the loading sites, skidding with caterpillar tractors (harvesting in 2008 and 2013 – with wheel tractors) with horse hauling-in.

In the stand there is an educational site established (one out of three sites of educational sample plot) with the area of 0.49 ha (square with the sides 70x70 m), where all trees with diameter more than 8 cm have received individual number and were marked with this number at the breast level. With the help of field geoinformation system Field-Map all trees were surveyed and information about them recorded, including such data as coordinates of each tree, its diameter, height, volume, horizontal crown projection and its spatial situation. At the educational site, which was



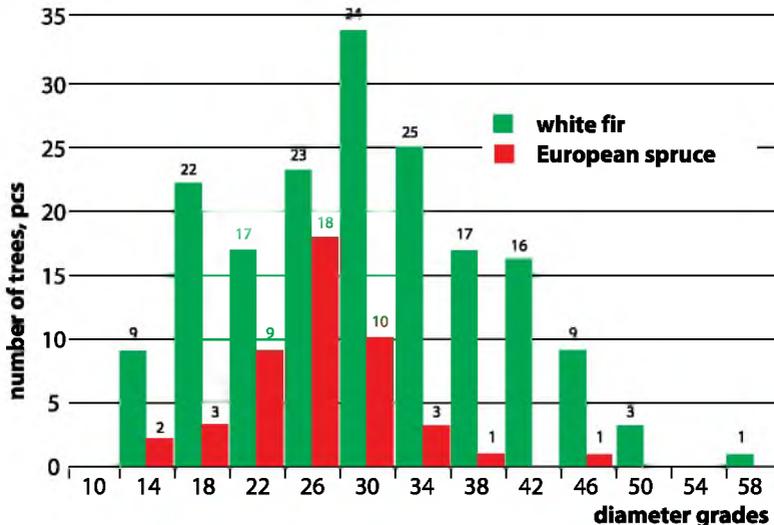
divided into squares 10x10 m each, in each squares for trees with diameter more than 8 cm and undergrowth which forms lower layer, species of trees, which are located there, its average height and coverage share was surveyed and recorded.

Educational site is established in order to carry out practical trainings, during which participants of field trainings will have opportunity for individual work on selection and marking of trees for harvesting in accordance with principles of close to nature silviculture.

Silvicultural-taxation characteristic of the stand in educational site #3:

At the site 223 growing trees of total volume of 203.3 m³ were measured, out of them 176 trees of white fir (79% of the total number of trees and 85% of the total volume), 47 trees of European spruce (21% of the total number of trees and 15% of the total volume). Total volume of the growing trees per 1 ha is 415 m³. Average trunk volume of growing trees – 0.91 m³, fir 0.98 m³ and spruce 0.67 m³. Growing trees of 10th and 14th diameter grade make 5%, trees of 18-30 diameter grades - 61% and trees of 34-58 diameter grades - 4%.

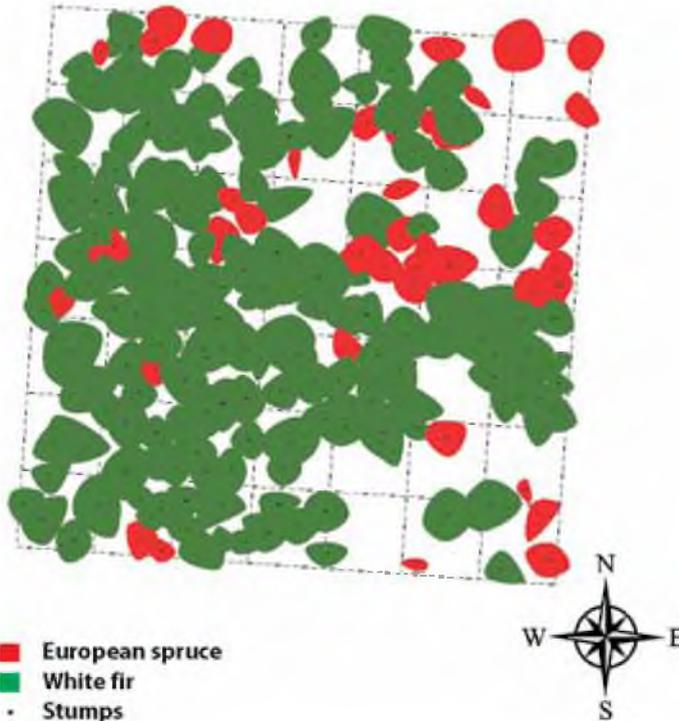
Graphic distribution of the number of trees by tree species and diameter grades is described in the picture 10.



Picture 10. Graphic distribution of the number of trees by tree species and diameter grades at the educational site #3.



Spatial situation of trees at the educational site #3 in Field Map Data Collector environment is shown at picture 11.



Picture 11. Spatial situation of trees at the educational site #3.

At the site spruce trees are present mainly in middle diameter grades – 18-38 and almost absent in 42nd and higher diameter grades, besides one tree in 50th diameter grade, due to its intensive drying and harvesting by selective sanitary cuts. Also at this site trees of beech, sycamore maple and other valuable species are absent, as earlier forest management system was not aimed at formation of target specie composition and desired structure of the stand. Spruce trees after conducted sanitary cuts are present mainly in lower and middle part of educational site, which border neighbouring subcompartment #7.



Based on taxation measurements the following characteristics of the stand identified: specie composition: 8 White fir 2 European spruce; average diameter – 30.6 cm; average height – 21.7 m; density – 0.7, stock – 203.3 m³ or 415 m³/ha; thickness – 455 pcs/ha.

Distribution of total stock and number of trees by diameter grades is described in table 7.

Table 7.

Diameter grade, cm	Total number of trees, pcs	Number of harvested trees, pcs.	Volume of all trunks, m ³	Volume of harvested trunks, m ³	Intervention intensity, %
10					
14	11		1.438		
18	25		5.816		
22	26		10.495		
26	41		24.62		
30	44		37.23		
34	28		31.42		
38	18		26.81		
42	16		29.92		
46	10		23.18		
50	3		8.43		
54	0		0		
58	1		3.99		
At the area 0.49 ha	245		203.3		
Per 1 ha	500		415		

Volumes of diameter grades are in direct correlation link with the number of trunks. Maximal value of stock is in 30th diameter grade due to the fact that there is the largest number of trunks in this diameter grade.



At the educational site in the lower layer there is natural regeneration at different stages of development. Distribution of the undergrowth by height and specie composition is shown in table 8.

Table 8.

Regeneration height (cm)	Specie	Number of squares	Share in total area (%)	Coverage in squares (%)
Up to 20 cm	Fir, beech	49	100	22
Up to 130 cm	Fir, spruce	49	100	26
Up to 400 cm	Fir, beech	6	12	17

Undergrowth with participation of fir and complementary beech and spruce dominates at the site. In all squares there is natural regeneration up to 20 cm high and up to 130 cm high respectively. At the same time presence of high undergrowth up to 4 m high is observed only in 6 squares.

TECHNOLOGY OF HARVESTING

Technological process of harvesting in the stands of educational sample plot was the same in all years. Felling of growing trees and wind fallen trees was done with the chainsaw, cutting of branches and cutting of trunks in pieces (mainly in 3 parts, if needed – in 4 parts) – with chainsaws directly at the felling place, skidding with horses from felling place to the loading sites, located near the road. Technological scheme of harvesting and sequence of works in educational sample plot with use of horse skidding is shown in picture 11.



→ Direction of skidding ● Storage == Forest road - - - Skidding trail

Picture 11. Technological scheme of harvesting
with use of horse skidding.

In recent years, with purpose to provide transport access to forest areas, near sites 5 and 7, forest road was constructed upward the slope, what has created conditions for use of up-to-date environmentally friendly forest machinery, made for operation in mountainous terrains – mobile cable forest transportation cranes (MCC). Use of this machinery eliminates the need of construction of in-land forest roads and skidding trails, which result in erosion of land. Besides this skidding trails ruins natural regeneration.

Technological scheme of harvesting with use of cable cranes shown at the picture 12.



→ Direction of skidding ● Storage == Forest road - - - Skidding trail

Picture 12. Technological scheme of harvesting with
use of cable skidding



One of the cable cranes, which could be used at the educational sample plot area is short-distance mobile cable crane MOZ-300. Technical characteristics of MCC: operational length – up to 250 m, pulling force 3.5-8.5 t, lifting capacity up to 3 t, needed capacity - 60 kVt, height of pole – 6 m, speed of cable transportation – 2-4 m/sec, weight of crane – 2700 kg, skidding method – upwards and downwards the slope.

ECONOMIC COMPARISON OF STANDARD FOREST MANAGEMENT ACTIVITIES WITH PROCEDURES OF CLOSE TO NATURE SILVICULTURE

At the examples of stands in subcompartments ##5 and 7 economic comparison of labour costs at each stage of forest harvesting works – felling, cutting of branches, cutting of trunk into pieces (at the felling place or at the forest loading place), skidding of logs to the loading site and warehouse works, and also general costs for the whole set of forest harvesting works was done. Main and additional salary was taken as a basis. For calculations the following three model options were used:

- option 1 – use of standard method;
- option 2 – implementation of forest harvesting works with requirements of close to nature silviculture (CTN);
- option 3 – implementation of harvesting works with use of mobile cable crane and according to requirements of CTN.

For the first two options the following technological process is foreseen: felling of trees with chainsaw, cutting of branches and knots and cutting trunk into parts with chainsaw, skidding of logs to the loading site and its storage with the help of horse transport. For third option the following technological process was taken as a basis: felling of trees with chainsaw, cutting of branches and knots with chainsaw, skidding of logs to the loading site with cable crane, cutting trunks into parts with chainsaw and storage for further transportation. Calculation was done using current norms of work taking into account average volume of trunk, volume of



harvested timber per 1 ha, average skidding distance for some species, which were harvested, and also valid wages and labour costs in mountain conditions. For first two options initial figures for calculation were taken for the same technologies and natural production conditions. For the third option much smaller distance of skidding was taken as a basis, which is typical for work of short distance mobile cable cranes. Results of the calculation are presented in table 9. Calculation took into account differences in harvesting activities with use of traditional technological processes, and processes where close to nature silviculture approaches are used, which significantly influence price value. Above mentioned differences are divided into standard or those, which are applied for both methods of harvesting (e.g. slope, barriers, pulling cable against the slope, natural conditions) and costs, typical for close to nature silviculture. These costs are related with more difficult practicability of the terrain during harvesting regarding presence and need in preservation of lower layer both during harvesting and skidding. Besides this, trees or groups of trees, assigned for harvesting, are distributed in the stand. It is needed to find them and bring the cable there. Also it was taken into account, that in order to preserve standing trees from damage, during the skidding it is important to conduct certain manipulations with logs or trunks. Such additional costs, but in different values, are foreseen for all above mentioned model options (see table 10). Additional costs (extra payment) of harvesting include cutting of trunk into two or more parts, what is often done during selective cuts with use of horse transport and what decrease length and initial volume of trunk several times. This eliminates risk of damage to the standing trees while transporting harvested timber.

Name		Unit	Model costs within different harvesting methods		
			Standard method <i>(option 1)</i>	With use of CTN <i>(option 2)</i>	With use of mobile cable crane and CTN <i>(option 3)</i>
			Specie	Specie	Specie
			Spruce, fir	Spruce, fir	Spruce, fir
Volume of harvesting		m ³	283	283	283
Average trunk volume		m ³ /pcs	1.75	1.75	1.75
Harvesting	Norm of time need	Norm. hour/m ³	0.67	0.67	0.50
	Additional costs <i>(extra)</i>	%	14	29	29
	– standard method*	%	14	14	14
	– CTN**	%	0	15	15
	Need in time	Norm. hour	216.2	244.6	182.5
	Salary rate	UAH/ norm. hour	18.06	18.06	18.06
	Labour cost	UAH	3904.57	4417.48	3295.95
Cost per unit		UAH /m ³	13.80	15.61	11.65
Number of pieces		pcs	3	3	0
Skidding distance		m	410	410	140
Skidding	Norm of time need	Norm. hour/m ³	1.35	1.35	0.22
	Additional costs <i>(extra)</i>	%	54.5	62	82
	– standard method*	%	42	42	42
	– CTN**	%	12.5	20	40
	Need in time	Norm. hour	590.3	618.9	113.3
	Salary rate	UAH/ norm. hour	13.78	13.78	16.58
	Labour cost	UAH	8134.33	8528.44	1878.51
Cost per unit		UAH /m ³	28.74	30.14	6.64
Storing	Norm of time need	Norm. hour/m ³	0.10	0.10	0.37
	Additional costs <i>(extra)</i>	%	4	4	4
	Need in time	Norm. hour	29.4	29.4	108.9
	Salary rate	UAH/ norm. hour	13.78	13.78	16.58
	Labour cost	UAH	405.13	405.13	1805.56
Cost per unit		UAH /m ³	1.43	1.43	6.38
Total	Total costs for labour force	UAH	12444.03	13351.05	6980.02
	Average costs	UAH /m ³	43.97	47.18	24.67



Table 9. Calculation of model costs within different harvesting methods.

Notes:

* standard costs are used in all harvesting methods (slope, ..., locality, pulling of cable etc.)

**additional costs are more often used within CTN method, but also happen during standard forest management.

Table 10. Additional costs within methods of close to nature silviculture

Name of factors, which cause additional costs		Size of additional costs, %		
		Option 1	Option 2	Option 3
Felling	1. Work in the stand with undergrowth 75 cm high and more	0	7.5	7.5
	2. Cutting of trunk into two and more parts	0	7.5	7.5
	Total	0	15	15
Skidding	1. Work in the stand with undergrowth 75 cm high and more or work in 2-layer stand	0	2.5	2.5
	2. Work with special barriers, pulling or pushing trunks or logs	2.5	7.5	7.5
	3. Search of trees during selective harvesting	10	10	10
	4. Pulling out the cable during transport of trunks or logs for certain distance	0	0	20
	Total	12.5	20	40

Analysis of conducted calculations show that cost of labour in first two options is higher for second option, meaning when CTN principles are applied. Difference in labour cost is not more than 10%. In this case increase of labour cost in case of use of close to nature silviculture principles is observed only during harvesting and skidding of logs. This is related to the above mentioned aspects of works done, which influence the price.

Lower costs of works of harvesting and transportation and higher costs of storage works is typical for the third option. Lower costs of harvesting are explained by absence of such work as cutting of trunk into parts. Lower cost of skidding related with much shorter (more than three times) skidding distance. Higher cost of storage works is explained by the need



of transportation of trunks from the cable crane way, its shortening and storage. Total cost of work is also lower than in first two options.

It is important to point out, that this calculation do not take into account costs of equipment purchase. Although long-term use of close to nature silviculture results with decrease of labour costs related to the possibility to harvest more volumetric trees (trees are harvested selectively after reaching optimal maturity (target diameter), and also significant decrease of need in cost demanding tending activities (nursing of cultures and young forest).

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Excursion guide for the close to nature silviculture site

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The background is a solid light beige color. It features several large, white, stylized geometric shapes that resemble folded paper or abstract architectural elements. One shape is in the top left corner, another is in the middle right, and a larger, more complex one is in the bottom right. These shapes have sharp corners and overlapping edges, creating a sense of depth and movement.

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