



Forestry of Ukraine: Current Situation, Challenges and Ways to Tackle Them

Oleg Styranivsky^{a,*}, Mykola Herys^a, Oleksandr Rybak^b, Andriy Shchupak^a

^a Forest Machines Department, Ukrainian National Forestry University, Generala Chuprynyky 103, 79057 Lviv, Ukraine, styran@nltu.edu.ua (O.S.); mherys@ukr.net (M.H); andriyshchupak@gmail.com (A.S.)

^b Forest Resources Use Department, State Forest Resources Agency of Ukraine, Shota Rustaveli 9a, 01601 Kyiv, Ukraine, o.rybak@forest.gov.ua

HIGHLIGHTS

- Ukraine's forests perform many functions.
- Forest resources meet the country's need for timber, and their use is done sustainably.
- Ensuring the sustainability of forests requires comprehensive technical re-equipment and introduction of innovative and environmentally sound technology in forestry.

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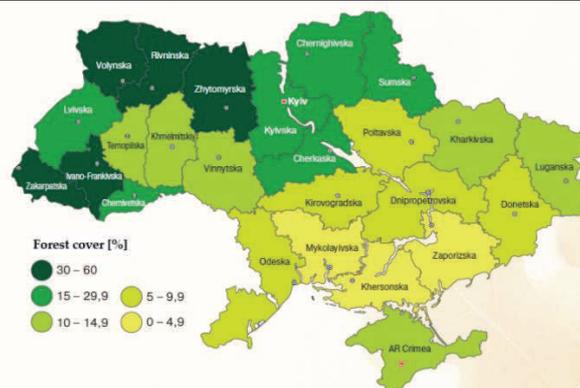
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GRAPHICAL ABSTRACT



ABSTRACT

This paper analyzes the current state of the forest sector in Ukraine, by the special features of forests and forest management. It has been found that the forest cover does not meet the optimal level, which should be 20 %. It has been proved that the actual wood use is smaller than the allowable cut, ensuring a sustainable forest management. The total volume of the harvested merchantable timber is around 21-22 million m³. The analysis of the forest roads network in Ukraine has shown that its density is insufficient and several times lower than in Europe. To ensure a sustainable forest development it is advisable to work out a strategy for the development of the forest industry in Ukraine. The main objectives of such a strategy should be those of improving the forestry regulatory framework, the models and mechanisms of forest public administration, the state's financial system of forestry and economic support, and of developing state programs for the forest roads construction, technical re-equipment, introduction of modern innovative and environmentally-friendly technologies for forest growing, care, protection, conservation and logging.

* Corresponding author. E-mail address: styran@nltu.edu.ua

1. INTRODUCTION

The forests of Ukraine are its national wealth and by their purpose and location perform mainly water-conservation, protection, sanitary-hygienic, health-improving, recreational, aesthetic, and educational as well as other functions. In addition, forests are a source to meet the needs of society for forest resources.

All forests on the territory of Ukraine, regardless of the land on which they grow and in whose ownership they are, form the Forest Fund of Ukraine, which is protected by the State. The rational use and protection of forest resources is currently an urgent task, the resolution of which guarantees the economic, environmental and social stability of our country.

The period of independent formation and development of Ukraine is the period of the creation of a market-oriented economic system, new social relations and values. Political and economic reforms have posed a number of new challenges for the country's forestry, related to reprioritization within the society as a whole. Modern views of the role of forests not only as a source of timber and forest products, but also as a significant environment- and climate-forming factor, have necessitated the improvement of existing and the development of new strategic approaches to the forestry management.

The purpose of this paper is to study and analyze the current state of forest management in Ukraine, to establish the main trends and urgent problems and to outline promising directions for the development of the country's forest complex for the fullest possible implementation of its existing potential.

2. METHODS

During this research the methods of empirical and experimental-theoretical analysis, as well as the methods of mathematical statistics, were used. To achieve the objective, it was necessary to collect and analyze a significant amount of information, in particular data characterizing the state of forest resources and their contribution to the country's economy (the amount of forest stock, the rate of forest cover, age and species composition), forest owners and users, peculiarities of forest management (volumes and methods of logging and forest regeneration, the state and specifics of forest management planning, monitoring and certification, forest protection against pests, diseases and fires, electronic system of timber tracking), characteristics of the forest road network, technical support and the degree of forest-related processes mechanization etc. A significant part of such data was obtained from open sources, such as annual public reports of individual forest users, State statistical authorities, and alike. Methods of mathematical statistics were used for data processing and generalization.

However, some information, such as current data on technologies and machinery used for logging, reforestation and road construction, was difficult to find in open sources. The professional literature often lacks these data or the data may be irrelevant (outdated) due to the rapid pace of

changes in the forest road construction and technical support of forest-related processes. For this reason, to process and generalize the forestry engineering data, the empirical research methods (observation, measurement, interviewing individual specialists and experts, scientists, representatives of forest users and contractors performing certain works) were used. To establish individual characteristics, the optimal forest cover and density of forest roads in particular, the analogy and comparison methods were used.

3. RESULTS

3.1. Characteristics of Forest Resources and their Contribution to the Economy

The total area of forest land belonging to Ukraine is of 10.4 million hectares, and it includes 9.6 million hectares covered with forest vegetation. The forest cover of Ukraine is 15.9%. But, despite the rather small forest cover of the territory, Ukraine ranks 9th in Europe in terms of forest area and 6th in terms of timber stocks [1].

The main features of forests and forestry in Ukraine are:

- Relatively low average level of forest cover of the territory;
- Forest growth in different natural areas (Polissya, Forest-steppe, Steppe, Carpathians and Crimea);
- Mainly environmental values of the forests and their large share (about 50%) with a regime of limited forest use;
- A large share of protected forests (over 16%), which has a steady upward trend;
- Affiliation of forests by numerous permanent forest users;
- A large area of forests is in the area of radioactive contamination, etc.

The vast majority of forests are state-owned. About 1.3 million hectares (13%) of forest land are in the permanent use of communal enterprises subordinated to local authorities' bodies. The share of privately owned forests is less than 0.2% of the total forest land area. About 800 thousand ha of forest lands of state ownership is not provided for use and attributed to reserve lands.

Ukraine has historically formed a situation with subordination of state forests to numerous permanent forest users (managed forests are given for permanent use to enterprises, institutions and organizations of various ministries and agencies). The largest area of forest land (about 73%) is used by forestry enterprises, which are coordinated by the State Forest Resources Agency of Ukraine (SFRA). The main tasks of the SFRA are:

- Implementation of state policy in the field of forestry and hunting, as well as protection, conservation, rational use and reproduction of forest resources;
- Implementation of public administration in the field of forestry and hunting;

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- Participation in the development and implementation of national, interstate and regional programs in the field of protection, increasing of productivity, management and regeneration of forests.

The structure of the State Forest Resources Agency of Ukraine consists of its territorial bodies, enterprises, institutions and organizations of state ownership. Forest management at the local level is carried out by the state forestry enterprises. They are responsible for all types of forest operations. In addition, some enterprises have primary wood processing facilities.

An effective tool for forest conservation is the creation of natural protected areas. To date, 16.8% of forests belonging to the State Forest Resources Agency of Ukraine are protected. It should be noted that over the past 30 years, the area and number of natural reserves in the forest lands has increased 4 times. In **Figure 1** is shown the distribution of forests by their main target functions.

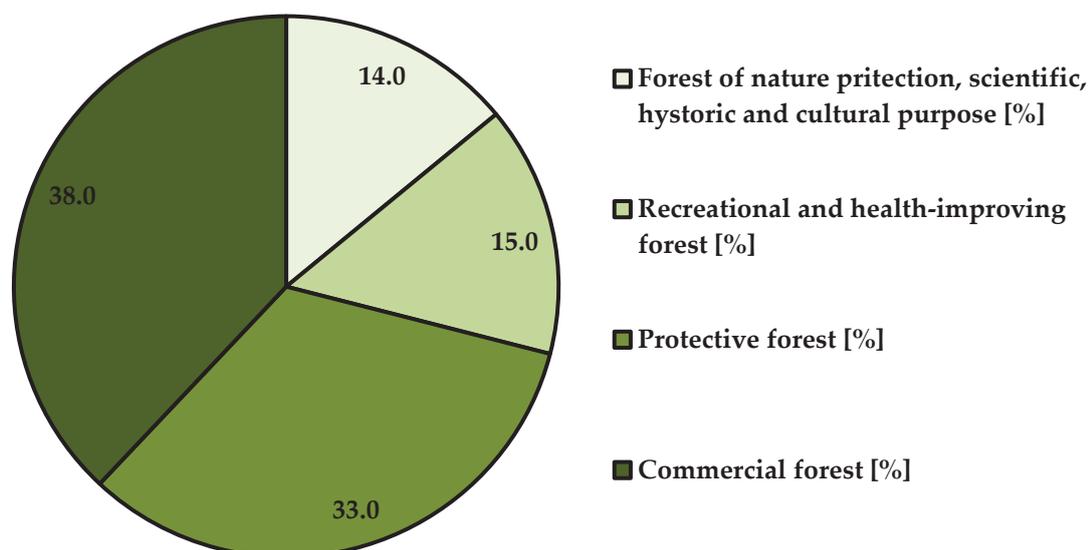


Figure 1. Distribution of Ukrainian forests by their main target function

Conditions for afforestation in Ukraine are extremely heterogeneous, so forests are distributed throughout the country unevenly (**Figure 2**). Forest cover in different natural areas has significant differences and does not reach the optimal level at which forests have the most positive effect on climate, soils, water resources, counteract erosion processes, as well as to provide the maximum amount of wood. According to experts, in order to achieve the optimal level of forest cover in Ukraine, which should average 20%, it is necessary to plant about 3 million hectares of trees. The forest structure in relation to age is dominated by middle-aged plantations, while the proportion of harvestable stands is 18.7% (**Figure 3**). The average age of forests is over 60 years, and there is a gradual aging of forests, which leads to the deterioration of their sanitary condition. Ukrainian forests are composed by more than 30 species of trees, among which the dominant ones are the pine (*Pinus silvestris*), oak (*Quercus robur*), beech (*Fagus sylvatica*), spruce (*Picea abies*), birch (*Betula pendula*), alder (*Alnus glutinosa*), ash (*Fraxinus excelsior*), hornbeam (*Carpinus betulus*), fir

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(*Abies alba*). Coniferous plantations hold 43% of the total area, in particular, pine - 35%. Hardwood plantations hold 43%, particularly oak and beech - 37% (Figure 4).

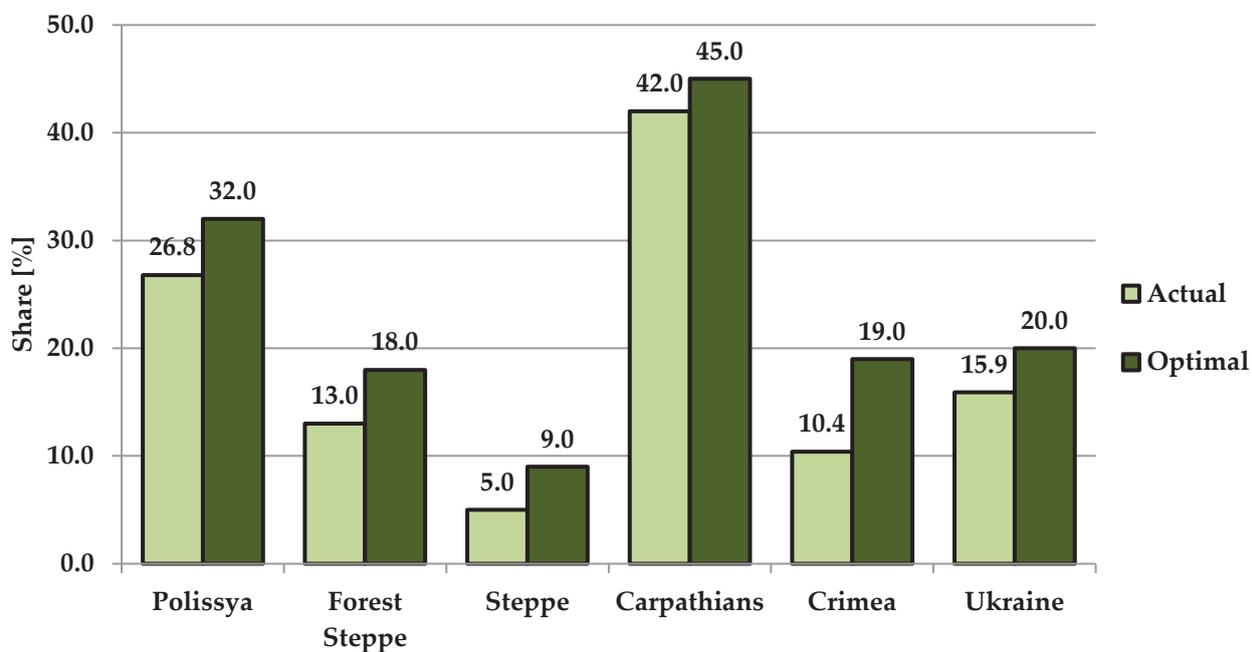


Figure 2. Forest land-cover share on natural regions in Ukraine

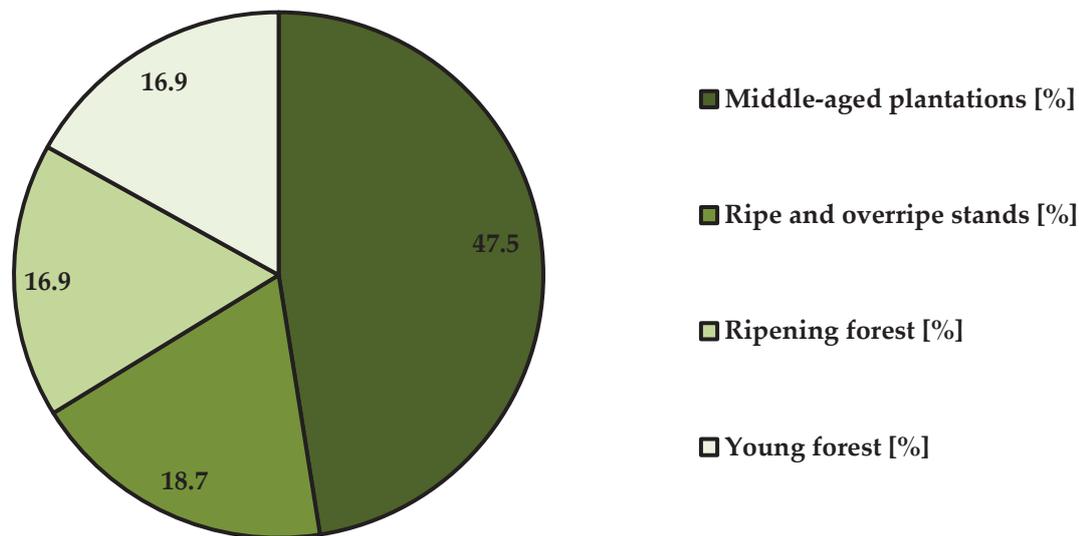


Figure 3. The age structure of Ukrainian forests

The growing stock is estimated at 2.1 billion m³. The forests of Ukraine grow an average rate of 35 million m³ per year. The average annual growing stock in the forests of the State Forest Agency is 3.9 m³ per 1 hectare and ranges from 5.0 m³ in the Carpathians to 2.5 m³ in the Steppe

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zone. There is a gradual increase in stock, which confirms the significant economic and environmental potential of forests.

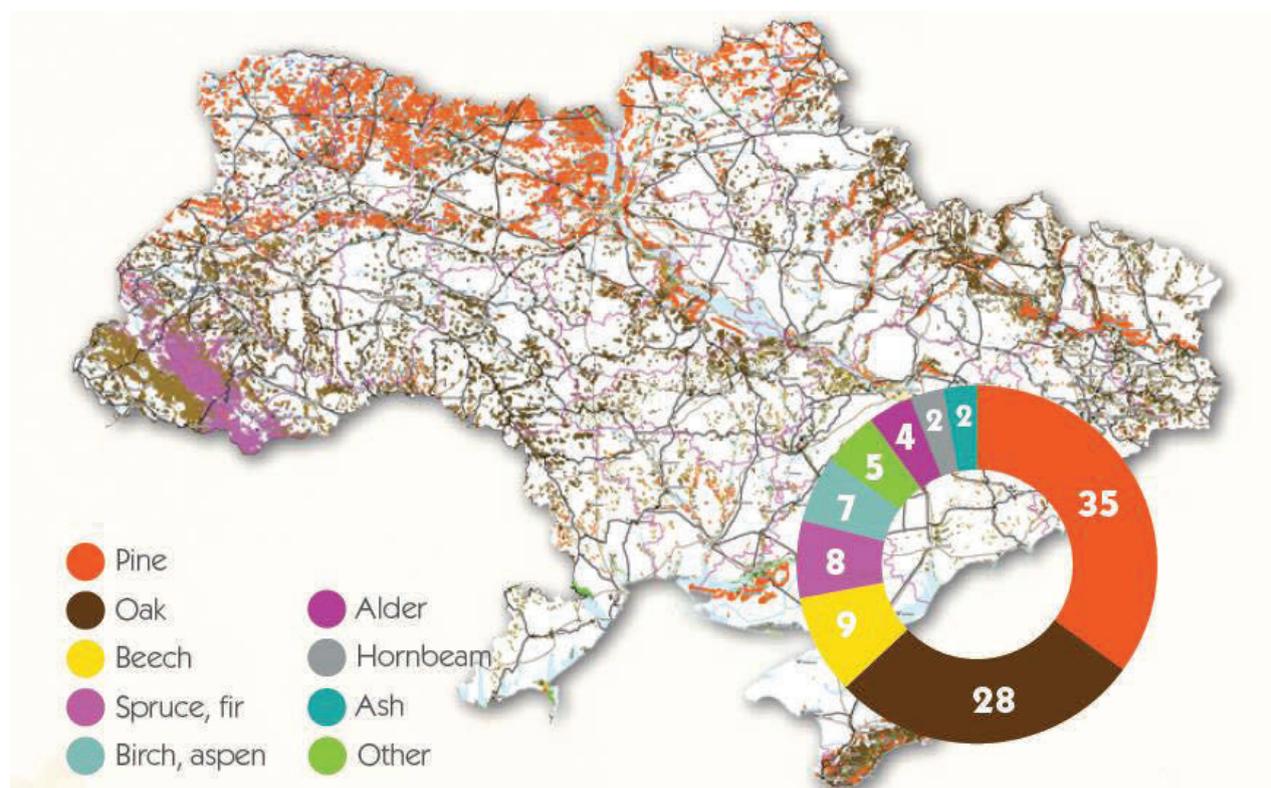


Figure 4. Species composition in the Ukrainian forests. Legend: numbers represent the shares.

In the forests of the State Forest Agency, the stock per hectare is about 240 m³ (7th position in Europe); however, in Ukraine this indicator is lower - 218 m³ (ranking Ukraine on the 9th position in Europe) – mainly due to the forests of reformed agricultural enterprises, which are spared and are in a bad sanitary condition.

The activity of forestry enterprises belongs to those types of economic activity, the share of which in the structure of Ukraine's economy is insignificant: the value of their products in the total structure of gross domestic product is 0.40 - 0.45% [2]. At the same time, the development of local communities and business, job creation, formation of a healthy ecological environment, etc. depend on its efficiency.

3.2. Forest Management and Use of Forest Resources

Forest management involves the implementation of a set of measures for the protection, conservation, rational use and extended forest regeneration. The main requirements for forestry in Ukraine, the use of forest resources, regeneration of forests, increasing their productivity,

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organizing protection and conservation, financing relevant measures etc., are regulated by the Forest Code of Ukraine [3]. Enterprises, institutions, organizations and citizens conduct forest management taking into account the economic purpose of forests, environmental conditions, and are obliged to:

- Ensure the strengthening of water-protection, protective, climate-regulating, sanitary and hygienic, health-improving and other useful functions of the forests in order to improve the environment and protect human health;
- Ensure continuous, sustainable and rational use of forest resources to meet the needs of manufacturing industries and population in timber and other forest products;
- Carry out forest regeneration;
- Ensure the increased productivity, improvement of the qualitative composition of forests, as well as the conservation of biotic and other biodiversity in forests;
- Protect forests against fires, pests and diseases, illegal logging and other damage;
- Ensure the rational use of the forest areas.

Forest resources are the basis of the forestry economics and the volume of their use is set to ensure the continuity of different forest functions (conservation, protection, sanitation, health-improving and economic). As a result of use of the forest resources, forestry gets its own funds to cover regeneration, protection and other forest-related measures (recently the state has stopped the forestry financing). Wood is harvested within the final fellings, thinning, sanitary and other cutting types. The limit of timber harvesting within final felling is provided by allowable cut, which should be approved taking into account the principles of continuity and sustainability of use of forest resources. Recently, allowable cut was set at 9.6 million cubic meters, and its actual implementations was up to 90% [1]. So, the actual volume of forest use is smaller than the allowable cut, which ensures an environmentally sustainable forest management (**Table 1**).

Table 1. Volumes of final felling in the forests belonging to the State Forest Resources Agency of Ukraine (merchantable timber, million m³)

Indicators	By years				
	2015	2016	2017	2018	2019
Allowable cut	9.6	9.6	9.8	9.9	9.6
Actual cut	8.4	8.4	8.5	7.5	7.4
% of the allowable cut	88	88	87	76	77

The total volume of merchantable timber harvested from all fellings is around 21-22 million cubic meters (**Table 2**). Timber harvested within final fellings stands for 40% of the total amount of harvested timber. The potential reserves and capacity of Ukrainian forests are large and, according to expert opinions, not fully utilized. The use of annual growth is about 64%, while in Europe this figure is 70-80%. Taking into account the increase in the area of mature and overmature stands in Ukraine, an increasing of amount of harvested timber can be foreseen for the coming years.

Table 2. Volumes of merchantable timber harvested in the forests of Ukraine, (million m³)

Indicators	By years				
	2015	2016	2017	2018	2019
Total volume, of which	21.9	22.6	21.9	22.5	20.9
- final felling	9.1	9.3	9.4	8.3	7.9
% of the total volume	42	41	43	37	38
- thinning and other felling	12.8	13.3	12.5	14.2	13.0
% of the total volume	58	59	57	63	62

It should also be noted that since 2017 there has been a steady trend towards a decrease in the volume of clear cuttings. This is due to the adopted policy of phased transition from clear to gradual and selective cutting systems, which is typical within the European Union.

The main task of forest users is the cultivation and regeneration of forests. According to the legislation, any area of clear cuttings has two years during which the forest needs to be restored. Such a period is due to prepare the soil and carry out other activities necessary for planting a forest or promoting its natural regeneration. Reforestation is usually carried out the next year after felling or sometimes, if all the conditions are met, the very same year. Reforestation of harvested forest areas are increasing and are carried out by means of forest regeneration and afforestation. Over the past two years the annual average work of forest regeneration covered 50 thousand ha (Figure 5). The decrease in reforestation work was due to a decrease in the volume of clear cuttings and a consistently higher level of natural regeneration.

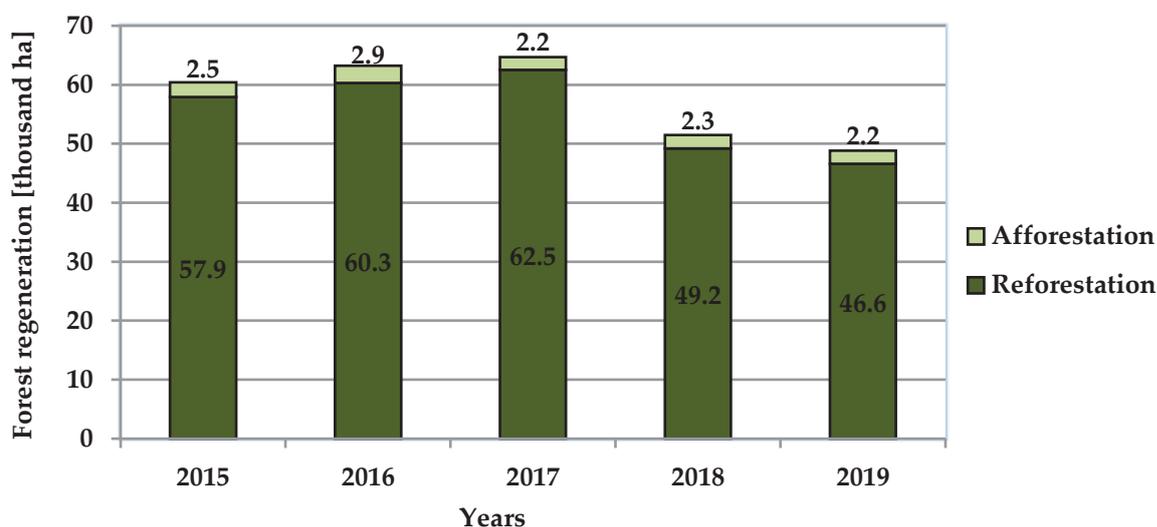


Figure 5. Dynamics of forest regeneration in Ukraine

To sustain large-scale afforestation operations, sufficient facilities were created. State forest enterprises, subordinated to the State Forest Resources Agency of Ukraine, own 3.4 thousand ha of forest nurseries, 11 ha of greenhouse complexes, where about 246 million standard seedlings and 3.6 million plants for landscaping were grown in 2018. To receive high-quality forest seeds, a permanent 40.9 thousand ha forest base was established, including:

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- 2.1 thousand ha of plus stands;
- 1.1 thousand ha of permanent seed orchards;
- 15.6 thousand ha of permanent seed stands;
- 22.0 thousand ha of genetic reserves;
- 4.6 thousand plus trees.

The current increasing trend of the state forest cover is one of priority areas of forest management development. In Ukraine, every second hectare of forest is created artificially. Over the last half century, more than 1,4 million ha of soil protection stands were planted on agricultural non-usable lands, of which 150 thousand ha along the banks of small rivers and reservoirs. In addition, there were planted 440 thousand ha of forest shelter belts to protect more than 13 million ha of arable land.

Forest management planning, as a set of measures aimed to organize an effective forest management, is required for all forests in Ukraine. Forest management planning provides authorities and forest users with valuable information about the current state of forests, forest resources, qualitative and quantitative changes of forest reserves, makes forecasts, determines scientifically-based regulations of sustainable, rational and environmentally balanced forest management, as well as develops a range of measures for forest regeneration, conservation and protection. Currently, two categories of forest inventory are carried out:

- Economic (basic forest management planning);
- Operational (permanent forest management planning);

Basic forest management planning is the basis for working out promising projects on forestry organization and development for a 10-year period. The main objective of permanent forest management planning is to maintain up-to-date information about the forests. Based on primary and permanent forest management planning data, forest maps and geospatial databases were created and maintained up-to-date. Forest maps and geospatial (mapping) databases were established for almost all forests subordinated to State Forest Resources Agency of Ukraine, as well as for large forest areas of other forest users. Databases are part of the informational support for a sustainable forest management and are often used for production and scientific purposes.

Regulatory framework for forest monitoring includes the Forest Code of Ukraine, Laws of Ukraine "On Environmental Protection" and "On Flora". Forest monitoring is part of the state environmental monitoring system. According to the Regulation on the State Environmental Monitoring System approved by the Cabinet of Ministers of Ukraine, State Forest Resources Agency of Ukraine is responsible for monitoring of forest soil, forest vegetation and game fauna. Ukraine joined the pan-European process of forest protection and signed the Strasbourg Resolution S1 on monitoring of forest ecosystems (Resolution "European Network of Permanent Sample Plots for Monitoring of Forest Ecosystems"). The necessity of forest monitoring is caused by the implementation of a number of other international obligations of Ukraine, in particular: the UN Convention on Long-Range Transboundary Air Pollution, the UN Convention on Biological Diversity, and the United Nations Framework Convention on Climate Change.

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Forest monitoring in Ukraine is conducted in accordance with the requirements of the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests within the region of the United Nations Economic Commission for Europe (UNECE ICP Forests). Monitoring under UNECE ICP Forests is carried out at two levels: Level I (large-scale monitoring), which provides a systematic collection of information on changes in forest state over time and space, and Level II (intensive monitoring), which provides an in-depth study of the impact of stress factors on forest ecosystems. Based on the forest monitoring results the overall condition of forests in Ukraine was found to be satisfactory.

Implementation of certification activities is carried out by internationally or nationally accredited companies. Such certification procedures guarantee the independence, impartiality and objectivity of the forest management assessment. Ukraine adheres to the international forest certification scheme of the Forest Stewardship Council (FSC), an international non-profit non-governmental organization dedicated to promote responsible forest management worldwide. As of March 1, 2019, the area of certified forests in Ukraine reached 4.281 million hectares (41% of forests respectively). The vast majority (97.6%) of all certified forests is in the permanent use of state forestry enterprises, subordinated to the State Agency of Forest Resources of Ukraine. Certified forests are unevenly distributed and concentrated mainly in the western and northern regions of the country.

An important focus area of forestry enterprises of the State Agency of Forest Resources of Ukraine, which requires a set of organizational and practical measures, is the protection of forests from pests, diseases and other negative impacts. As of January 1st, 2019, the total forest area affected by drought amounted to 413 thousand hectares, of which Scots pine (*Pinus silvestris*) – 222 thousand hectares, Norway spruce (*Picea abies*) – 27 thousand hectares, European oak (*Quercus robur*) – 100 thousand hectares, other plantations – 64 thousand hectares. According to updated information (2019), the total forest area affected by drought in the State Forest Resources Agency of Ukraine was 270 thousand hectares (**Figure 6**), which indicates a decline in outbreaks of bark beetle drying due to timely measures to improve the sanitary state of forests (sanitary felling).

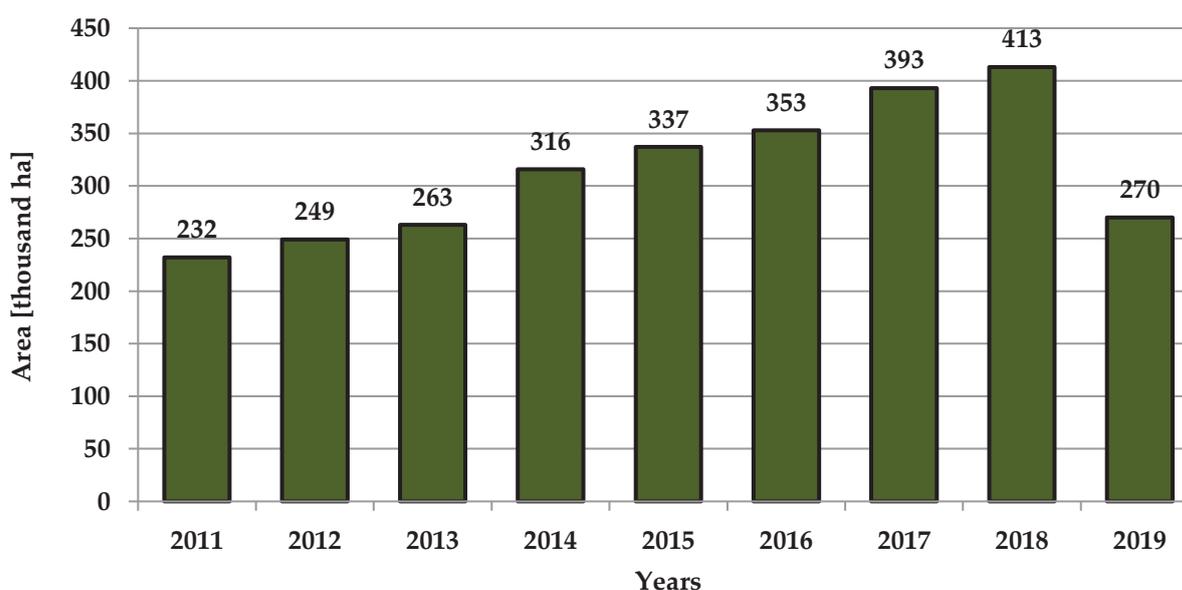


Figure 6. Dynamics of forest areas affected by drought in the State Forest Resources Agency of Ukraine

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The area of plantations damaged by windfalls and windbreaks in 2019 amounted to 19.9 thousand hectares, accounting for 670 thousand cubic meters. In the past, artificial forests in the south and east of Ukraine suffered the most from pests and diseases, but recently, due to favorable climatic conditions, the forest pests and diseases have spread throughout Ukraine. The dynamics of areas affected by forest pests and diseases is shown in **Figure 7**.

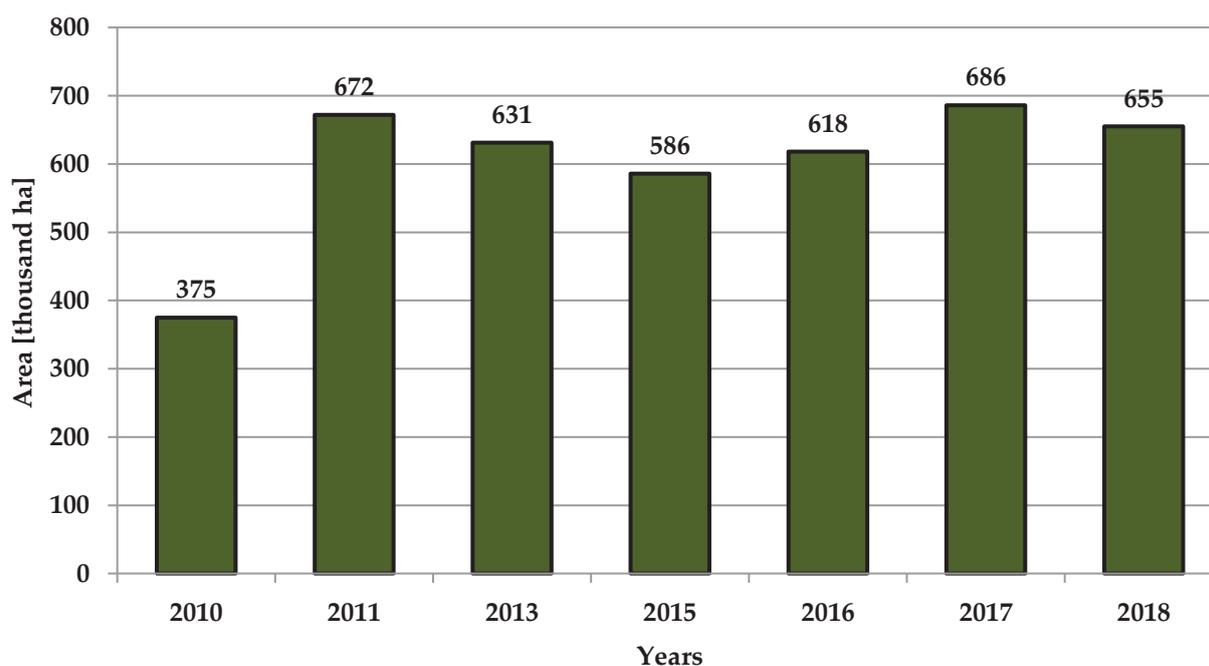


Figure 7. Dynamics of pests and diseases in forests of the State Forest Resources Agency of Ukraine

Forest protection against pests and diseases is carried out by a state specialized forest protection service, which is based on 7 state specialized forest protection enterprises. This service performs the following tasks: supervision, inventory of forest pests and diseases, forest pathology research, assignment and implementation of forest protection measures, methodological assistance to field employees. The priority of the state forest protection service is the development and implementation of biological pest control agents. Such agents are not harmful to humans or the environment and are used in densely populated areas of Ukraine and in forests where the use of chemical pesticides is prohibited.

As a rule, the main cause of forest fires in Ukraine is the violation of fire safety requirements in forests during periods of high and extreme fire danger, as well as burning on agricultural lands. The dynamics of forest fires is shown in **Figure 8**. A network of 507 fire observation towers has been set up in the forests of the State Forest Resources Agency, of which 337 are equipped with a television surveillance system. The enterprises of the State Forest Resources Agency systematically raise public awareness as to complying with fire safety requirements in forests, detecting violators of these requirements and fining them.

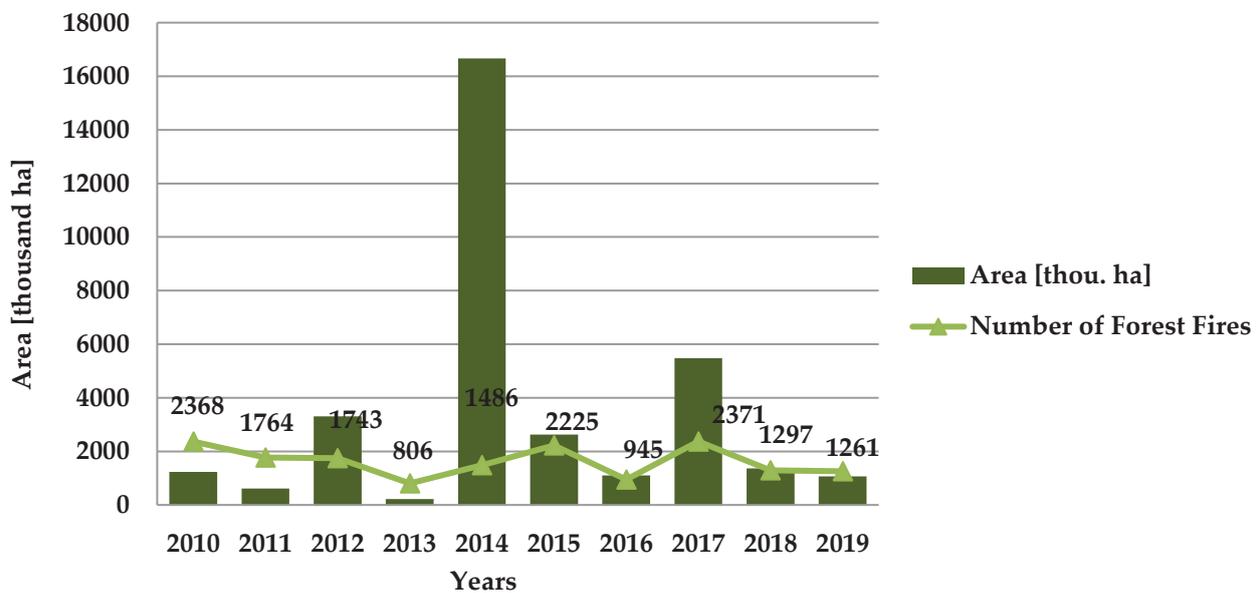


Figure 8. Dynamics of forest fires in the forests of the State Forest Resources Agency of Ukraine

More than 1.7 thousand forest units, 273 forest fire stations and about 17 thousand employees of the state forest protection center directly protect forests from fires. Forest fire departments are equipped as follows: 644 fire trucks, 467 forest fire protection modules, 1107 power pumps, 8.9 thousand back-pack sprayers, more than 2.1 thousand radio stations, etc.

3.3. Characterization of Forest Transport Network

The basis of sustainable development of forestry in Ukraine, rational and environmentally safe use of natural resources, efficient operation of tourism and recreation industries is a balanced network of forest roads. Transport routes play an extremely important role in the forestry sector of mountainous regions, where forest areas are located in large areas and are characterized by difficult terrain, soil and hydrological conditions, low concentration of harvested wood per unit area, one-sided flows of cargo and other factors.

The transport network of the Ukrainian forestry industry combines a network of skidding trails, by which it carries out the primary transportation (skidding) of timber from the felling site to loading points, and a network of forest roads to deliver wood from forest to the consumer. Skidding trails are divided into branch (within the felling area) and main (for delivery of wood to forest roads). The state of the skidding trails network is characterized by the value of the average skidding distance. Currently, the values of average skidding distances, in particular in the Carpathians, exceed the optimal several times and in some cases reach the length of several kilometers, indicating a significant distance of operational forests from forest roads, insufficient density and low branching of the road network.

According to their purpose, forest roads are divided into three types [4] (Figure 9):

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- I type – the main directions which connect forest roads into a forest transport network and connect forests with general purpose roads;
- II type – roads that serve separate territories of the forest area, connect them or separate forestry objects with the main directions;
- III type – provides access to forestry sites and haven't further branching, as well as fire roads.

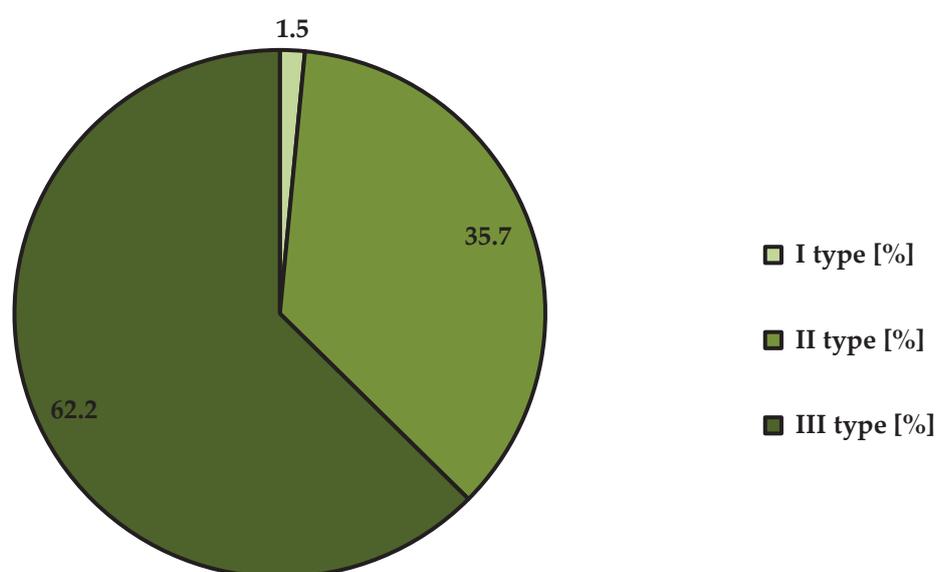


Figure 9. Structure of forest roads network in the Ukrainian forests

At the beginning of 2007, the total length of roads in the forests of the State Forest Resources Agency of Ukraine was 74.4 thousand km (including about 17 thousand km - public roads, which run through the state forest area) [5]. However, about 62% of all forest roads were type III roads (Figure 6). More than half of them had a width of the roadbed less than the normative values. Improved pavements (asphalt, gravel or gravel treated with binders) are rare on forest roads. More than 75% of the length of forest roads is not properly drained. Forest roads in the Carpathians are characterized by significant longitudinal slopes. On some sections, it exceeded the normative value more than twice. The year of 2007 was a turning point in the improvement of forest transport infrastructure, primarily due to the fact that in this year government funding was allocated for the construction of new forest roads and it has been introduced a new, more efficient, and more environmentally friendly, "excavator" construction technology. New forest roads began to be laid by methods of landscape design, at a sufficient distance from water flows, equipped with appropriate coverage and drainage structures.

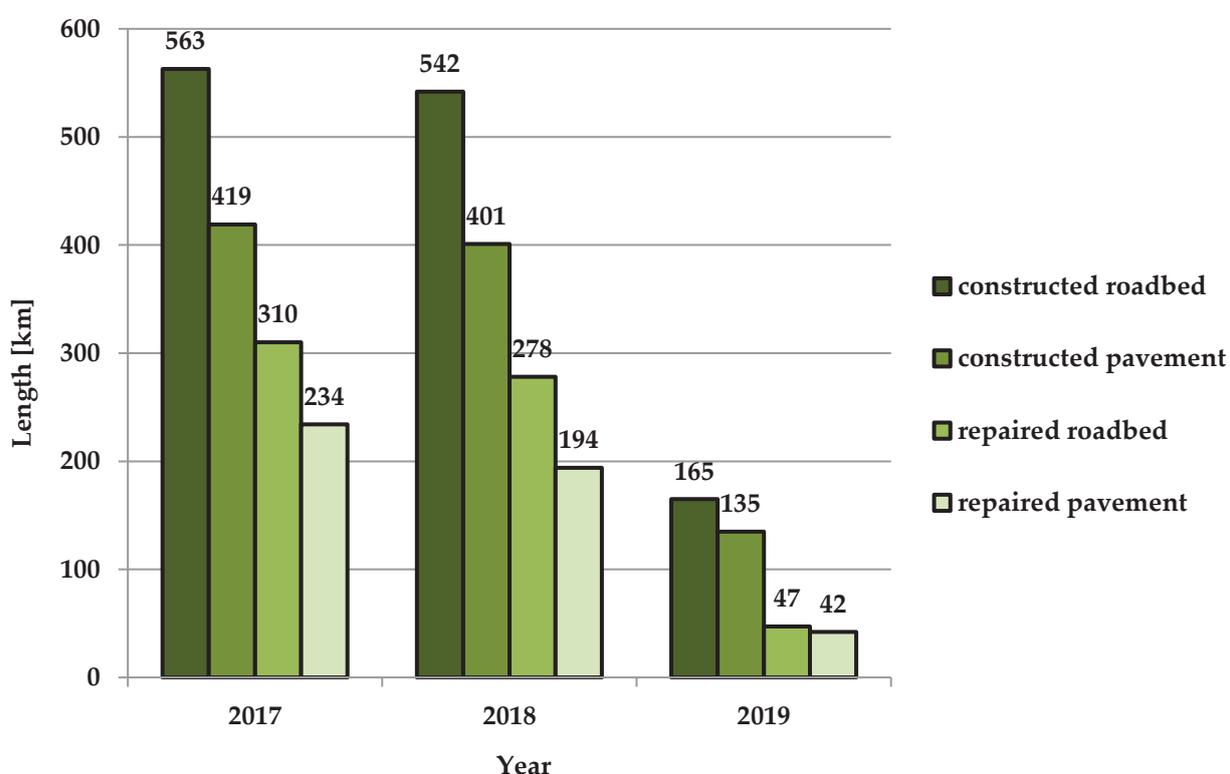


Figure 10. Construction and repairing of the forest roads in Ukrainian forests. Sources: [1, 6, 7]

Only in 2007–2016 about 5.3 thousand km of forest roads were constructed, repaired and put into operation, of which, about 1.9 thousand km in the Carpathian region. In some years, up to 1,000 km of forest roads were constructed and repaired. However, with the cessation of government funding in 2012 and subsequent changes in the regime of payment of taxes and fees by forest enterprises, construction works dropped, and in recent years amounted to several hundred km, which is several times less than the annual demand based on the position of transport development of new forests (Figure 10).

3.4. Characterization of Mechanization for Timber Harvesting

Two timber harvesting systems predominate in the forestry of Ukraine:

- Chainsaw - agricultural tractor with a trailer or with a winch/clam bunk (occasionally) – in Polissya;
- Chainsaw - skidder or (occasionally in inaccessible places) chainsaw - cable yarder - skidder) – in Carpathians.

Wood is transported mostly in assortments from 2 to 6 m long (85-88%) and occasionally in half-stems or stems. To perform certain types of work, including logging, construction of forest roads and so on, the state forest enterprises use their own technical means, or hire contractors from

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among private companies that have the appropriate permits and technical support. In 2019, about 83% of forestry work was performed by own technical means (Table 3).

Table 3. Availability of equipment at the enterprises of the State Forest Resources Agency of Ukraine (January 2020)

Name	Quantity, pcs	Name	Quantity, pcs
Tractors (skidders), total, of which	3577	Special machines, total, of which	585
Caterpillar tractors	305	Graders	44
Wheeled tractors	3272	Bulldozers	163
Forwarders	3	Excavators	309
Tractor trailers, total, of which	1428	Uprooters	6
Universal trailers	1233	Loaders	48
Timber trailers	195	Compactors	3
Skidding tractor winches	91	Scrapers	8
Mobile cable yarders	5	Other	4

Consider the example of the Lviv Regional Department of Forestry and Hunting use of forest machines for harvesting and transportation of wood. The forests of this department roughly model the production and operational conditions of the whole of Ukraine. Here, annually harvests are about 900 thousand m³ of wood in mountain, foothill and plain forests. Today, forestry enterprises of Lviv region harvest wood on their own (52%), as well as by contracting private companies (48%). So far, all the wood here is felled and processed by the use of chainsaws. As of the beginning of 2020, Lviv region enterprises used 397 chainsaws, most of which (57%) were produced by Stihl [8] (Figure 11).

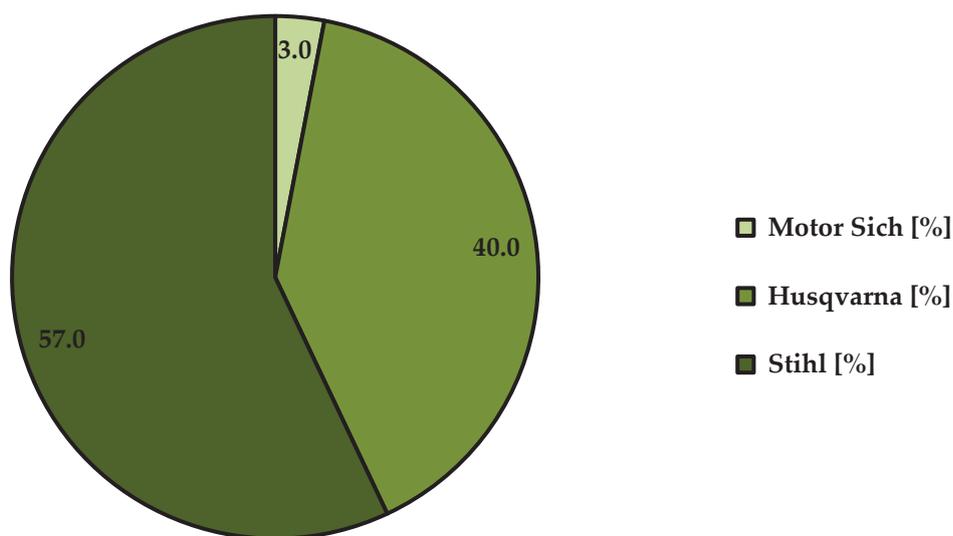


Figure 11. Availability of chainsaws at forestry enterprises of Lviv region

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There have been isolated attempts to use harvesters in logging. However, these were machines of private foreign contractors. All harvested timber is usually skidded to the loading site located near a forest road. To do this, there is a variety of equipment in use, starting with the use of horse skidding and ending with the use of forwarders. Cable systems are used in difficult mountain natural and operational conditions. In total, the enterprises of Lviv region operates 2 mobile cable systems manufactured in Slovenia MOZ 300 and the Czech Republic - LARIX 3T.

Wheeled agricultural tractors equipped with skidding winches are often used for the primary transportation of timber. This greatly facilitates the work and makes it possible to pull the wood to the tractor from a distance of up to 50 m. The forestry enterprises of Lviv region use 44 tractor winches, the vast majority of which are manufactured by Tajfun [8] (**Figure 12**).

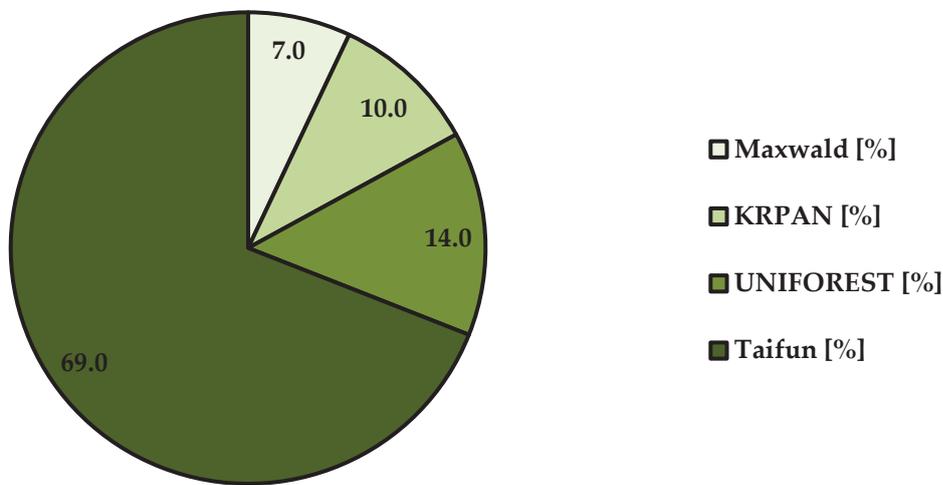


Figure 12. Availability of tractor skidding winches at the forestry enterprises in Lviv region

Recently, timber trailers with hydraulic manipulators in combination with agricultural tractors have been used to replace skidding machines. There are 32 such machines (**Figure 13**), most of which were produced by Weimer [8]. Productivity of timber transportation by timber trailers is from 20 to 50 m³ per work shift.

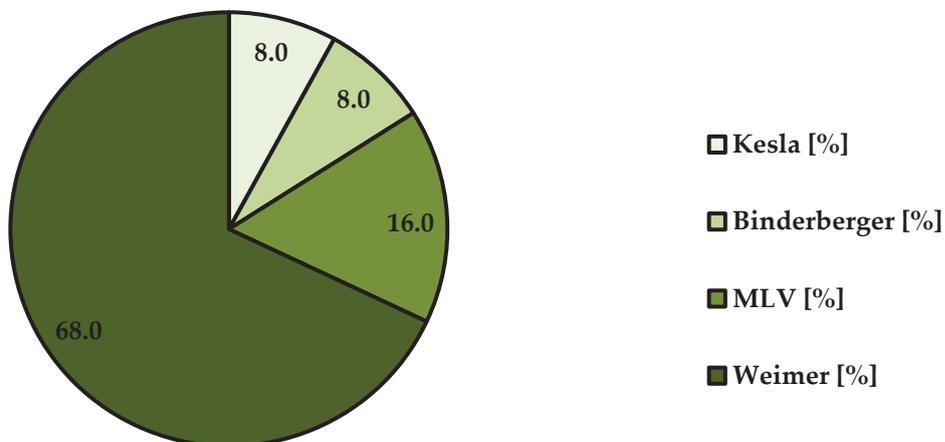


Figure 13. Availability of tractor timber trailers at the forestry enterprises of Lviv region

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Forwarders show a much higher performance. However, such machines are mostly operated by contractors. The brands used in timber harvesting are Timberjack, Ponsse, Mini Bruunett, Kockums, and Valmet - total of 5 units. So far, only one of the 16 forestry enterprises in the Lviv region, SE "Brody Forestry", holds its own forwarders. There are Amkodor 2662 (3 units) produced by the Republic of Belarus [8]. The performance of these machines depends on the operating conditions and the distance transportation and it is of 30 to 120 m³ per shift. A significant advantage of using such machines is that the wood supplied to consumers is uncontaminated, without damage, and the environmental condition of the logging sites after the work of forwarders is much better.

More than 130 units of timber transport vehicles are used for timber transportation on the basis of KrAZ, MAZ, URAL, KAMAZ and ZIL trucks. The vast majority of timber trucks are equipped with hydraulic manipulators. The most common of them are Epsilon Palfinger - 18 units, OMTL - 15 units, Weimer - 14 units and Oniar - units [8]. At the forestry enterprises of Ukraine, as a whole, operate more than 2 thousand units of timber transport vehicles (**Table 4**).

Table 4. Availability of vehicles for timber transportation at the enterprises of the State Forest Resources Agency

Name of the indicator	Value
Number of own vehicles for transporting timber, units, of which:	2199
Vehicles for stem transportation	241
Vehicles for wood assortments transportation	1450
Vehicles for non-timber transportation	508

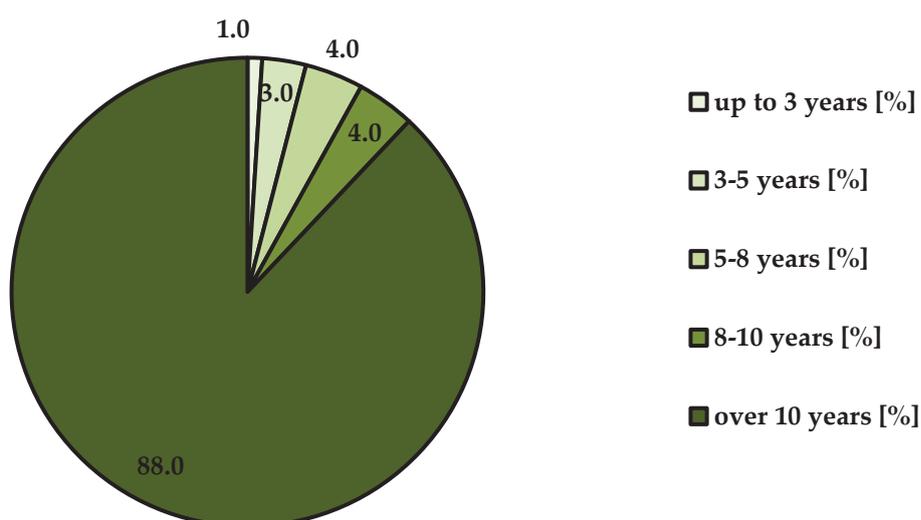


Figure 14. Age structure of the timber transport vehicles

The age structure of timber transport vehicles is shown in **Figure 14**. Among the available vehicles, machines over 10 years of age predominate (about 88%).

4. DISCUSSION

At the present stage the global community requirements are those for a forest management that should sustain the multifunctional importance of forests to ensure the stability, quality and diversity in conjunction with annual incomes and employment opportunities for local people. In addition, the recently proclaimed European Green Course, which is the European Union's strategy and program of action for the near future, calls for Europe to become the world's first climate-neutral continent. This document pays special attention to nature protection, biodiversity conservation, climate change reduction, waste management, air pollution, industrial pollution, etc., which places additional, demands on the forestry industry.

One of the most environmentally dangerous economic activities is logging. A key part of logging operations is the primary wood transportation, during which a number of factors arise that directly or indirectly affect the forest environment, in particular the development of the skidding trails. It should be noted that the amount of mechanical soil damage depends on the skidding distance. Reducing this indicator allows to reduce both the economic costs (for the construction of skidding trails, fuels and lubricants, depreciation of machines, etc.) and environmental damage caused to the forest environment. In addition, skidding trails are usually not provided with transverse drainage and during heavy rainfall become places of intense surface runoff, which reduces the hydrological role of forests. The average skidding distance is derived from the degree of branching and density of the forest road network.

Analyzing the state of the forest road network in Ukraine, we can conclude that its density is several times lower than in European countries. In particular, in the mountainous forests of the Carpathian region, where it is concentrated to 40% of the usable wood stock, the density of the road network is critically low. It is only 3.5-6.0 m/ha. However, over 10% of the forest roads length, which are on the balance of state forestry enterprises require reconstruction or repair. This state of the forest transport network does not contribute to the successful implementation of a set of environmental measures, the introduction of environmentally friendly harvesting technologies, improved care of forest plantations, involvement in the use of pest and disease-affected wood in the Carpathians and Polissya, creating conditions for operational access of fire extinguishers to forest fires in the southern and eastern regions of Ukraine.

The creation of an efficient transport infrastructure in the forest is a prerequisite for the introduction of the principles of sustainable forest management. Forest roads are essential not only for forest management, restoration and protection, but also for the overall development of the region, the creation of new jobs and the improvement of working and living conditions. To ensure an integrated forest management there is a need in the coming years to build annually at least 300 km of new roads and to restore by reconstruction or by repair 600 km of forest roads, which requires substantial financial and logistical costs.

Given that the creation of an optimal structure of the forest road network is a long multi-stage process that requires significant investment, at the end of 2020 the State Forestry Agency of Ukraine initiated the development of the Concept of the State Targeted Economic Program of Forest Roads for the 2022-2026 years. The purpose of this program is to improve the existing forest

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transport infrastructure in accordance with regulatory requirements and to expand the network of forest roads to a level that meets the needs of the State in forest resources on the basis of inexhaustible forest use.

Implementation of most of the forest operations on the basis of sustainable development is also impossible without the use of modern systems of forest machines, resource-saving and environmentally friendly logging technologies. Today, the forestry of Ukraine is dominated by the traditional timber harvesting equipment, which is based on the use of hand chainsaws. The use of multifunctional machines (harvesters) is very limited. Usually, these are second-hand machines, having an age that reaches more than 10 years. This situation is due to the low financial capacity of Ukrainian forestry enterprises. Subsequently, the harvested timber is transported to forest roads. In mountainous conditions, skidders are usually used in these operations, and forwarders are used in the plains. However, due to the high cost of forwarders, there is a preference toward agricultural tractors equipped with trailers, which are characterized by low productivity, ergonomics and environmental safety. Skidders are typically harmful to the environment, in particular to the soil surface. In the conditions of Ukraine there are also used agricultural tractors fitted for forest operations, which in the case of repeated passes can cause irreparable damage to the forest environment.

As the analysis of the age structure of technical means for primary transportation of wood shows, these are often morally and technically obsolete machines. As for the timber delivery transport, the Ukrainian automobile plant KrAZ produces modern timber trucks, which are increasingly used for timber delivery in the condition of Ukraine. At the same time, these vehicles also need updating and modernization.

Modernization of logistics of forestry enterprises, updating of forest machinery systems should undoubtedly take into account global trends in forestry engineering, the use of multifunctional machines and mechanisms and minimize their impact on the environment, in particular:

- Transition to the production of a new generation of forest machines and mechanisms using the latest advances in automation and electronics;
- Design of machines using a modular approach;
- Expansion of universality, interchangeability of technical means in various technological processes;
- Improving the mobility and versatility of forest machines used in extreme conditions (soil with low bearing capacity, extreme conditions - frosts, high temperatures);
- Increasing the quality and reliability of machines using ultra-light and durable materials.

This necessitates the development of the State program for the production of domestic logging equipment and timber transport machines on the basis of the existing powerful machine-building base in Ukraine (HTZ, "Pivdenmash", "Motor Sich" and others). This program requires combining the efforts of the engineering industry with scientific, educational and design

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institutions of the forest sector. It is also necessary to resolve the issue of acquiring licenses for production of modern foreign forest machines.

5. CONCLUSIONS

The current state of forestry in Ukraine, which is largely the result of numerous changes in regulations and the formation of the market relations over the past decades, cannot be characterized as satisfactory. Establishment of new economic relations, ensuring sustainable development of the forestry, improving its management, multi-purpose and efficient use of forest lands and forest resources, overcoming contradictions between economic, environmental and social goals, etc. necessitate the formation of a specific strategy for forestry development in Ukraine. The main objectives of such a strategy should be:

- Improvement of the legal framework, the model and mechanisms of public administration in the field of forestry, taking into account the world experience and international obligations of Ukraine;
- Separation of the state control functions from the functions of management;
- Improvement of the state system of financial and economic support of forestry;
- Development of state programs to improve forest transport infrastructure, comprehensive technical re-equipment, introduction of modern innovative, environmentally safe technologies in forestry, forest care, forest protection and logging activities;
- Increasing the forest cover of the territory, preserving and increasing the biological diversity of forest ecosystems, strengthening their resilience to negative factors, in particular, climate change;
- Efficient use of forest resources on a market basis;
- Development of forestry science and education, expansion of international cooperation and improvement of the communication process, public awareness in the field of forestry, etc.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

EXTENDED ABSTRACT – REZUMAT EXTINS

Titlu în română: *Silvicultura în Ucraina: Situația actuală, provocări și modalități de abordare ale acestora*

Introducere: *Lucrarea de față analizează starea actuală a sectorului forestier din Ucraina și descrie caracteristicile de bază ale pădurilor și ale managementului forestier, în principal cele legate de suprafețele reduse ocupate de păduri, creșterea pădurilor în diverse zone geografice ale Ucrainei, importanța ecologică a pădurilor cu funcții principale de protecție, care ocupă o pondere însemnată (circa 50%) și în care recoltarea lemnului este limitată, ponderea mare a ariilor protejate (16%), caracterizată de un trend constant crescător, subordonarea pădurilor unui număr mare de utilizatori permanenți și, respectiv, localizarea unei părți importante din suprafața împădurită în zone cu contaminare radioactivă etc.*

Rezultate: *Există diferențe majore legate de gradul de împădurire specific diverselor zone din Ucraina, în general, acesta neîntrunind nivelul considerat a fi optim pentru a se asigura efectele pozitive necesare cu privire la climat, sol și resurse de apă, prevenirea eroziunii și furnizarea de lemn. Pentru a se atinge un nivel optim din acest punct de vedere, care este considerat a fi de 20% din suprafața țării, trebuie plantat un număr de circa 3 milioane de hectare. Volumul de lemn recoltat în prezent este mai mic decât posibilitatea stabilită, aspect care asigură un management sustenabil al pădurii din punct de vedere al efectelor asupra mediului. Volumul total de lemn recoltat în scop comercial este de circa 21-22 milioane metri cubi, ceea ce indică că nu este utilizat întregul potențial productiv al pădurilor din Ucraina. Analiza rețelei de drumuri forestiere din Ucraina indică faptul că densitatea acesteia este insuficientă și mult mai mică decât cea din Europa. În particular, zonele forestiere localizate în Munții Carpați, unde este concentrat 40% din volumul potențial valorificabil al pădurilor din Ucraina, densitatea rețelei de drumuri este foarte mică, de numai 3,5 – 6,0 m/ha. De asemenea, mai mult de 10% din lungimea drumurilor forestiere, care sunt în administrarea întreprinderilor forestiere de stat, necesită reparații majore. Pentru a se întruni necesitățile și prioritățile managementului forestier din Ucraina, în anii următori este necesară construcția anuală a cel puțin 300 km de drumuri noi și reabilitatea prin reparații a cel puțin 600 km de drumuri forestiere. Tranziția la aplicarea principiilor sustenabilității necesită re-echiparea industriei forestiere și introducerea de tehnologii moderne, inovative și prietenoase cu mediul. Contribuția sectorului forestier Ucrainian în Produsul Intern Brut al țării este considerată a fi nesemnificativă, fiind de ordinul a 0.40 – 0.45%.*

Concluzii: *Pe baza studiului realizat, se poate concluziona că starea actuală a pădurilor și a sectorului forestier din Ucraina este una nesatisfăcătoare, fiind rezultatul numeroaselor schimbări de natură legală și a relațiilor de pe piață. Pentru a se asigura o dezvoltare sustenabilă a pădurilor și a sectorului forestier, este necesară utilizarea polivalentă și eficientă a pădurilor, îmbunătățirea eficienței managementului, rezolvarea contradicțiilor care există între obiectivele de natură economică, de mediu și socială; acestea se pot realiza prin construirea unei strategii de dezvoltare a industriei forestiere în Ucraina. Principalele obiective ale unei astfel de strategii ar trebui să fie: îmbunătățirea cadrului legal prin luarea în considerare a experienței acumulate la nivel internațional și a obligațiilor internaționale ale Ucrainei, îmbunătățirea modelului și mecanismelor de administrare publică a pădurilor, dezvoltarea de programe de stat pentru construcția de drumuri forestiere, re-echiparea industriei și introducerea de tehnologii noi pentru operațiile necesare în pădure.*

Cuvinte cheie: *Industria forestieră din Ucraina, probleme actuale, management forestier sustenabil, infrastructură de transport forestier, reechipare tehnologică.*

REFERENCES

1. Publichnyi zvit Derzhavnoho ahentstva lisovykh resursiv Ukrainy za 2020 rik. Available online at: <https://mepr.gov.ua/news/34682.html>. (accessed on 24-10-2020).
2. State Statistics Service of Ukraine. Available online at: <http://www.ukrstat.gov.ua>. (accessed on 29-10-2020).
3. Lisovyi Kodeks Ukrainy. Available online at: <https://zakon.rada.gov.ua/laws/show/3852-12#Text> (accessed on 24-10-2020).

Styranivsky et al.: Forestry of Ukraine: Current Situation, Challenges and Ways to Tackle them

4. Styranivskyy O., Styranivskyy Y.O., 2010: Pryrodookhoronni zasady transportnoho osvoyennya hirskykh lisovykh terytoriy: monografiya. – Lviv: RVV NLTU Ukrayiny. Ukraine, p.2208.
5. Prystaya O., 2008. Problema staloho rozvytku lisotransportnoyi infrastruktury ta shlyakhy yiyi vyrishennya // Avtoshlyahovyk Ukrayiny. Ukraine, pp. 46-48.
6. Publichnyi zvit Derzhavnoho ahentstva lisovykh resursiv Ukrainy za 2017 rik: Available online at: <https://drive.google.com/file/d/1EJLTOTNxC7N2T1qDQ5-0LDKwyPIDWfEx/> (accessed on 15-12-2020).
7. Publichnyi zvit Derzhavnoho ahentstva lisovykh resursiv Ukrainy za 2018 rik: Available online at: https://drive.google.com/file/d/194P-skQpV9fi1BOdYBGSKix_u1yHlfhQ/view (accessed on 15-12-2020).
8. Hromiak Y., Konovalets I., 2020: Lisovi mashyny v derzhavnykh lisakh Lvivshchyny. Sohodennia. International scientific conference "forest engineering: new techniques, technology and environment" May 28-30, 2020 Abstract book. – Drohobych: POSVIT, p. 50.