

## Ecological Analysis of the Current State of Forest Resources in Forest Steppe of Ukraine

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### ABSTRACT

Forests perform essential ecological functions - water protection, sanitation, health, recreation, and aesthetics. The research aimed to substantiate the ecological and economic importance of forest resources in the Kyiv region and analyse their rational use and protection. The article shows that the Kyiv region belongs to the regions with an average level of forest cover – 592.8 thousand hectares or 22.2%. The level of forest cover is uneven in the area of the Kyiv Forest zone. It is 44%, and in the area of the Forest-Steppe, it is much lower and decreases from north to south. The use of forest resources in the Kyiv region in 2019 amounted to harvesting liquid wood of 999.5 thousand m<sup>3</sup>, and deforestation was carried out on 75.5 thousand hectares. The region's volume of forestry works and services amounted to 8,9 million dollars, and the wood stock makes 90805,9 thousand m<sup>3</sup>. Emphasis is placed on the importance of protecting the Red Book species of plants and fungi that grow in the forests of the Kyiv region. Examples of harmful economic activity in the areas belonging to the nature reserve fund and large-scale fires in April 2020, which covered more than 3.5 thousand hectares of forests in the region and caused damage to forest fauna and flora. The studied region's positive environmental and economic factors have been admitted by planting trees on an area of 2151 hectares and sowing seeds of forest species on an area of 67 hectares in 2020.

**Keywords:** forest resources, conifers, the area of the nature reserve fund, deforestation, forest fires, tree diseases, red book species, fungi.

## INTRODUCTION

Forest ecosystems provide essential ecological services and resources, which is why they are highly valued by humanity [Watson et al., 2018; Debal, 2014; Isabel, 2020; Ammer et al., 2018; Franklin, 2020]. It is known that forest ecosystems are characterised by the high intensity of the biological cycle of substances and energy, having a contribution to terrestrial biomass. Forests are one of the crucial components of the natural environment, covering about 30% of the land area (FAO, 2012; Mehring et al., 2008). It affects the climate, water and air purity, protects agricultural land from winds and water flows, forms the carbon balance of the atmosphere, and preserves biodiversity [Shvidenko et al., 2017; Pilli et al., 2018; Ameztegui, 2018; Schuh et al., 2022; Venalainen, 2020; Marques et al., 2019; Pastur et al., 2020]. Future losses of forest coverage could happen due to deforestation and conversion to other types of land use. That could negatively affect the earth total freshwater reserves, threatening the survival of millions of people and harming the environment [Ekhuemelo et al., 2018].

Currently, in the European Union, great attention is focused on implementing current forest policy and conserving forest biodiversity to improve the ecological state of the environment [Aggestan et al., 2018]. At the United Nations World Conference on Environmental Quality and Further Human Development, held in Rio de Janeiro (1992) in the Agenda for the XXI Century Action Program, scientists focused on environmental issues related to deforestation and the preservation of global forest functions and forest areas. The program sets out the objectives of ensuring a holistic and rational transition to the sustainable and environmentally safe development of forests, renewable use of forest resources, their development and conservation. As a result, the United Nations has approved a program to restore the world's forest landscapes, committing to creating new forests by 2030 on an area of 350 million hectares [Lendyel & Zhulkanych, 2018].

The actual forest area of Ukraine is 10.4 million hectares, including 9.6 million hectares covered with forest vegetation or 15.9% of the state territory. At the same time, despite the relatively small forest cover of the territory, among European countries, Ukraine ranks 9<sup>th</sup> in forest area and 6<sup>th</sup> in terms of total timber reserves. Moreover, the territory of Ukraine is located in several

geographical zones; therefore, afforestation is heterogeneous. Consequently, the forests in the regions will be unevenly distributed [Report of the State Agency of Forest Resources of Ukraine, 2019]. Analysing the report of the State Agency of Forest Resources, we note the introduction of two state programs of the Cabinet of Ministers of Ukraine, which provide for the main goals in the field of forestry. The first program is entitled “Ukrainians use natural resources more efficiently and economically”, and the second – is “Ukrainians preserve natural ecosystems for posterity”.

In December 2019, the Cabinet of Ministers of Ukraine adopted a regulation to approve the procedure for monitoring domestic consumption and quality control of domestic raw timber. This act of governance introduces mandatory electronic accounting of wood by all forest users in Ukraine. Such an approach will ensure control in forest use regarding extra logging and sales of timber in order to avoid uncontrolled exploitation.

### Review of publications on the topic of research

Reliable information on the current state of forest resources in Ukraine, methods of forest management, access to the scale of use of forest resources and the facts about illegal logging can be obtained from many information sources. These include the annual reports of the State Agency of Forest Resources of Ukraine, publications of the State Statistics Committee of Ukraine and regional main statistical offices; reports of regional departments of forestry and hunting, regional departments of forestry utilities and other forest users; professional publications of research institutes and educational institutions [Henyk Ya, Henyk O, 2011; Novosad, 2011].

According to the literature [Buksha et al., 2014; Yukhnovskyy et al., 2013; Raspopina et al., 2019; Bartniczak, B & Raszkowski, A. 2018; Solomou et al., 2018; Löf, M., Madsen, P., Metslaid, M. et al., 2019], the list of critical ecological functions includes water and wind protection, sanitation, health, recreation, aesthetics, and education. The most critical service for the environment of the forest is acting as a regulator of the water regime. Trees influence the formation of water balance and river runoff. Also important is the protection of soils from dangerous water-erosion processes, acting as soil protection, climate-forming and climate-regulating factor.

Forests are unique ecosystems containing many organisms of flora and fauna, as well as a variety of fungi, with a high degree of concentration. Accumulated biomass in forest crowns forms a considerable amount of organic matter, supporting the growth of primary productivity and the diversity of organisms contributing to primary soil formation [Kucher et al., 2022]. Therefore, forested areas are essential for biodiversity conservation. In Ukraine, about 41% of plant species and 31% of animal species listed in the Red Book of Ukraine live in forests [State Agency Data of the forest Resources of Ukraine, 2017].

Recovery of oxygen on the planet and maintaining the composition of the atmosphere also largely depends on the functioning and productivity of forest resources, which give the atmosphere 6% oxygen. In globally growing industrialisation, forests are a leading factor in environmental stability, preservation and conservation. They clean the air from impurities of toxic gases, aerosols, and dust. For many, they are a place of recreation, treatment and tourism. It has been established that 1 ha of plantations retains 70 tons of dust and soot in 1 year and emits 4 tons of oxygen [Deforestation of Ukraine, forum]. Also, forests perform an important microclimatic function. In summer, the forest temperature is 2–4°C lower than in open areas, and humidity is higher, allowing buffering of extreme weather events to influence biota. Moreover, the air in the forest is saturated with phytoncides inhibiting pathogenic bacteria growth and sanitising the environment. The research aimed to analyse the ecological importance of the Kyiv

region's forest resources and their rational use and protection. The object of research was forest ecosystems typical in the Kyiv region. The research subject was the ecological properties of forests and their role in ecosystems and society.

## RESULTS AND DISCUSSION

Several indexes indicate an ecologically balanced relationship between arable land, sustainable lands, reservoirs and forests. However, analysis of forest resources in Ukraine regions showed that those indexes deviate from optimum, mainly in soil-related and geographical areas of Ukraine. The Kyiv region is no exception, with forest areas in Polissya and the Forest-Steppe geographical zones with an average forest cover level from 21 to 30% (Fig. 1) [Rehionalna dopovid, 2021]. The total area of the Kyiv region's forest fund to 01.01.2021 was 648.7 thousand ha, which was 22.2% of the territory [Regional Report, 2021].

The forest cover level is uneven in the region's districts and decreases from north to south. Thus, in the area of Kyiv Polissya, it is 44%, and in the Forest-Steppe (Zhuriv and Yahotyn districts), only 2% [Stepanenko, 2018]. Therefore, to achieve the optimal forest cover of 23% for the Kyiv region, it is necessary to increase the afforestation area by at least three per cent. At the same time, a particular part of forests also needs radical reconstruction and replacement with more valuable and productive forests. Furthermore, old-grown forests are characterised

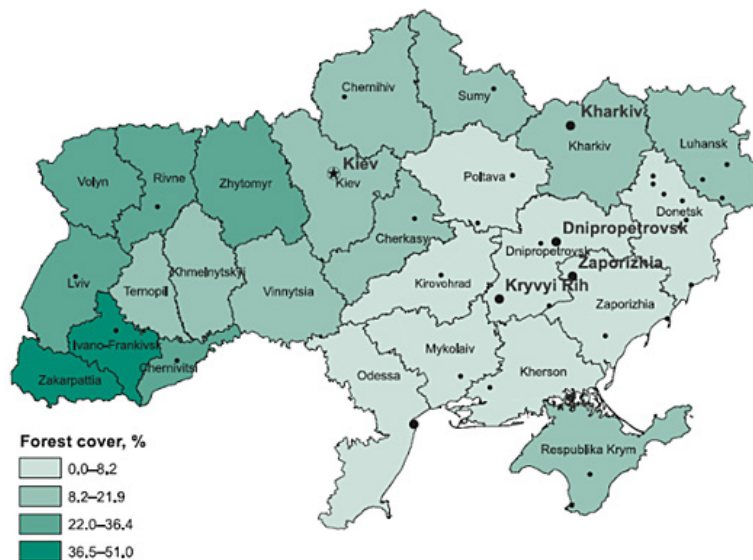


Fig. 1. Ranking of regions of Ukraine by forestry level, % (data of the State Geocadastre of Ukraine)

by deteriorating sanitation causing reduced environmental protection functions, especially in oak and undergrowth forests of the third and older generations [Tkach et al., 2013].

The ecological value of forest areas is also depicted in the ability to balance economic activities and energy conservation by achieving energy balance in forest ecosystems through aggregating renewable and energy resource storage. Such balance is critical in the current climate change environment. Therefore, the World Bank is constantly researching the overall economic value of forests and developing methods for valuing the ecological functions of ecosystems and territories [Vasylyshyn et al., 2018]. Furthermore, as was said before, forest areas of conservation and recreational importance accumulate and store carbon [Ramage et al., 2017]. Moreover, adapting the vulnerability of trees in plantations to adverse factors by selecting planting materials and protecting ancient forests (Table 1).

The global importance of forests is also related to the water protection in forest plantations influencing all parts of moisture exchange: water

resources, water runoff and soil protection from erosion. A critical component is the hydrological role of forests, which is formed from moisture regulation by the planting system - soil (water-regulating properties). Its positive consequences are an increase in groundwater resources (water protection role) and a decrease in slope water runoff, and a uniform return of moisture into the channel network (stock-regulating value) [Yukhnovskyy et al., 2013; Berezhniak, 2014].

The primary function of the forest’s water protection is preventing the occurrence of sloping water runoff and erosion-mud phenomena, flood regulation and increasing the resources of soil nutrition of rivers (Fig. 2). Forest belts also play an essential role in the region’s forest resources. Forest belts on agricultural lands protect the soil against different types of erosion. Today in Ukraine, about 350 thousand ha of protective and 90 thousand ha of water-regulating forest belts exist. Under its protection are 13 million hectares of land, only 40% of arable land. The achievement of ecological safety in agricultural landscapes of Ukraine is available only by the increase of the

**Table 1.** Example of Climate Smart Forestry policies and measures that combine mitigation and adaptation principles [Buksha, 2018]

Prevention (mitigation)	Adaptation
Increasing carbon sequestration by increasing forest area and tree population and conserving forest carbon stocks: - afforestation, reforestation and forest reconstruction; - an increase of forests in agroecosystems; - increasing carbon stocks and the ability of forests to absorb carbon through forestry measures; - increase in carbon content in soils	Reducing vulnerability and enhancing the adaptability of trees and forests, especially in vulnerable forest ecosystems: Forest biodiversity management: - selection of planting material of appropriate origin and preference for adaptive species; - protection of ancient forest stands; - protection of functional groups and critical species; Protect against landscape fragmentation and strengthen biodiversity corridors.



**Fig. 2.** An example of the soil protection function of forests is the reduction of slope runoff and soil erosion (Goloseevsky forest slope, Kyiv)

number of shelterbelts more than twice nowadays. Because good protection of fields by forest belts not only prevents the development of water and wind soil erosion but also contributes to an increase in yield by 18-30% [Zhu & Song, 2021; National Project of shelterbelts renovation].

Forest bogs are also essential for the soil’s accumulation and retention of moisture. However, their reclamation and drainage are often negative, leading to lower groundwater levels. Therefore, conserving wetlands is of exceptional ecological importance for protecting forest ecosystems’ biotic and landscape diversity. For forests to fully perform their essential ecological functions, it is necessary to have healthy trees. Therefore, we analysed data on general felling in the region, starting from 1971 to 2020 (Table 2).

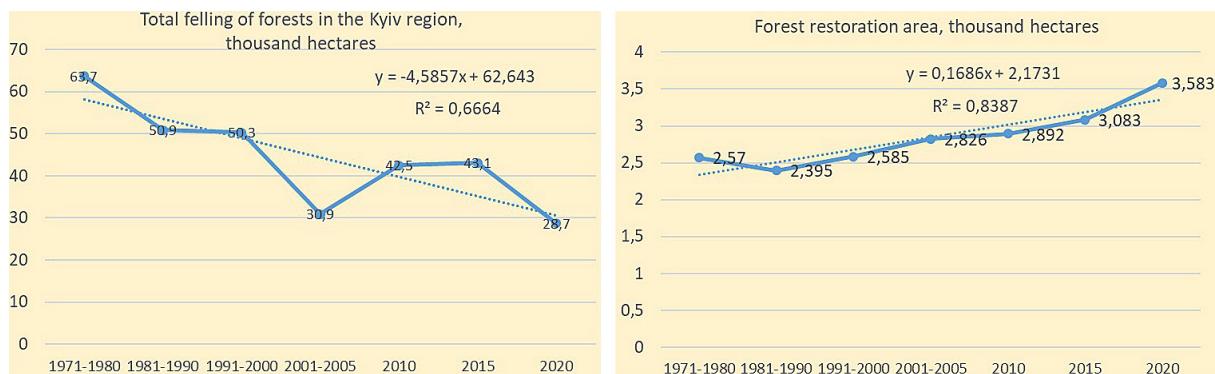
We can see, until 2005 there was a tendency to decrease the area under felling, which in 2001-2005 was carried out on average by 30.9 thousand hectares. Later, over the years, the felling area grew significantly, where in 2010 it was 42.5 thousand hectares, and in 2015 – 43.1 thousand

hectares, sharply decreasing as of 2020 – 28.7 thousand hectares. Therefore, based on the regression analysis, we predict that by 2025 general felling will be carried out on an area of about 18.0 thousand ha (Fig. 3).

As for measures to restore forests, their area over the years was stable and equal in size and slightly increased as of 2020, when the total forest restoration area was 3.58 thousand hectares. In particular, in 2015, the area under sowing forest plantations was 2.49 thousand hectares, and under natural regeneration – it was 0.359 thousand hectares. The regression analysis of these data shows a slight increase in reforestation areas. The linear equation for calculations is presented in Fig. 3. The coefficient of determination ( $R^2$ ) is also relatively high, which was  $R^2 = 0.66$  for general felling of forests, and  $R^2 = 0.84$  for areas of restored forests. The high correlation between the artificially planted forest and its natural renewal should also be noted, where the correlation coefficient was  $r = 0.93$ . From the above, there follows a tendency to decrease the area of felling

**Table 2.** Dynamics of changes in the forest activities in the Kyiv region of Ukraine over the past 50 years, in thousand ha [data taken from the Kyiv regional and Kyiv city management of forestry and hunting]

Activity	Years							± до 1971
	1971–1980	1981–1990	1991–2000	2001–2005	2010	2015	2020	
General logging	63.7	50.9	50.3	30.9	42.5	43.1	28.7	-35.0
Logging for forest care	19.3	21.0	13.1	11.0	14.7	14.8	-	-4.5
Reforestation area	2.570	2.395	2.585	2.826	2.892	3.083	3.583	1.013
Sowing & planting forests	2.261	2.137	2.249	2.425	2.477	2.487	-	0.226
Natural renewal	0.195	0.097	0.282	0.335	0.358	0.359	-	0.164
Forest pathology observation	187.9	192.4	1165.5	293.1	298.4	289.4	-	101.5
Protection of forests from pests and diseases	22.92	25.45	28.90	22.39	29.19	25.09	19.45	3.47
Using of biological preparations	0.070	0.710	1.043	0.721	0.680	0.680	-	0.610



**Fig. 3.** Dynamics of changes in total forest felling (a) and the area of their restoration (b) in the Kyiv region

and a slight increase in the area of forest restoration, which certainly cannot but please. The state forestry companies, working under the supervision of the Kyiv Regional and City Departments of Forestry and Hunting, have fulfilled the annual plan for afforestation ahead of schedule. Thus, as of June 2020, about 1,749 hectares of forest crops have been created. It was planned to implement these measures on an area of 1,545 hectares. The main forest-forming species are *Pinus sylvestris* and *Quercus robur*. In 2017, 3552.0 ha of forests were rehabilitated (115.7% of the planned), including 3069.0 ha of sowing and planting.

Of particular value are forest ecosystems, which are part of the network of nature reserves. The main legal instruments for implementing the European Union's biodiversity policy, which affects forest ecosystems and management, are the directives on protecting wild birds and conserving wildlife habitats. The main goal is to ensure biodiversity by protecting natural habitats, including those that provide shelter for wildlife on the European territory of European Union member states [Kaliszewski, 2018].

As of January 1, 2021, 238 objects of the nature reserve fund with a total area of 292,440 hectares have been created in the Kyiv region. The percentage of reserves is 10.40%. Such facilities include the Chernobyl Biosphere Reserve, the Belozersky and Zalissia National Nature Parks; 4 regional landscape parks; 16 reserves of national importance and 92 of local importance; 91 natural monuments; dendrological parks of national importance; 15 parks-monuments of landscape art; 16 protected tracts [Materials of State Ministry of Environmental Control, 2021]. In addition, the protection of rare species of endangered plants and typical natural plant communities is carried out [Polyvach, 2016]. According to the Law on Flora, these plant species are subject to special protection. They are listed in the Red Book of Ukraine and international red lists. Information

on the protection of inexhaustible use and reproduction of plants is presented in Table 3.

The total number of species of plants and fungi growing in the region and listed in the Red Book of Ukraine is 129 (Table 3). The number of species of plants and fungi listed in the annexes to the Convention on the Conservation of European Wildlife and Natural Habitats is 2. Rare plants found in the forests of the southern part of Kyiv Polissya include such species: *Lycopodium annotinum*, *Botrychium multifidum* (Fig. 4), *Lilium martagon* (Fig. 5), *Epipactis helleborine*, and *Pulsatilla patens* [Vasylyuk, 2012]. Therefore, these plants need special attention and protection.

At the same time, there are known cases of illegal economic activity of people in the territories of the nature reserve fund. These include the unauthorised development of minerals as a sand quarry on the territory of the reserve "Tulinetsky forests", the use of nature reserves areas as training grounds for competitions on high-altitude vehicles in reserve "Vasilkovsky Carpathians", the creation of nurseries for wild animals in reserve "Dibrova", installation of memorial and cultural buildings on rare plant populations in Kopachiv



Fig. 4. *Botrychium multifidum*

Table 3. The number of species of plants and fungi protected in the Kyiv region, [Regional Report, 2021]

Number of protected plant and fungal species	In 2020
Species of plants and fungi in the region, units	65
% of the total number of species of Ukraine	59
Species of plants and fungi listed in the Red Book of Ukraine, units	129
Species of plants and fungi are listed in the annexes to the Convention on the Conservation of European Wildlife and Natural Habitats, units	2
The species are listed in the appendices on international trade in wildlife species and endangered flora (CITES), units	30



Fig. 5. *Lilium martagon*

Slopes Reserve [Regional Complex Programme]. Other factors affecting forest resource reduction and quality are anthropogenic and natural fires. According to the Main Department of Statistics in the Kyiv region, in 2019, there were 567 forest fires, and the total area of forest land affected by fires amounted to almost 75.5 thousand hectares. Large-scale forest fires occurred in the northern part of the region in the spring of 2020. It was causing an ecological catastrophe for our state and the environment, irreversible damage, and air pollution by releasing carbon monoxide and smog. Such pollution reached the territory of Kyiv city, affecting the population. In April 2020, firefighters eliminated large-scale fires for several days, causing significant damage to forest fauna and flora. The fire destroyed a large part of forests - the fire covered more than 3.5 thousand hectares in the Chernobyl Exclusion and Unconditional (Compulsory) Resettlement Zones.

Negative phenomena that have a detrimental effect on forest ecosystems include the drying up of stands among pine plantations in the region. In studies [Maurer & Pinchuk, 2019], groundwater decline, pests, and pathogens are the leading causes of deforestation, as harmful as climate

change influence. In connection with modern climate changes, a unique role must be given to forest pathology observation, their protection from pests and diseases, and the practical use of ecologically safe biological preparations. In 2015, the area of forest pathology surveys was 289.4 thousand hectares. The protection of forests from pests and diseases was 25.09 thousand hectares, and the use of biological preparations was carried out on an area of 0.680 thousand hectares (Fig. 6).

Most forest pests belong to the class of insects. Ticks and vertebrates have a somewhat smaller impact. During periods of mass reproduction outbreaks, insects can spread over hundreds of hectares, severely damaging trees. At the same time, their growth is lost, weakening and drying. To prevent the mass spread of tree pests, such plantations are treated with insecticides (chemicals) that are toxic to beneficial biota species. Biological measures are ecologically safe, including resettlement of beneficial birds, hanging bluebirds, increasing the area under fruit tree species to attract birds to damaged forests better, and resettlement of forest ants. Mass reproduction of trunk pests of forests depends on the viability of trees, plantations and their sanitary condition.

Therefore, it is necessary to carry out preventive forestry measures in plantations with deteriorated sanitary conditions, which will increase the biological stability of plantations. It includes the creation of mixed crops with undergrowth, planting trees most adapted to local environmental conditions and relatively resistant to pests and diseases, rationally carrying out maintenance and sanitary felling, and cleaning felling sites from felling residues. Furthermore, it is crucial to carry out forest protection measures on a larger scale that would contribute to the growth of the resistance of plantations to pests and diseases and

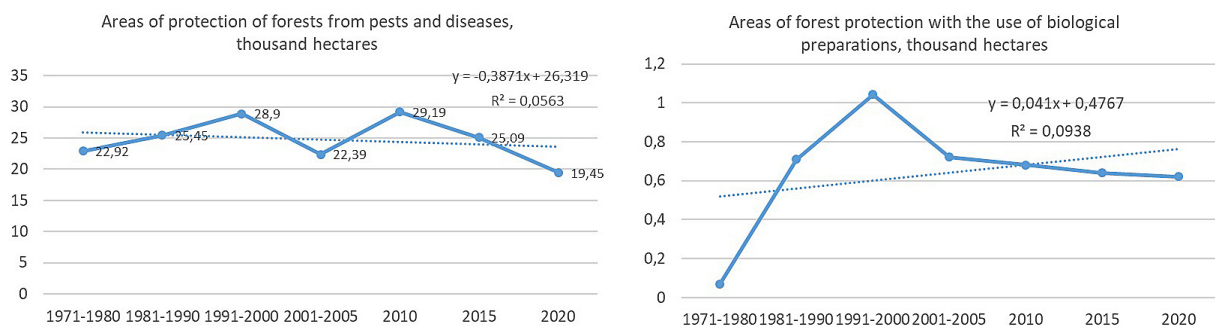


Fig. 6. Dynamics of changes in forest protection areas from pests and diseases (a) using biological preparations (b) over the past 50 years in the Kyiv region, thousand hectares

significantly smaller losses of productive wood. Therefore, the development and practical implementation of biological means of combating forest pests should be included in the priority areas of activity of the forest protection service. Such measures will not be harmful to the local population and the environment in general, especially in areas where chemical means of control are prohibited.

Among the measures to improve the condition of forest plantations in the region, the Decree of the head of the Kyiv Regional State Administration named “Regional Comprehensive Forest Development Program of Kyiv region until 2027” was introduced [Regional Complex Programme]. It supports the implementation of measures for the reconstruction and restoration of agricultural forests, protective forest plantations in fields and along highways, railways, and water bodies, afforestation of degraded lands within the Kyiv region, efficient use of wood in industrial forests, plantations of fast-growing plantations following the Land Code of Ukraine. Furthermore, the program includes developing the region’s forest (municipal) fund, ensuring the increase of forest areas, improving the condition of forest plantations and their cultivation, and preserving biological diversity. In addition, several measures are aimed at protecting forest plantations, including against fires.

## CONCLUSIONS

Kyiv region belongs to the regions of Ukraine with an average level of forest cover, where 745.9 thousand hectares or 20.4% of the territory is covered by forest. The importance of conservation and protection of Red Book species of plants and fungi found in the region’s forests and identified cases of illegal economic activities in protected areas were highlighted. Damage to the ecological condition of forest ecosystems resulted from large-scale forest fires in the region. More than 3.5 thousand hectares of forests were damaged, affecting forest fauna and flora in April 2020. The positive aspects of the regional forest use were identified as planting forests and the ongoing introduction of an integrated Kyiv regional program of forest fund development until 2025.

We recommend that annual sanitary and selective felling should be carried out in forests characterised by the mass spread of pathological processes and associated with the destructive action of pests. It allows for the elimination of

dry, diseased and weakened forests by pests. That artificial forest plantation must be created in the freed areas. It is also appropriate and ecologically safe to develop and introduce biological means of combating forest pests in the region.

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