Long term forest management planning in Ukraine

- A case study

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Swedish University of Agricultural Sciences
Master Thesis no. 155
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ABSTRACT

The forest sector of Ukraine has big potential for future development. But to follow present economic trends long perspective planning should be introduced into forest management. There are a lot of computer models that make integration and comparing long term scenarios for forest development possible. Unfortunately, they are not implemented in Ukraine.

The aims of this study were to apply fundamentals of strategic planning using a computer model landscape simulator in a forest estate example and to show how different management programs, road network expansion and timber hauling method can affect harvest and standing volume.

The study area was Nyzhnobystrivske forest estate, situated in the central part of Ukrainian Carpathians. Thirteen scenarios of development within 4 management programs were suggested for the estate. Each of scenarios depended of hauling method and road network situation.

The results showed harvest and standing volume depend on management program, hauling method and road situation. Within management programs, the highest indexes showed no clear cuts type for both standing and harvest volume. The highest harvest volume was in the case of an improved road network, and the lowest volume in hauling with cable setting. Standing volume showed an opposite trend. The highest volume found when hauling with cable setting, and the lowest for improved road network.

Evaluated landscape simulator model could be used for future long term forest modelling and received results in acceptance of management decisions.

Keywords: long term planning, landscape simulator, management programs, scenarios of development, forest road network, harvest volume, standing volume.

РЕФЕРАТ

Лісогосподарський сектор України має великий потенціал для майбутнього розвитку. Але для того, щоб відповідати сучасним економічним трендам, у лісову галузь необхідно впроваджувати планування на віддалену перспективу. Розроблено багато комп'ютерних моделей, які дозволяють інтегрувати та порівняти довгострокові сценарії розвитку лісового господарства. Нажаль, вони не знайшли застосування в Україні.

Отже, метою дослідження було впровадити основи стратегічного планування, використовуючи комп'ютерну модель Landscape simulator на прикладі окремого лісництва і показати, як різні програми управління, розширення лісотранспортної мережі та методи трелювання деревини впливають на обсяг заготівлі та запас.

В ролі дослідної ділянки було обрано Нижньобистрівське лісництво, яке розташоване в центральній частині Українських Карпат. Для лісництва було запропоновано 13 сценаріїв розвитку в межах 4-х програм управління. Кожен з сценаріїв залежав від способу трелювання та стану лісотранспортної мережі.

Результати виявили залежність обсягу заготівлі та запасу від програми управління, способу трелювання та стану лісотранспортної мережі. Серед програм управління найвищі показники спостерігали для програми, що виключала суцільно-лісосічні рубки як для обсягу заготівлі, так і для запасу; найбільший обсяг заготівлі спостерігали у випадку удосконаленої транспортної мережі, найменший – у випадку трелювання канатною установкою; запас же навпаки – найбільший у випадку трелювання канатною установкою, найменший для удосконаленої мережі.

Адаптована модель Landscape simulator може бути використана для подальшого планування на віддалену перспективу, а отримані результати - для прийняття управлінських рішень.

Ключові слова: планування на віддалену перспективу, landscape simulator, програми управління, сценарії розвитку, лісотранспортна мережа, обсяг заготівлі, запас.

CONTENTS

1. INTRODUCTION

After the collapse of the USSR most Ukrainian forest enterprises were not ready for fast changes in the market situation. In these conditions the main question was how to survive, and questions about long perspective planning were not so important. The experience of foreign countries shows that enterprises which chose the right position due to all their possibilities (that is putt into practice strategical planning) have an advantage on the market.

To consider the importance of forest resources in Ukraine, long-term planning in forestry sector is necessary. According to Kolisnyk, the necessity of new planning methods in Ukrainian forestry was supported by a number of scientists. But still the main question about the mechanism of strategical planning is in discussion.

Effective planning in the forestry sector should enclose at least one rotation period. Many computer models make comparing the long term scenarios for forest development possible. Unfortunately they are not implemented in Ukrainian forestry. That is why forecast and analysis of long term dynamics in the forest sector is a very important question (Poliakova et al., 2001).

1.1. Planning in the forestry sector of Ukraine and it potential possibilities

Main principles and state level problems. All forests in Ukraine are owned by the state. Sixty-eight percent of them belong to the State Committee of Forestry, which is the main authority in forest and game management. The rest are owned by other ministries. The State Committee has the following hierarchical structure: Regional forestry and hunting enterprises, State enterprises and forest estates (State Forest Committee of Ukraine).

Forest management in Ukraine is an important state action that considers organization and planning (Murahtanov at al., 1993). It is based on forest resource use such as wood and non-wood products, as well as: conservation, protection and social functions (Tsuryk, 2003).

Forest inventory and forest management planning is realized by the State organization “Ukrderzhlisproekt”. This organization cares about following all rules and instructions (Tsuryk, 2003). Long-term planning for “Ukrderzhlisproekt” is planning of the management activity for 10 year periods. The main strategic backgrounds for all these plans are allowed annual cut level that cannot be higher then mean annual increment and afforestation with native tree species. Ten-year plans should be strict followed and any changes on the operational level not preferable. As example, due to such a plan, timber that doesn’t have current demand on the market can be felled. So, planning system in Ukraine is not flexible or adapted to the market economy. There is also need to develop the next trends on the national level: National forest inventory and elaboration of ecosystem and assortment models (Ukrainian-Swedish project, 2001-2004).

Enterprise (estate) level problems. Due to particularities in forest management planning described above, the problems of enterprise and estate levels are (Ukrainian-Swedish project, 2001-2004; Kolisnyk; Forza project):

- Enterprise (estate) executes plan elaborated by "Ukrderzhlisproekt" and usually cannot change it;
- Enterprise (estate) cannot plan according to law independently to increase its profit;
- Enterprise (estate) has no tools (computers, programs) for planning and personnel does not have proper skills;
- Enterprise (estate) doesn't do strategic planning and it's oriented on outdated approaches;
- Planning here is focused on current problems' solution. It leads to problems in production structure and ineffective use of potential;
- Planning doesn't include local public opinion.

Potential possibilities of sustainable development in Ukrainian forestry sector. Ukraine has a huge potential in the forest sector. Solving problems in forestry planning can increase the main economical and social indexes. According to Information about Forestry Sector in Ukraine, Its State and Possibilities (2006), it has considerable potential to increase contribution to the national economy by increasing harvest volume, using economic and social benefits and trading in quotas of emission greenhouse gases etc.

Consequently, Ukrainian forest sector has a big potential for future development. But there has been almost no change since Soviet times, and the National economy cannot follow present trends (Nordberg, 2007). Changes are needed and changes in forest management planning are no exception.

1.2.Forest road network in Ukraine

General characteristic. Very often scientists connect the effective use of forest resources with the forest road network situation. This question is one of the most discussed concerning sustainable forest development.

"Ukrderzhlisproekt" institution is responsible for all kinds of work connected to planning in forestry including the forest road network projects (State Forest Committee of Ukraine). Building of the roads usually could be done by some private or state organization that should follow the project made by the institution.

According to statistical data, total length of roads in Ukrainian forests is 74 400 km. Approximately 17 000 km of it are roads of common use. The density of the forest road network is 10.1 m/ha. Excluding roads of common use, the density falls to 7.8 m/ha (Prystaia, 2008). But still those indexes differ in different parts of Ukraine. In the mountain region density is 3.5-6 m/ha. The average density of forest road network in Ukrainian Carpathians is 2-6 times lower compared to other European countries with the same geomorphologic conditions. Over half of forest roads have a width lower than it should be according to normative indexes. Asphalt or gravel as cover of the road is uncommon; 85% of forest roads are built without any cover. Over 40% of it needs repair (Styranivskyi et al., 2009).

These problems are critical for Ukrainian Carpathian Mountains. Sections of these roads have double the slope compared to standards. Almost all of them are built through valleys or along river beds and are often destroyed during floods (Styranivskyi et al., 2009). So, the forest road network in Ukraine (especially in mountains region) is characterized by an unsatisfactory technical state that doesn't promote effective use. Poor roads causes decreased harvest level, worsening of social and hygienic labour conditions, use of archaic transport technique and rising problems with afforestation, fire safety, forest protection, recreational use etc.

Main fundamentals in the forest road network planning. Creation of local forest road network is influenced by many factors (Chertov et al., 1994; Picman, Pentec, 2006; Potocnik, 1998):

- Natural conditions – geomorphologic, soil and climate;
- Present road network and its parameters;
- Forest management – harvest volume, terms of forest operations, technology and parameters of harvest and transport technique;
- Nature protection fundamentals – presence of protected areas, fire safety etc.;
- Social needs – public, tourists and recreational needs, agriculture, hunting;
- Standards – technical requirements for forest road projects.

Creation of a forest road network is a multilevel task that goes through regional, enterprise and estate levels (Gladkov et al., 1994).

Future forest road networks should be investigated from spatial, time and functional dimensions (Hruza et al., 2000).

1.3. Ways to increase effectiveness of transporting operations

The effectiveness of timber transporting operations depends not only on the road network situation, but also on hauling method. Presently, the most common hauling method in Ukraine is hauling with tractor. But cable setting is another technique that can be used to haul timber especially in mountain regions. It's also possible to combine these two methods. Both techniques should be analyzed from the economic and ecological perspectives in order to increase transport operation effectiveness.

Economic perspective. Over 20% of all cost of round timber comes from transportation (wood and operatives transporting) (Styranivskyi et al., 2009). According to Korzhov research (1994), a four times increase of road density (from 5 m/ha to 20 m/ha) will increase production by 60%, amount of realizable timber by 30% and decrease hauling cost by 70%. So, improvement of road network will increase functioning effectiveness of forest estate. In particular it will decrease the cost of initial wood transport and increase harvest volume and working efficiency. But forest category (production forest, protection forest etc.) should be taken to into consideration when increasing road density. Only then estate will get the best economic benefits (Demir, Hasdemir, 2005; Demir, 2006).

The economic efficiency is also affected by hauling method. Each of these methods needs different investments and has different hauling costs in different natural conditions (Styranivskyi, 2009).

Ecological perspective. From an ecological point of view, the forest road network of Ukraine has a lot of problems with its condition and accordance with standards. This influences sustainable management in forestry sector, and improvements of the present road situation can positively affect sustainable issues and reduce soil erosion in areas where roads are in bad state or without cover (Styranivskyi, 2009).

Different hauling methods have different ecological effects. Hauling with tractor is the main reason for soil erosion. The average soil erosion volume is 240-260 m^3/ha. In mountain conditions, over 8% of haul tracks on the felling area increase soil erosion to 500 m^3/ha. In general, haul tracks account for 70% of total soil erosion on the felling area (Parpan et al., 1988; Gordienko, 1995). It depends on felling area length, slope, cover and atmospheric precipitation (Byblyuk et al., 2005, 2008; Owende et al.; FAO, 1998; Rice, Sherbin). Another negative ecological effect consists of the high sediment yield to streams that has a strong influence on water quality and aquatic life (Binkley, Brown, 1993; Forman, Alexander, 1998; McClelland et al., 1999; Grace, 2002). Negative issues like unsafe trafficking, air and noise pollution, flora and fauna degradation should also be noted (Jaarsma, 1994, 1997; Jaarsma, Van Langevekle, 1996). Cable setting decreases soil erosion 5-7 times (Gumen, 1986; Kalutskyi et al., 1973; Sabadyr, Korzhov, 2005), leaving 81.4% of felling area unharmed. Cable setting use ensures the lowest soil erosion volume – 21 m^3/ha (Korzhov et al., 2006).

2. AIMS OF THE STUDY

Concerning the present situation in forest sector of Ukraine, I decided to try to introduce new fundamentals into forest management planning, stress the weakness in it and show possible ways to increase efficiency of the sector. The aims of the research are:

- ✓ To illustrate possible way of strategic forest management planning in Nyzhnobystrivske forest estate of State Enterprise “Khust forest research holding” example;
- ✓ To suggest possible management programs and answer: how do they affect the harvest and standing volume?
- ✓ To show possible ways to increase harvest volume in road network expansion and use of different hauling methods example and to answer the following questions:
  - How do harvest and standing volume depend on road network expansion and hauling methods?
  - How much additional volume could be harvested using different scenarios?

3. MATERIALS AND METHODS

3.1. Short characteristic of the study area

Accordingly to The Project of Organization and Development (2007), Nyzhnobystrivske forest estate of State Enterprise “Khust forest research holding” is situated in the central part of Zakarpatia region in Ukraine. It’s a mostly forested area located in the middle part of the Ukrainian Carpathians Mountains. Populated areas and agricultural lands are also situated there. The total area of estate is 4872 ha (see Appendix 1).

Climate. The climate is temperate continental. The average annual temperature is +8.8°C, annual precipitation is 1090 mm and mean annual humidity is 78%. The forest growth here is strongly affected by light frosts and floods.

Forest fund. Corresponding to the forest division on categories in Ukraine (2007), forests are divided into: environmental protection, scientific and history-cultural purpose forests, recreational-health forests, protective forests and exploitation forests. Due to this classification, 49.2% of the forest area in Nyzhnobystrivske estate is exploitation forests, rest of the area is protective forests with management. Non-forest land (tillage, pastures, rivers, houses etc) occupy 11.6% of the total area. Forests here are dominated with middle age stands, a result of high harvest level during the Second World War (see *Figure 3.1*). Current annual increment for forest lands is 4.2 m^3 per ha and standing volume is 293 m^3 per ha in average (see *Figures 3.2 and 3.3*). The dominant tree species of estate is beech (85.3%). Planted spruce forests occupy 7.2% of forest area. Hornbeam, oak, ash, alder, maple and others species also grow here (see *Figure 3.4*).

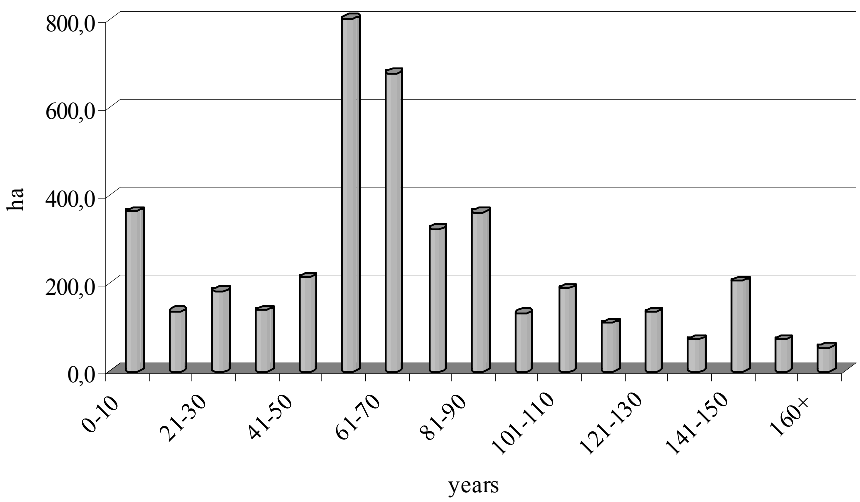


Figure 3.1. Present age class distribution

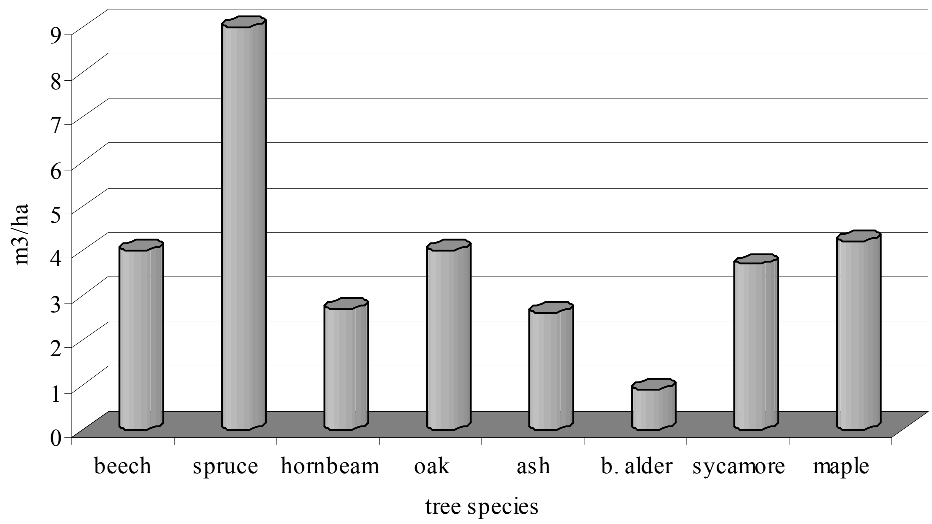


Figure 3.2. Current annual increment

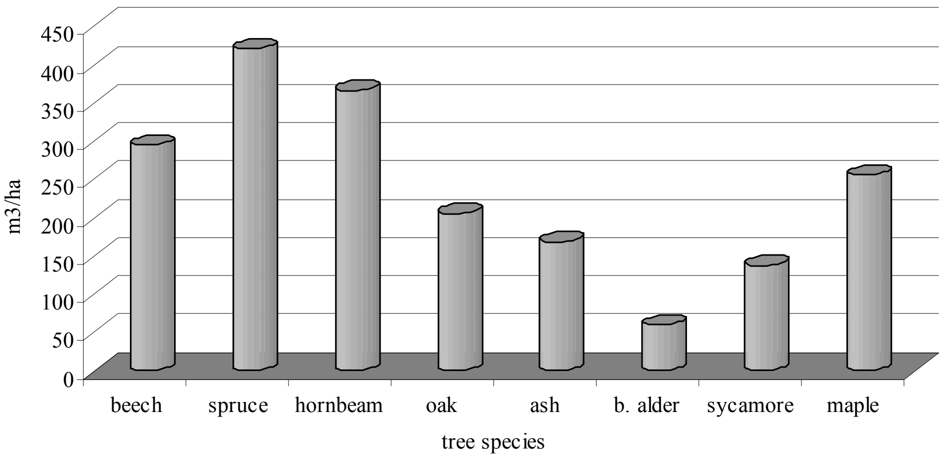


Figure 3.3. Present standing volume

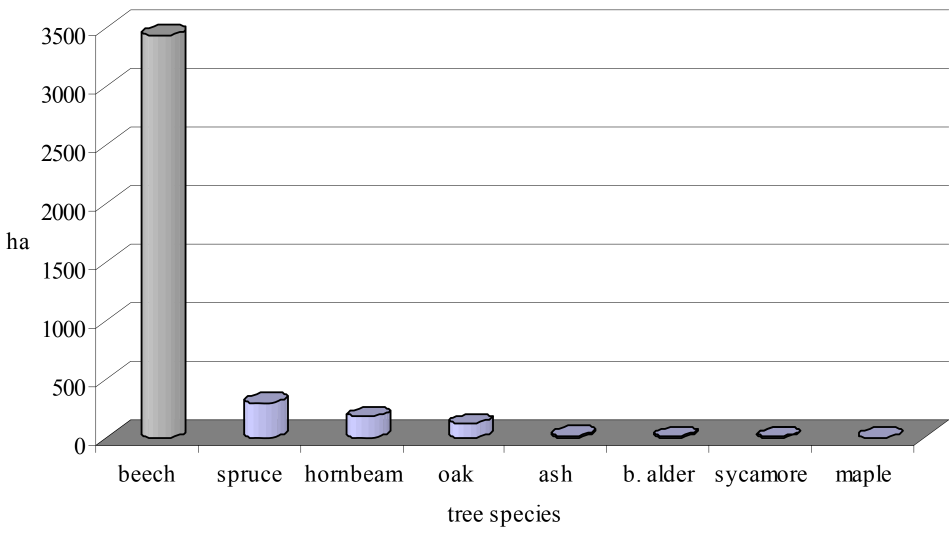


Figure 3.4. Present tree species composition

Forest road network. Nyzhnobystrivske forest estate is situated in the district with a low developed road network. There are 10 automobile roads of common use which are covered by asphalt or gravel and 18 hauling roads without any cover that are used only for hauling timber. The total lengths are 14.58 km and 9.02 km, respectively. Only 58.1% of automobile roads are inside the forest estate area. The roads here are in very bad technical condition, and only 42% are suitable for use (see Appendix 2).

Forest management activities. The average annual harvest volume in Nyzhnobystrivske forest estate is 2 m^3 per ha. To improve quality and productivity of the stands, the estate does forming and sanitation cuttings. Annually they occupy an area of 110 ha in average. Due to the soil conditions, Nyzhnobystrivske forest estate lands have successful natural regeneration of beech, but still the primary way to afforest lands here is to plant seedlings. The estate is characterized with good sanitary condition. The main disease is root rot in spruce forests. Non-forest products (hay, berries, mushrooms, herbs etc.) are used by local inhabitants for personal needs. The forest estate doesn't use the area for hunting. The main activity here is harvesting timber from final felling.

3.2. Landscape simulator

The landscape simulator LANDSIM is the computer program created in the Swedish University of Agricultural Sciences which simulates the development of every land-unit controlled by a specified management program. The development of each individual area is projected as a result of management applied for the treatment unit. The simulation periods in this case are 5-years periods. Forest land areas are projected using the growth simulator from the SMAC-model (Sallnas, 1990), which allows for handling three management activities: final felling, thinning and no activity. In general, the program is used for long perspective planning in the forestry sector.

Importing landscape information. To work with the landscape simulator the following information represented in areas and describing the initial state of the landscape is needed: land use, volume, age, site quality and species composition. Each of those variables is divided into a number of classes. For age there are 33 age classes with 5-years periods (1st class – 0 years, 2nd class – 1-5 years, … , 33rd class – more then160 years). There are 8 species classes for different tree species or groups of tree species and 4 site quality classes that are different for 4 regions. There are also 10 volume classes which depend of site class (Sallnas, Anderson, 2009).

Also information that describes non-forest lands such as agricultural land, pastures, water, bogs etc.; which estate the treatment units belong to and which treatment unit the areas belong to is needed. This gives a possibility to collect all 25×25 m areas together and get general picture of the estate.

Output variables from the Landscape simulator. The results from a projection of forest development are compiled and presented in one map (for volume and land use classes) and 6 different tables:

- Harvest - harvested volumes and areas divided on estate, period, treatment and tree species class;
- Standing Volume – volume at the end of period divided on estate, period and species class;
- Tree Species Class – area of different tree species classes divided on estate and period;
- Age Class – area of age classes (5 years) divided on estate and period.
- Age Class Area – area of age classes (5 years) divided on estate, period and tree species class;
- Age Class Volume – standing volume in age classes (5 years) divided on estate, period and tree species class.

General work scheme in Landscape simulator is shown in *Figure 3.5.*

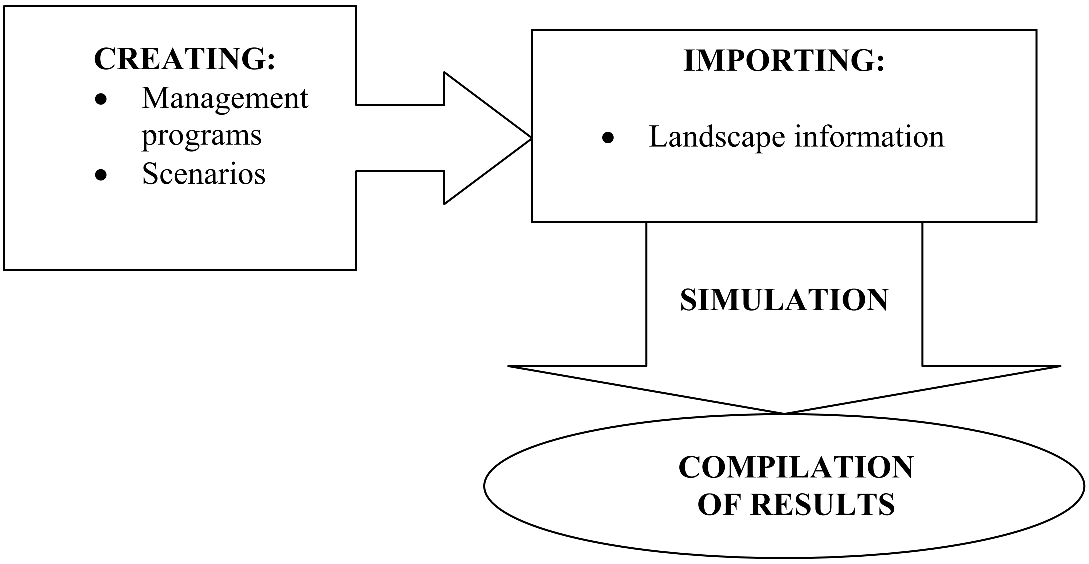


Figure3.5. General work scheme in Landscape simulator

3.3. Ukrainian data base adaptation to Landscape simulator

Initial data to work in Landscape simulator were Nyzhnobystrivske forest estate's GIS data set with maps in vector format (Ukrderzhlispoekt, 2008). To use that data in landscape simulator variables should be first classified (Sallnas, 1990) and then converted into raster format.

Age was divided into 33 five-year periods due to previous classification.

Tree species classes were divided into 8 classes due to main tree species on the plot: 1st class – beech, 2nd – spruce, 3rd – oak, 4th – hornbeam, 5th – sycamore, 6th – ash, 7th – black alder and 8th – maple.

To make a division on 4 site classes, a definition of region was made. For that bonitet scales that indicate site quality in Ukrainian forests and depend on age, high and parentage (natural or vegetative) were converted to potential mean increment. Due to the highest mean increment for main tree species in the estate (for beech) the most suitable region in model was chosen. So, site classes were separated like this: 1st class - <5 m^3/ha, 2nd – 5-7 m^3/ha, 3rd – 7-9 m^3/ha and 4th - >9 m^3/ha (Sallnas, 1990).

Volume classes depended on site classes (see *Table 3.1*). They were classified according to classes described in A Matrix growth model (Sallnas, 1990).

Table 3.1. Volume classes' definition

Volume class (upper limit), m^3/ha	Site class			
	1	2	3	4
1	30	35	40	45
2	45	57	67	78
3	63	85	103	123
4	86	122	151	185
5	114	169	213	262
6	147	225	284	349
7	187	289	363	442
8	231	358	446	540
9	280	432	533	645
10	>280	>432	>533	>645

3.4. Creating of management programs and scenarios

Management programs. A management program is a set of rules for how a treatment unit should be managed in the landscape simulator. According to Ukrainian laws, rules and traditions in forestry (especially in mountain region) the recommended management programs were:

- Standard. The lowest legal age for final felling according to the Forestry Act was chosen. The minimum age for final felling is 101 years for beech, spruce, oak and sycamore; 71 years for ash and maple; 61 years for black alder and 51 years for hornbeam (Mazepa, Terelia, 2008). It was decided to start commercial thinning at age 41 years for beech, oak and sycamore; at age 36 years for ash, black alder and maple; at age 26 years for spruce; and at age 21 years for hornbeam. Standard management programs expect that after clear cut the same tree species will be planted. Exceptions are hornbeam, ash and maple plots. They will plant oak instead.

- Standard with conversion. The program is the same as the standard. The difference is that spruce plots will be planted with beech after final felling.
- No clear cuts. This management program expects only thinning. The start age for treatments here is the same as in the standard and standard with conversion programs.
- No management. This kind of management excludes any activity in forest concerning timber harvest operations.

Scenarios. A scenario is a set of rules how special management program for each of treatment units should be chosen. Management scenarios were created in a GIS software using the shp-dataset (the information about management scenario was stored and saved in the dbf-files together with all other attributes of the polygons and imported to landscape simulator).

All scenarios took into consideration the rules of final felling in the Ukrainian Carpathian Mountains forests (2008). The main characteristics for choosing a special kind of management on a specific plot was its transport accessibility (possibility to get plot for harvest operations) and hauling method. For transport accessibility I used the present forest road network and project of improved forest road network where all forest lands are accessible for harvest operations and do not depend of the hauling distance (Styranivskyi et al., 2009). For the present forest road network, I recommended three hauling methods with following maximum hauling distance: 1) timber hauling with short distance cable setting (400 m); 2) timber hauling with tractor (800 m); 3) timber hauling with cable setting and tractor (1200 m) (Styranivskyi et al., 2009). A short description of all management scenarios is shown in *Table 3.2.*

Table 3.2. Scenarios concerning management programs, road and hauling alternatives

Road and hauling alternatives / Management program	Present road network. Hauling distance, m			Improved road network
	400	800	1200	
Standard	Timber is harvested in standard way in distance 400 m from roads. Rest of the area is not managed	Timber is harvested in standard way in distance 800 m from roads. Rest of the area is not managed	Timber is harvested in standard way in distance 1200 m from roads. Rest of the area is not managed	Timber is harvested in standard way from all forest lands of estate
Standard with conversion	Timber is harvested in standard with conversion way in distance 400 m from roads. Rest of the area is not managed	Timber is harvested in standard with conversion way in distance 800 m from roads. Rest of the area is not managed	Timber is harvested in standard with conversion way in distance 1200 m from roads. Rest of the area is not managed	Timber is harvested in standard with conversion way from all forest lands of estate

No clear cuts	Timber is harvested only from selective cuttings in distance 400 m from roads. Rest of the area is not managed	Timber is harvested only from selective cuttings in distance 800 m from roads. Rest of the area is not managed	Timber is harvested only from selective cuttings in distance 1200 m from roads. Rest of the area is not managed	Timber is harvested only from selective cuttings from all forest lands of estate
No management	Forest lands of estate are not managed for timber harvest			

So, in general, 13 scenarios of development within 4 management programs were suggested. Each of scenarios depended on hauling method and road network situation.

3.5. Simulations and compilation of results

Simulations were done for all management scenarios for 100 years (20 periods).

After compilation, results were exported to Excel and converted for further analysis.

Each new simulation was started with a new management scenario but with the same landscape information.

4. RESUTS

4.1. Variables dependence of management program

4.1.1. Harvest volume

Different stand variables depend of different factors. Besides road network expansion and hauling method, harvest volume is affected by management type. Due to similarity in shape of curves inside every road and hauling alternatives, comparison of harvest volume variation during 100 years is simulated for improved road network only (see *Figure 4.1*).

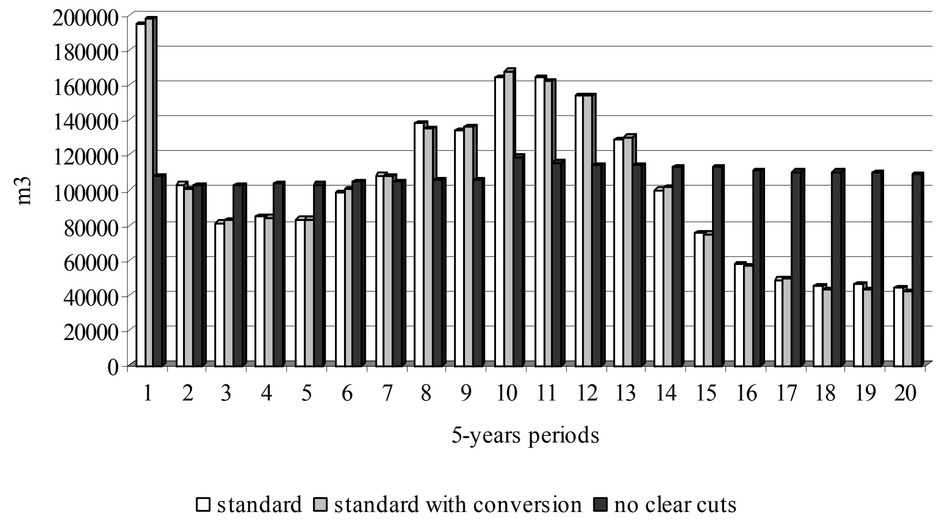


Figure 4.1. Harvest volume dependence of management program (for improved road network)

Figure 4.1 shows that in the case of standard and standard with conversion management program the estate will get uneven volume of harvested timber during the 100 years period. In the beginning of that period the harvest level will be high, but after that it will decrease until the 3rd period. After 50 years, volume will decrease again and have the lowest index in the end of that period. As for no clear cuts type, the curve looks more or less even. Harvest volume here has a small increase peak after 50 years.

4.1.2. Standing volume

As in the case of harvest volume, comparison of standing volume variation during simulated period in different management programs for perfect road network is shown. In the graph below no management program for the estate is also included (see *Figure 4.2*).

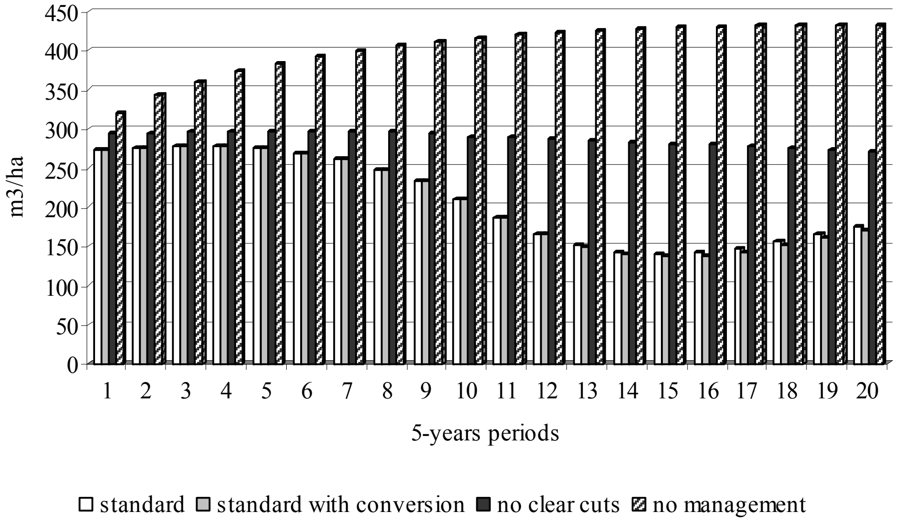


Figure 4.2. Standing volume dependence of management program (for improved road network)

When comparing different ways of management, the standing volume curve for standard and standard with conversion management shows almost the same shape. The lowest index for those types is in 15^{th} period. After that volume starts to increase again. As for no clear cuts management, the standing volume shows more even and higher results, but after 45 years it has a small decrease. In the case of no management operations standing volume increases for 50 years and after that remains almost stable.

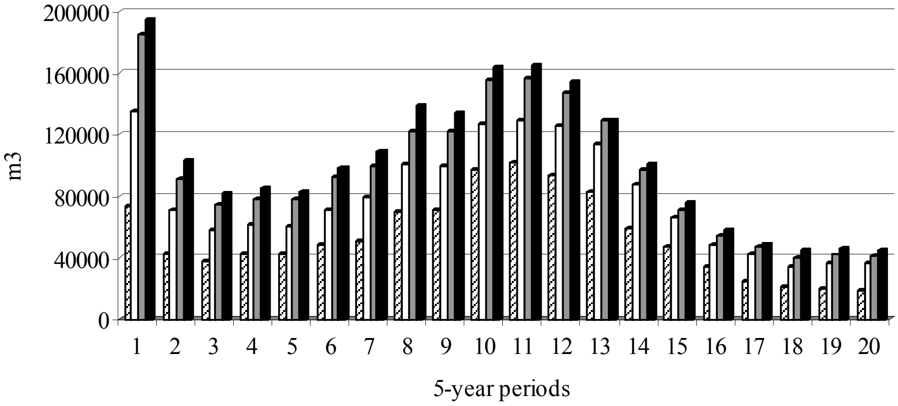
4.2. Variables dependence of road network expansion and hauling method

4.2.1. Harvest volume

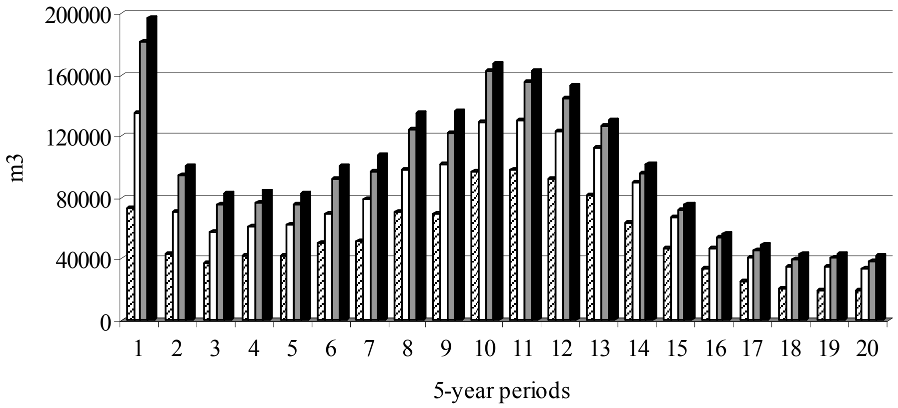
The harvest volume during the simulated period depends on the management program and scenario. The time profile of this dependence is illustrated in *Figure 4.3(a, b, c)* and the table with exact numbers is given in Appendix 3.

The result shows that an improved road network will give the highest harvest volume. Hauling timber 1200 m gives a similar volume, and the lowest volume is achieved with short distance cable setting and existing road network.

a) Standard management



b) Standard with conversion management



c) No clear cuts management

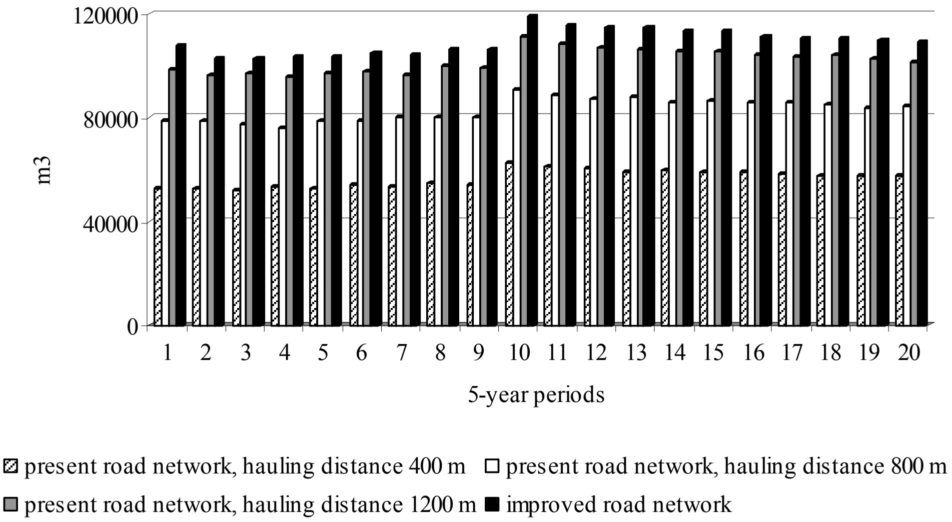


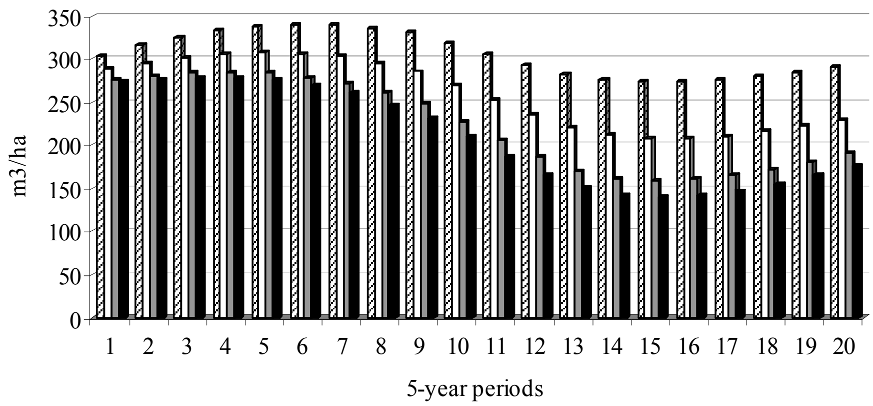
Figure 4.3. Harvest volume dependence of road network expansion and hauling method in different management scenarios

4.2.2. Standing volume

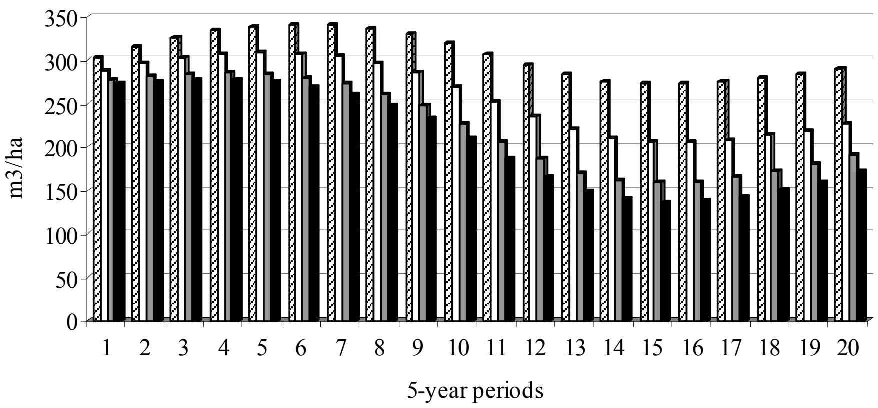
Standing volume also depends on the scenarios we've chosen. This dependence for different management programs in the periods profile is illustrated in *Figure 4.4 (a, b, c).* The table with exact numbers is showed in Appendix 4. Standing volume classes' distribution in the end of simulated period is illustrated in Appendix 5.

According to *Figure 4.4 (a, b, c)*, with increasing managed forest area decreases standing volume. The highest volume indexes are for hauling distance of 400 m, and the lowest is for improved road network. Compared to the lowest indexes in the case of an improved road network, standing volume is on average 8, 25 and 47% higher for hauling with cable setting and tractor, hauling only with tractor, and hauling only with cable setting, respectively for standard and standard with conversion management types. For no clear cuts management program, volume is 3, 10 and 20% higher compared to the lowest indexes.

a) Standard management



b) Standard with conversion management



c) No clear cuts management

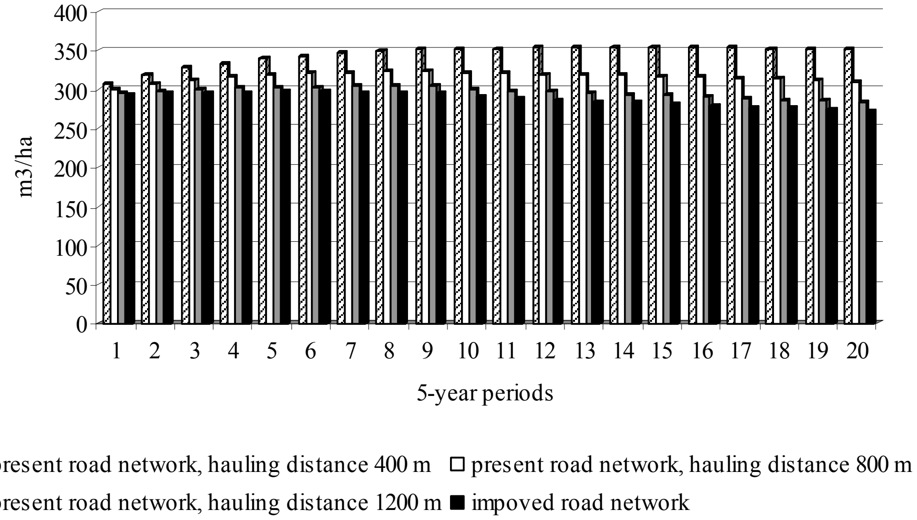


Figure 4.4. Standing volume dependence of road network expansion and hauling method in different management scenarios

4.2.3. Mean annual increment

Growth of the stands during simulated period is affected by road network expansion and hauling method. Comparison of mean annual increments for 100 years for different road and hauling alternatives is illustrated in *Figure 4.5*.

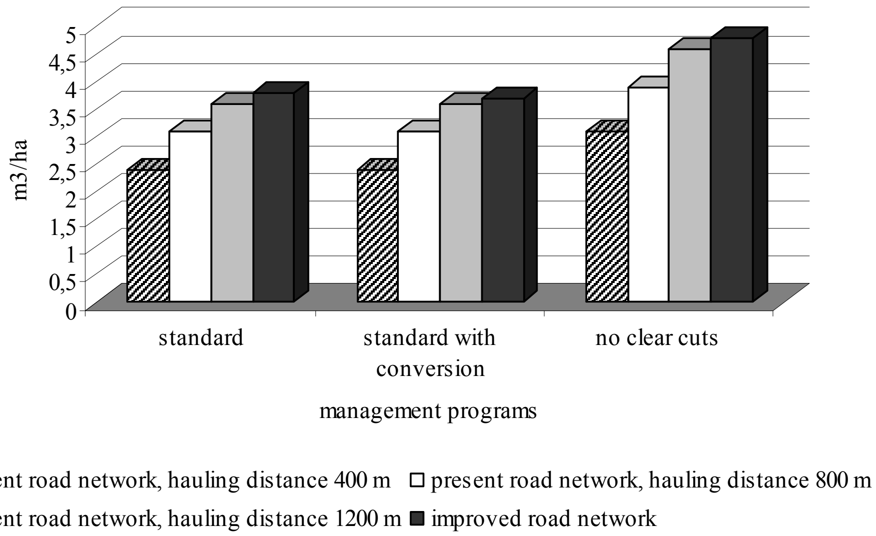


Figure 4.5. Mean annual increment dependence of road network expansion and hauling methods in different management scenarios

The result shows that an improved road network can positively affect on stands growth and mean annual increment indexes will be the highest in this case. Hauling timber

1200 m gives a similar numbers, and the lowest growth is achieved with short distance cable setting and existing road network.

4.3. Additional harvest volume accordingly to road network expansion and hauling method

At the present time, Nyzhnobystrivske forest estate uses tractors for hauling operations (average hauling distance is 800 m). It's shown in *Table 5.1* how much additional volume (in total for all periods) the forest estate could harvest using different management scenarios in the end of simulated period.

Table 4.1. Additional harvest volume in different management scenarios

Management	Harvest volume ($1000\ m^3$)	Harvest volume	
		$1000\ m^3$	%
Standard:			
Present road network, hauling with cable setting (within 400 m distance)	1079	-503	68
Present road network, hauling with tractor (within 800 m distance)	1582	0	100
Present road network, hauling with both tractor and cable setting (within 1200 m distance)	1922	340	122
Improved road network	2055	473	130
Standard with conversion:			
Present road network, hauling with cable setting (within 400 m distance)	1077	-502	68
Present road network, hauling with tractor (within 800 m distance)	1578	0	100
Present road network, hauling with both tractor and cable setting (within 1200 m distance)	1917	339	121
Improved road network	2053	474	130
No clear cuts:			
Present road network, hauling with cable setting (within 400 m distance)	1131	-527	68
Present road network, hauling with tractor (within 800 m distance)	1658	0	100
Present road network, hauling with both tractor and cable setting (within 1200 m distance)	2036	378	123
Improved road network	2181	523	132

Comparing different management scenarios with additional harvest volume point of view it is evident that an improved road network can increase the amount of harvested wood by 30-32%. Both cable setting and tractor for hauling can increase that amount by 21-23%. In the case where the estate will decide to use only cable setting for hauling timber in the present forest network condition, it will lose 32% of possible harvest volume.

5. DISCUSSION

5.1. Analysis of the results

Harvest volume. Obviously, an increase in the number of managed areas (expansion of road network or hauling distance) causes increase in harvest volume. But this dependence is not directly proportional (three times increase of hauling distance only doubled harvest volume) because two or three times increase of hauling distance will not increase two or three times harvested area.

Uneven harvest volume during 100 years in standard and standard with conversion management types could be explained by the present age class distribution (see *Figure 3.1*). So high harvest volume at the beginning is caused by felling long standing stands that occupy 11.2% of the total forest area. The second harvest peak is caused by middle aged stands (66.6% of the forest area) that will be ready for final felling after 50 years. Stable harvest volume in no clear cuts program is explained by a small dependence of age class distribution and by even distribution of the cuttings in time and space perspectives. But still, the only one possible reason that could cause a small increase of harvested timber amount after 50 years is the high number of middle age stands.

It's easy to see from *Figure 5.3* that standard and standard with conversion programs have similar shapes. The reason for that could be a small amount of spruce forests (7.2% of the total area) that should be converted into beech stands. One more case that can cause that similarity is the same legal age for final felling for beech and spruce. In such good soil conditions that age could be lower for spruce, which could possibly increase total harvest volume.

As for comparison of different management programs in general, no clear cuts type of management shows the highest results after 100 years period. The harvested volume here at the end of the simulated period is 5-6% on average higher than in standard and standard with conversion type. Possible explanations for that could be differences in mean annual increment. For no clear cuts management it's 1-1.5 m^3/ha per year on average higher, and more activity in estate causes more intensive growth.

In general, the results look more or less realistic. The difference between factual average harvest volume of estate and simulated harvest volume could be explained by the harvest ratio: Nyzhnobystrivske forest estate cuts only 48% from annual increment. Also not all forest roads in estate are suitable for use in management operations (a lot of them need a reconstruction).

Standing volume. Increase of managed areas causes a decrease in standing volume. It's easy to see a correlation between harvest and standing volume (compare *Figures 4.1 and 4.2*). Decreases in standing volume in different management programs are explained by increasing harvest volume in these time periods.

Similarities in shapes of standard and standard with conversion programs should have the same explanation like in the harvest volume example.

The average standing volume during the 100 year period is higher for no clear cuts type of management compare to standard and standard with conversion programs (approximately 38% higher in average). So, no clear cuts management gives higher indexes in both harvest and standing volume cases. But these higher indexes could be caused also by a landscape simulator model particularity: the model was elaborated for standard even age management type.

As for no management scenario for the entire estate, it could be possible that there is some error because it's hard to include natural forest processes (dying wood, etc.) in the model.

Economic and ecological issues. It's really hard to find a balance between economic and ecological issues. Sometimes they can exclude each other. So, the main task for the forest estate is to notice all possible results and make a decision based on the main objectives.

From an economic perspective, Nyzhnobystrivske estate has a good possibility to increase harvest volume by expansion of road system or hauling distance. At the same time, it needs a big investment for that. For example, to build 1 km of road in the estate condition, the enterprise should invest approximately 70 000 euro (Styranivskyi, Chaskovskyi 2009). To make the road network perfect this forest estate should build 75.2 km of roads (Styranivskyi et al., 2009). To use cable setting for hauling timber, Nyzhnobystrivske estate needs to buy at least one portable setting that cost approximately 100 000 euro (Styranivskyi, Chaskovskyi 2009). If the forest estate would decide to apply the no clear cuts management program it will probably need more then one cable setting. One more economic issue is in hauling cost: the cheapest way to haul timber is using both tractor and cable setting (0.33 euro/m^3). The tractor hauling cost is 12% more expensive (0.37 euro/m^3), the cable setting hauling – 51% more expensive (0.49 euro/m^3) (Styranivskyi, 2009).

From an ecological perspective, changes in the forest road network scheme should be done since it doesn't suit modern requirements (mostly all forest roads in the estate lie through valleys, along of river beds). That can also decrease soil erosion in places where roads and hauling tracks already exist. Use of cable setting is one more possible way to decrease hazardous influences on the environment. But at the same time using only cable setting for hauling timber needs expansion of the forest road network. So, back again to the economic issue, the forest estate in this case should invest money in both roads building and buying a portable setting.

National perspective view. On the state level, the forest road network and hauling method problems are not so significant throughout Ukraine. They concern mainly mountain regions. That is why to increase outcomes from forest enterprises all over the country new ways of management should be found. From that point of view it's good to try to adapt new approaches in planning using experience of different countries.

5.2. Is use of the landscape simulator for long term planning suitable for Ukraine?

Estate level. There were some problems in adapting data base of Nyzhnobystrivske forest estate to the landscape simulator model. These problems were caused by a discrepancy in Swedish and Ukrainian measures of stand variables. The first discrepancy consists of different systems to evaluate site quality (in Sweden its site index, in Ukraine – bonitet scale). The second one was caused by differences in land-use classes' definition. Also there could be some misunderstandings caused by different silvicultural programs concerning thinning and felling regimes in both countries. But in general, the data base was successfully adapted to the model and the results showed realistic indexes. That's easy to see if compare current annual increment and mean annual increment during simulated period. Also it's good to stress the critical valuation of results because the model could have some errors and randomness. It didn't take into consideration damages that could be caused by pests and diseases, natural conditions etc. But at the same time it shows general trends of forest development ("All models are wrong, but some of them could be useful" by PM Eko). The evaluated landscape simulator model could be used for future long term forest modelling, and the received results could be used in management decisions.

State level. To adapt landscape the simulator model in all Ukrainian forest estates is not possible. The reason for that is lack of forest information collected in digital format. At the present moment a GIS data base is completed only for Zakarpatia region. Also there are few enterprises in the others regions of Ukraine that use GIS. One of the main explanations according to such a situation is not enough financing from the state side. Usually enterprises don't have money to invest into inventory and transferring data to the digital format on their own.

So, it proves one more time that changes in all forestry planning systems of Ukraine is an important question. In the present market situation, enterprises need more independent from all government organizations, Committees and Ministries to be more flexible, should be able to self-finance and make decisions.

5.3. Conclusions

This work showed that it's possible to use fundamentals of the strategic planning for the long perspective in the forestry sector of Ukraine. For that I used the computer model landscape simulator developed in Swedish University of Agricultural Sciences.

In the landscape simulator, I integrated 13 possible scenarios of forest development using 4 different management programs during 100 years. As one of the ways to increase harvest volume, I chose road expansion and hauling method as an example. Comparing all scenarios the following inferences could be made:

- ✓ Harvest and standing volume are affected by management program, road expansion and hauling method;
- ✓ No clear cuts management program increased harvest volume by 5-6% on average compared to standard and standard with conversion programs which give more or less similar results;
- ✓ Expansion of the forest road network can increase harvest volume by 30-32%; both cable setting and tractor use for hauling timber can increase that amount by 21-23%; hauling only with cable setting in present road network condition can decrease amount of harvested timber by 32%;
- ✓ The average standing volume for no clear cuts management program has 38% higher indexes on average compared to standard and standard with conversion programs;
- ✓ Expansion of forest road network can decrease standing volume by 25% (10%) in standard and standard with conversion programs (no clear cuts program) compared to hauling with tractor in the present forest road network condition; hauling with both tractor and cable setting – by 17% (7%) respectively; hauling with cable setting only can increase this volume by 22% (10%);

Use of one of the methods to increase harvest volume described above depends of the numerous economic and ecological factors. The most beneficial way from an ecological point of view needs the highest investments. The main economic question is absence of financing. Possible solution for those problems could be concession of more wide rights to the forest estates to make their activity more flexible and adapted to the market economy.

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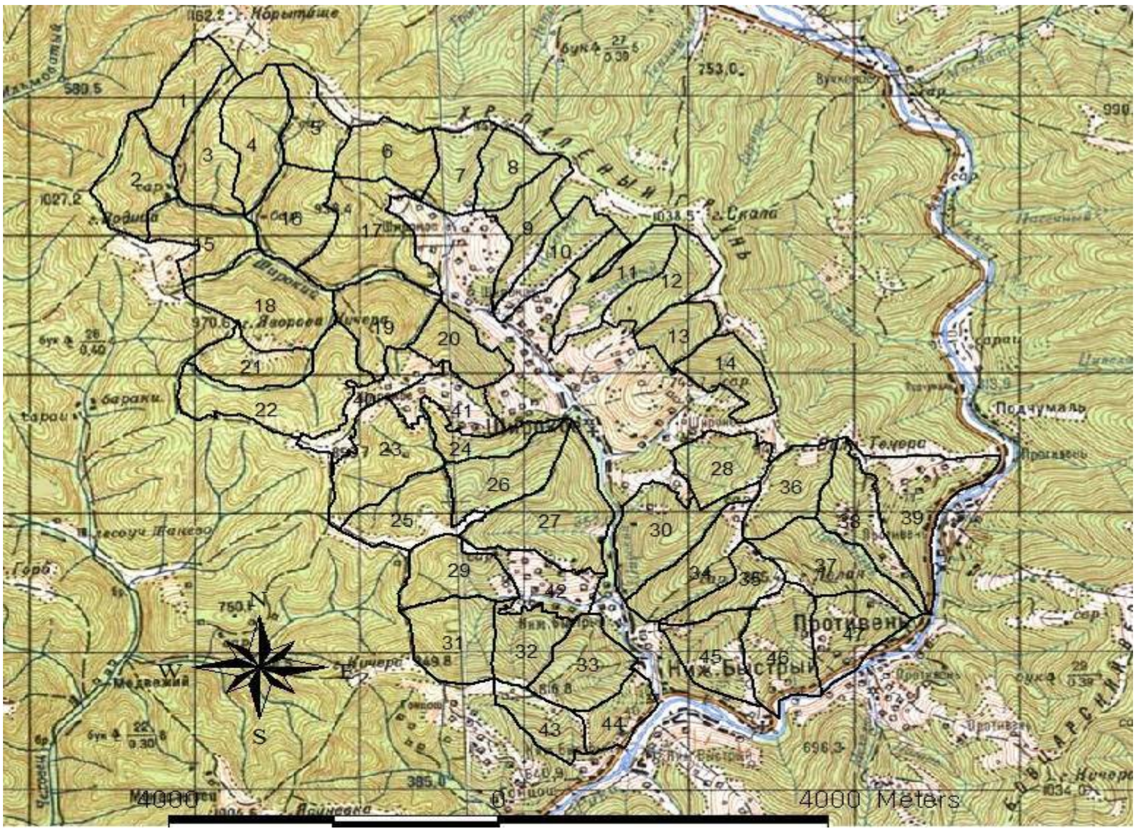
APPENDIX 1

The study area location

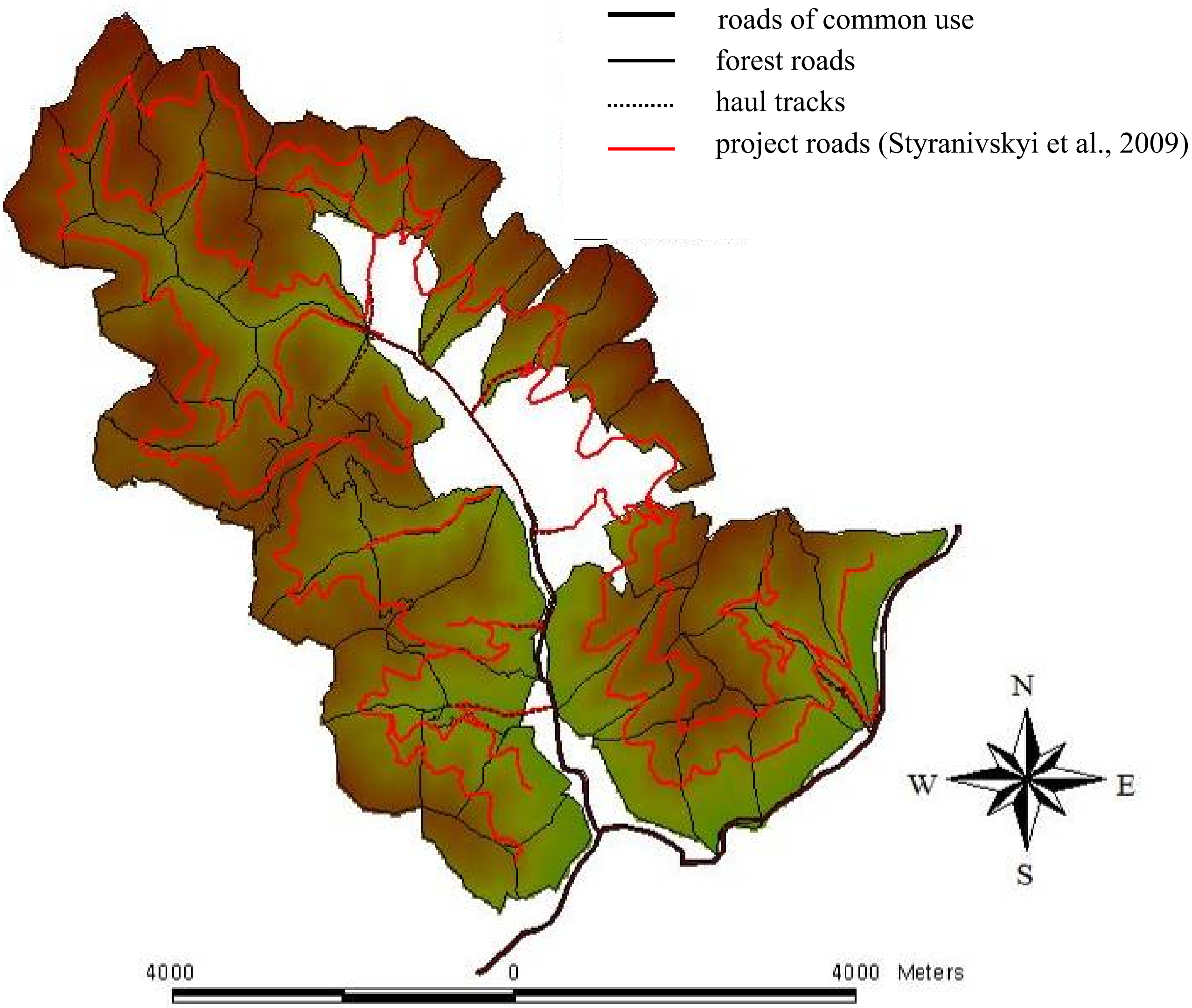


APPENDIX 2

The road network in Nyzhnobystrivske forest estate

The total length of all roads:

- Present roads – 23,6 km
- Projected roads – 75,2 km



APPENDIX 3

Harvest volume (1000 m^3) in standard management program

5-years periods	Improved forest road network			Present forest road network								
				Hauling distance 400 м			Hauling distance 800 м			Hauling distance 1200 м		
	Th	FF	Total	Th	FF	Total	Th	FF	Total	Th	FF	Total
1	42	153	195	23	50	73	33	102	135	39	145	184
2	47	56	103	25	18	43	36	35	71	44	47	91
3	47	34	81	26	12	38	36	22	58	44	31	75
4	47	38	85	27	16	42	37	24	61	45	32	78
5	47	36	83	26	16	42	37	24	60	44	33	78
6	48	51	99	27	22	49	37	33	71	45	47	93
7	44	65	108	25	26	51	36	43	79	42	58	99
8	40	98	138	24	46	70	33	67	101	38	84	122
9	31	103	134	19	52	71	26	73	100	29	93	122
10	34	130	164	21	76	97	29	97	126	33	123	156
11	24	140	164	14	88	102	21	108	129	23	134	157
12	18	136	154	10	83	94	16	110	126	17	129	146
13	15	114	129	8	74	82	12	102	114	14	115	129
14	13	87	100	7	51	58	10	77	88	12	86	97
15	14	62	76	7	40	47	11	55	66	13	58	71
16	15	42	58	7	27	34	12	36	48	14	41	54
17	16	33	49	7	18	25	13	30	43	15	32	47
18	17	28	45	8	13	21	12	22	34	16	24	40
19	19	27	46	9	12	20	13	23	37	17	25	42
20	20	24	44	9	10	19	14	22	36	19	23	42
Total	600	1455	2055	330	750	1079	476	1106	1582	563	1360	1922

Harvest volume (1000 m^3) in standard with conversion management program

5-years periods	Improved forest road network			Present forest road network								
				Hauling distance 400 м			Hauling distance 800 м			Hauling distance 1200 м		
	Th	FF	Total	Th	FF	Total	Th	FF	Total	Th	FF	Total
1	43	155	198	23	50	74	32	103	135	39	142	181
2	47	53	101	26	17	43	37	34	70	44	51	95
3	47	36	83	25	12	37	36	22	58	44	31	75
4	48	36	84	27	15	42	38	23	61	45	32	77
5	47	36	83	27	15	42	37	25	62	45	31	76
6	49	51	100	27	23	51	38	32	69	45	47	93
7	44	64	108	25	26	51	36	43	79	41	56	97
8	40	95	135	24	46	70	33	66	98	39	85	124
9	31	105	136	19	52	70	27	75	102	30	92	122
10	35	133	168	21	77	97	29	100	130	33	129	162
11	24	138	162	14	83	98	20	110	130	23	132	155
12	19	135	154	10	83	93	16	108	124	17	128	145
13	15	115	130	8	73	81	12	100	112	14	113	127
14	13	89	101	7	56	63	11	79	90	12	84	96
15	14	61	75	7	40	47	11	57	67	12	59	72
16	15	42	57	7	26	33	11	35	47	13	41	54
17	16	34	50	8	18	26	12	29	41	15	31	46
18	16	27	43	7	13	20	12	23	35	14	25	39
19	17	26	43	8	12	20	12	23	35	16	25	41
20	17	25	42	8	11	19	13	21	33	16	23	38
Total	597	1456	2053	328	749	1077	471	1107	1578	559	1358	1917

Harvest volume (1000 m^3) in no clear cuts management program

5-years periods	Improved forest road network	Present road network		
		Hauling distance 400 м	Hauling distance 800 м	Hauling distance 1200 м
1	108	52	79	99
2	103	53	78	96
3	103	52	77	97
4	104	54	76	96
5	103	53	79	97
6	105	54	78	98
7	104	53	80	97
8	106	55	80	100
9	106	54	80	99
10	119	63	91	111
11	116	61	89	109
12	114	60	87	107
13	114	59	88	106
14	113	60	86	105
15	113	59	86	106
16	111	59	86	104
17	110	58	86	104
18	110	57	85	104
19	110	58	83	102
20	109	58	84	101
Total	2181	1131	1658	2036

APPENDIX 4

Standing volume (1000 m^3) in different scenarios

5-years periods	Standard program				Standard with conversion program				No clear cuts program				No manage-ment program
	Improved forest road network	Present road network			Improved forest road network	Present road network			Improved forest road network	Present road network			
		Hauling distance 400 m	Hauling distance 800 m	Hauling distance 1200 m		Hauling distance 400 m	Hauling distance 800 m	Hauling distance 1200 m		Hauling distance 400 m	Hauling distance 800 m	Hauling distance 1200 m	
1	1179	1305	1241	1191	1177	1305	1242	1191	1263	1325	1294	1273	1382
2	1186	1360	1276	1210	1187	1359	1275	1210	1269	1371	1317	1284	1474
3	1197	1404	1303	1225	1196	1404	1305	1225	1273	1408	1338	1292	1546
4	1195	1433	1319	1227	1193	1434	1321	1227	1275	1436	1357	1299	1605
5	1186	1454	1328	1222	1183	1456	1327	1222	1276	1459	1369	1304	1652
6	1159	1461	1321	1199	1156	1461	1323	1199	1276	1477	1380	1306	1691
7	1125	1466	1307	1173	1124	1465	1309	1173	1276	1492	1386	1309	1723
8	1061	1446	1269	1122	1063	1445	1273	1122	1273	1504	1391	1307	1750
9	1001	1425	1230	1070	1000	1424	1233	1070	1269	1514	1395	1307	1773
10	904	1372	1161	979	899	1372	1159	979	1251	1514	1385	1292	1793
11	806	1315	1088	886	804	1317	1085	886	1242	1517	1380	1284	1809
12	716	1262	1016	802	713	1264	1013	802	1233	1520	1376	1277	1823
13	650	1216	952	732	644	1219	950	732	1225	1522	1372	1273	1834
14	613	1191	913	694	603	1188	907	694	1217	1523	1370	1265	1843
15	601	1176	896	682	589	1173	886	682	1208	1522	1365	1258	1850
16	611	1176	898	690	596	1172	887	690	1202	1521	1360	1250	1856
17	635	1188	909	709	616	1180	897	709	1193	1519	1354	1243	1859
18	669	1206	933	743	650	1199	918	743	1185	1517	1348	1234	1862
19	710	1229	959	780	690	1222	944	780	1176	1513	1343	1228	1864
20	757	1257	992	824	737	1249	977	824	1168	1509	1337	1222	1865
Ave-rage	898	1317	1116	958	891	1315	1112	958	1237	1484	1361	1275	1743

APPENDIX 5

Volume classes distribution in the end of simulated period. Standard management program

a) Improved forest road network

b) Present road network. Hauling distance 1200 m

c) Present forest road network. Hauling distance 800 m

d) Present forest road network. Hauling distance 400 m

- felling areas; - volume classes (1^{st} - 10^{th});
- private farmstead; - pastures

Volume classes distribution in the end of simulated period. Standard with conversion management program

a) Improved forest road network

b) Present road network. Hauling distance 1200 m

c) Present forest road network. Hauling distance 800 m

d) Present forest road network. Hauling distance 400 m

- felling areas; - volume classes (1^{st} - 10^{th});
- private farmstead; - pastures

Volume classes distribution in the end of simulated period. No clear cuts management program

a) Improved forest road network

b) Present road network.
Hauling distance 1200 m

c) Present forest road network.
Hauling distance 800 m

d) Present forest road network.
Hauling distance 400 m

- felling areas; - volume classes (1^{st} - 10^{th});
- private farmstead; - pastures