

## ECOLOGICAL AND ECONOMIC ASPECTS OF AFFORESTATION IN UKRAINE IN THE CONTEXT OF SUSTAINABLE LAND USE

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**Abstract.** Over the past half a century, the total area of forests in the world has decreased significantly. Ukraine belongs to sparsely wooded and wood-deficient countries as the share of forest cover is 15.9% against the required optimal value of 25-30%. Steppe areas are characterized by 1.9–4.8% of woodland. The total area of forest land belonging to the forest fund of Ukraine is currently 10.4 million ha, including 9.6 million ha of forest vegetation; there are restrictions on woodland management for about 3.5 million ha of forests. In Ukraine, 4.03 million ha of forests were cut down in 2008–2017; moreover, about 170.7 thous. ha were destroyed by fires, pests, storms and poachers; only 16.3% of this area was recovered. In order to ensure the optimal forest cover, it is necessary to differentially restore the forest area in Ukraine on 6.0–9.2 million ha. The average shelterbelt ratio in some physical-geographical zones of Ukraine varies within 1.3–1.5%, whereas the optimal forest cover should be 3.0–4.5%. In particular, about 76.0% of the territory of the steppe zone of Ukraine has an insufficient forest cover, which causes systematic negative manifestations of water and wind erosion. This situation is aggravated by a high percentage of land under agricultural use in the southern regions - up to 97%, which results in a low degree of ecological sustainability of landscapes in preserving soil fertility. Retrospective analysis showed a significant (1.9–2.3 times) decrease in the area of shelterbelts over the past 60 years. The total loss of shelterbelts in Ukraine over the last 10 years is 10 071 ha, which has weakened the nature conservation function of forest plantations and caused large-scale manifestations of water and wind erosion. The research used data of the State Statistics Service and the State Geocadastre of Ukraine for 2008–2017. Deciphering the Earth remote sensing data and using a series of correctly calibrated MODIS satellite images (230 × 230 m geometric resolution) made it possible to determine the correlation between the spatial distribution of the forest fund and percentage of cultivated land in Ukraine. Using the Zonal Statistics of Spatial Analyst Tools module of the ArcGIS program there has been determined the percentage of forest cover and cultivated land within separate administrative and territorial units. The difficult situation in Ukraine in which the state of forest ecosystems does not meet the ecological and economic requirements is caused by challenges in making managerial decisions in the sphere of forestry. The results obtained make it possible to substantiate the need for spatial-differential

*practices of forest restoration and implementation of land and water conservation measures for land fund optimization on the basis of adaptive-landscape principles which will create preconditions for the rational use and rehabilitation of forest and land resources of Ukraine in the context of sustainable land use.*

**Ключові слова.** *Напрями підготовки, спеціальності у сфері землеустрою, природничі науки.*

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## **Introduction**

in European countries, forests occupied about 70-80% of the territory up to the middle of the XIX century. During the evolution of agriculture their area decreased by 15%. Nowadays, the forest cover of the territories of the developed countries ranges from 18% to 34.4%. Over the last half-century, the total forest area has significantly decreased, and the greatest losses have been experienced by the developing countries. Taking into account the current population trends and the ploughness of territories, over the next 30 years the world's forest reserve is projected to decrease by 32.1% per person (State of the World..., 2000). The state of forest ecosystems is determined by the direct influence of anthropogenic factors, which manifests in the decrease of forests as a result of logging, construction, creation of reservoirs, open cast minings, fires, etc. Economically exploited forests experience violation of conditions of natural forest growth, change of all landscapes components and relations, change of temperature conditions, reduction of relative humidity, increase of wind speed, decrease of conservation ability of forests, depletion of biomass and reduction of recovery of energy resources by 25-30%.

Domestic scientists (Shvydenko A.Z. et al., 2018) have proposed a systematic assessment of Ukraine's forest vulnera-

bility to climate change (Lisetskiy F. et al., 2018; Pichura V.I. et al., 2019) based on scenario analysis and simulation of forest-climatic resources dynamics. Forests, being a part of the natural sphere of territorial ecosystems, perform a number of the most important, unique environmental, economic and social functions. They influence the water exchange and condition of aquatic ecosystems (Kalinin G.P., 1950; Voronkov N.A., 1973; Pichura V.I., 2016, 2018), prevent water and wind erosion of soils (Pobedinsky A.V., 1979; Buryak J.A., 2015; Lisetskii F. N. et al., 2014; Dudiak N.V. et al., 2019), prevent the formation of gullies and landslides, fix sand landscapes and control the level of groundwater (Pichura V.I. et al., 2014), preserve landscapes, play the multifunctional role in improving the environment (Gensiruk S.A., 2002; Petrovich O.Z., 2014), promote obtaining of guaranteed yields of agricultural products and increase of soil fertility (Lukisha V.V., 2013). The degree of forest cover of territorial ecosystems ensures preservation of their natural ecological balance, which is significantly disrupted by human economic activities. Given the current conditions of high anthropogenic load, for the purpose of protection and target oriented restoration, it is necessary to search for the optimal interaction between a man and the nature to ensure balanced relations in the rational exploitation of the natural resources of the territorial ecosystems.

*The objective of study* is to investigate the current status and to determine the environmental and economic aspects of Forestation in Ukraine in terms of sustainable land management, to propose the main ways of their solution.

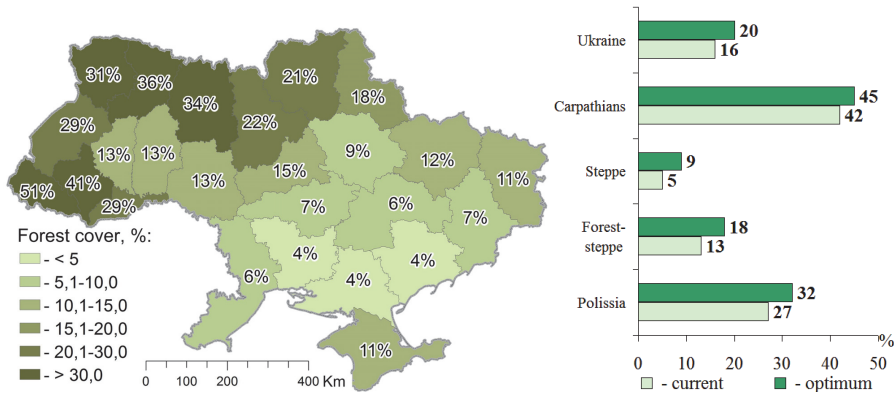
### **Materials and methods**

In the course of study we have used the data from the State Statistics Service and the State Service of Ukraine for Geodesy, Cartography and Cadastre (StateGeoCadastre) for the years 2008–2017. Decryption of Earth remote sensing data and use of a series of properly calibrated *MODIS* images (geometric resolution  $230 \times 230$  m) allowed for determination of the ratio of spatial distribution of the forest fund and the ploughness of agricultural land in the territory of Ukraine. The up-to-date satellite images data from various satellites is available on the official website of the United States Geological Survey (<https://earthexplorer.usgs.gov/>). Spatial differentiation of the ploughness of agricultural land was carried out based on a series of *MODIS* images as of 23.04.2016 and 13.08.2016. Decryption of images was carried out based on the values of *NDVI* (Normalized Difference Vegetation Index) dimensionless index within the range of 0.3–0.4. A high degree of correlation of *NDVI* values of satellite images with the aboveground vegetation phytomass during their vegetative activity peak (June month) allowed for determination of the spatial differentiation between forested area and forest belts by high *NDVI* values – above 0.8. An additional specification of spatial distribution of coniferous forests was carried out based on the satellite images made in the winter period with

*NDVI* values above 0.6. Using of Zonal Statistics module of *ArcGIS* Spatial Analyst Tools allowed for determination of the forest cover and the ploughness of land in the separate administrative-territorial units.

### **Results and discussion**

Ukraine belongs to sparsely forested and forest deficient countries. Forests in Ukraine are unevenly distributed, their most part accounts for Polissia and Ukrainian Carpathians. During the period of 1880–1924, 2 million ha of Ukraine's forests were destroyed; the forest cover during this period reduced by 5%. The current total area of forest land belonging to the forest fund of Ukraine is 10.4 million ha, including forest vegetation occupying 9.6 million ha. 79% of the forest area (including 73% of those of the State Forest Resources Agency) is in permanent state use, 7% of the forest fund of Ukraine is in non-permanent use, 13% is subordinated to local self-government bodies, 1% is privately owned. The forest fund includes forest land, including protective stands of linear type covering at least 0.1 ha. In general, Ukraine's forest cover with the optimum value of 25–30% is 15.9%, and in most steppe regions this figure does not exceed 1.9–4.8%. Ukraine ranks 9<sup>th</sup> by forest cover among European countries. Forest cover in different natural zones has significant differences (Fig. 1) and does not reach the optimum level in terms of provision of important social, economic, environmental, landscape-stabilizing and raw material functions. The most wooded regions are Zakarpattia, Ivano-Frankivsk, Rivne, Zhytomyr, Volyn and Chernivtsi regions. Zaporizhzhya, Mykolaiv and Kherson regions have the lowest indices.



**Figure 1. Spatial differentiation of forest cover of the territory of Ukraine**

In addition to economic importance, forests protect soil and water from pollution and degradation, oxygen release and carbon sequestration, which promotes crop yields, preserves landscape and biological diversity, creates environmentally friendly living conditions, etc. About 3.5 million ha of forests have restrictions on forest management, in particular, this is the territory that was exposed to radiation contamination as a result of the Chernobyl accident (1986). Based

on the data of the State Statistics Service, 4.03 million ha of forests in Ukraine during 2008-2017 (Table 1) were logged, about 170.7 thousand ha were destroyed by fires, pests, storms and poachers, and only 16.3 % of this area was restored.

As of 1 January 2019, the total area of dried forests was 440 thousand ha, of which 55.2% accounted for scots pine, 24.3% – for common oak, 5.9% – for European spruce and 14.6 % – for other stands.

**Table 1. Characteristics of change in Ukraine’s forestlands areas (2008–2017)**

Years	Area of logging, thousand ha	Destroyed, thousand ha			Reforestation and creation of new forests, thousand ha		Protected from pests, thousand ha
		by fire	by insect pests and storms	for other reasons	total	incl. by enterprises of the State Forest Resources Agency	
2008	425	5,5	N/A	N/A	78,1	66,9	N/A
2009	358	6,3	N/A	N/A	80,7	69,7	N/A
2010	402	3,1	17,0	0,7	70,1	60,8	81,9
2011	422	0,9	14,5	1,0	72,4	61,5	141,2
2012	417	2,9	16,4	1,0	70,1	57,6	89,7
2013	415	0,3	15,5	0,7	67,7	55,4	99,6
2014	383	2,3	13,8	1,5	58,0	50,0	31,8
2015	399	8,6	16,8	2,4	60,4	51,0	46,0
2016	386	1,6	16,3	1,5	63,2	52,6	37,2
2017	419	8,8	10,8	0,5	64,7	53,8	46,1
Total	4026	40,3	121,1	9,3	685,4	579,3	573,5

During this period, about 530 thousand ha (13.15%) of stands were restored. In 2018, the total volume of illegal logging was 17.7 thousand m<sup>3</sup>, and the amount of damage was USD 4.37 million, fire damage reached USD 1.02 million. Based on the official data of the State Forest Resources Agency, in 2018, the industry enterprises harvested 16.5 million m<sup>3</sup> of timber, of which 32.0% was exported for a total amount of UAH 14.98 million. Based on the results of economic and financial activity of the forest enterprises, the sale of products (goods, works, services) brought USD 629.2 million of net income in 2018, of which the industry enterprises received about USD 417.98 million of net income. Ukraine ranks 34th in Europe by ratio of forest area to the total land area. The forest area, which accounts for 1 person in Ukraine, is 14 times less than in Eastern Europe. By total wood stock index (2.1 billion m<sup>3</sup>) Ukraine ranks 6th among European countries.

It has been established that Ukraine's forests may produce about 160 million t of organic matter per year, remove more than 290 million t of carbon dioxide from the atmosphere and emit 210 million t of oxygen. Over the 1 year, the forest yield in Ukraine has amounted to 35 million m<sup>3</sup> of wood. The average annual change of stock per 1 ha in the State Forest Resources Agency's forests is 3.9 m<sup>3</sup> with its spatial differentiation from 5.0 m<sup>3</sup> (Carpathians) up to 2.5 m<sup>3</sup> (Steppe zone). In order to get optimum indices of the forest cover, it is necessary to differentially restore the size of Ukraine's forest area by 6.0–9.2 million hectares. Based on the Letter of Appeal (No. 03-2057 dd. 10.11.2016) of the Accounting Chamber of Ukraine to the Chairman of the Verkhovna Rada of Ukraine on the results of performance

audit of the use of budgetary funds for forestry and hunting sector, protection and defense of forests in the forest fund and management of objects of public ownership revealed a number of violations and gaps in Ukraine's forestry management. This is due to a significant decrease in the financial support for carrying out the appropriate forest improvement measures, the lack of documentation of the state forest inventory; reduction in the annual volume of forest restoration (by 31.2% in 2011–2015), which reduced the area of forest creation in new territories from 22.4 thousand ha (in 2011) to 2.4 thousand ha (in 2015); increase of timber harvesting volumes by 2.2 million m<sup>3</sup> compared to 2011. The decrease in the efficiency of economic activity of the state forestry enterprises is associated with the low performance of the Unified State Electronic Wood Accounting System in Ukraine, as evidenced by the fall in profitability in the first half of 2016 compared to 2015 from 7.8% to 4.7%. Today, the situation is complicated by the lack of proposals for sustainable development of Ukraine's forest improvement industry, and the measures presented in the Strategy for Sustainable Development and Institutional Reform of the Forestry and Hunting Sector of Ukraine for the period until 2022 have a declarative character with no clear deadlines and a situational forecast of the consequences of their implementation.

In Ukraine, the vast majority of forest belts were laid in the 50's and 60's of the XX century, and about 800 thousand ha of field protective forest belts – during the current period (Godovany A.Y., 2013). Since 2000, field protective forest belts have been subordinated to local councils, some of the field protec-

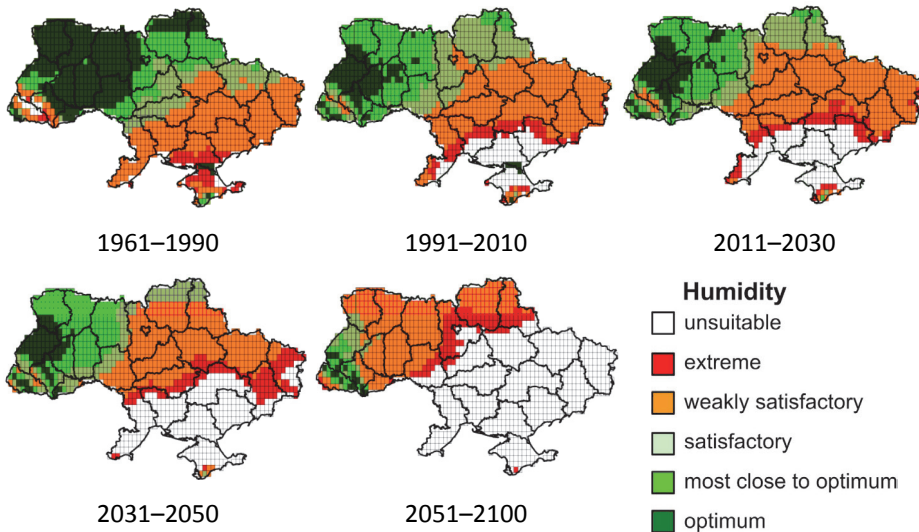
tive forest belts have been managed by the State Forest Resources Agency, the Ministry of Agrarian Policy and Food.

The complication of the situation in Ukraine, where a condition of the forest ecosystems does not meet the environmental and economic requirements, is caused by the complexity of management decisions in the field of forestry, which is due to a sustained forest growing and a complex forecasting of future scenario of environmental and economic situations, which requires state financial support, development and rigid implementation of an environmentally balanced system for managing national forestry with due consideration for the zonal requirements and norms of rational forest use.

The lack of rules and regulations for resolving issues of preservation and restoration of field protective forest belts causes their partial or complete destruction. This leads to a significant depression of the forest stand conservation

function and large-scale manifestations of water and wind erosion, which result into loss and weathering of the topsoil and its nonuniform spatial redistribution, which causes degradation of soils, fertility fall, which, in turn, leads to under-harvesting of crops. Wind erosion in Ukraine annually extends over 6 million ha, and in the years of drought and dust storms – up to over 20 million ha. In March 2007, zonal storms manifestations, which lasted from 10 to 30 hours with an average wind speed of 15-20 m/s., spilled over 12 million ha of agricultural land. According to the calculations of scientists [16], soil losses in the epicenter of a dust storm from a surface without vegetation amounted to 150-400 t/ha, and in another area – to 10-50 t/ha, which is 10-4000 times higher than the speed of the current soil formation. In the territory of Ukraine, due to erosion processes, agriculture loses from 10 to 12 million t of grain per year.

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**Figure 2. Spatiotemporal pattern of dynamics and forecast of change of climatic conditions of common oak growth in terms of humidity in 1960-2100 (Shvydenko A.Z. et al., 2018)**



The negative anthropogenically-induced influence on the condition of forest ecosystems and their restoration is exacerbated by manifestations in climate change. As a result of lookback study and climate change modeling, domestic scientists (Shvydenko A.Z. et al., 2018) have determined spatiotemporal patterns of inhomogeneity of change of the conditions of common oak growth in terms of humidity in 1960-2100 (Fig. 2).

It has been established that by the year 2100 more than 55% of the territory of Ukraine (the steppe and forest-steppe zones) will have unsuitable climatic conditions for regeneration of the common oak. The scientists have noted that climate change will lead to a shift in the forest distribution boundaries, replacement of zonal vegetation types, changes in the balance of forest formations and forest types; reduction of the viability of forests, their resistance to pests and diseases, increase in the intensity of forest drying; mass pest outbreaks; increase of fires in the number and scale (especially in coniferous forests); reduction of carbon deposits; decrease in productivity and marketability of forest stands; changes in the forests species composition; reduction of the level of biodiversity, especially of species with a small climatic range (stenotope) and species at the edge of ranges and endemic species.

During 1950–1990, in Ukraine there were planted 440 thousand ha of field protective forest belts, of which 350 thousand hectares have field protective purpose and 90 thousand ha – water-regulating. They provided protection for 13 million ha of agricultural land. Given that 1 ha of forest belt protects 20-30 ha of arable land, crops yields increase by 15-20% compared to unprotected field plots. The areas within the forest belts

are characterized by improvement of soil agrochemical properties, reduction of the speed of erosion processes (wind, water). In particular, the fields protected by forest belts are characterized by decrease of wind speed by 20-30% as well as by improved microclimatic conditions (in protected lands 80% of moisture penetrates into the soil, unproductive evaporation of moisture is reduced twice, surface air temperature increases by 1-3 °C, and the relative humidity – by 3-5%). In addition, the agricultural land protection against pollution by road transport emissions enhances, too. Therefore, it becomes possible to create favorable conditions for environmentally stable agriculture and formation of environmental and economic land management (Lukisha V.V., 2013; Openko I.A. et al., 2014). It is proved that for each unit of monetary resources invested in the forest improvement, agriculture receives 1.5-2.0 times more of gross output than as a result of fixed asset investment.

Therefore, protective forest belts form the basis of land and forest improvement (Table 2), reducing the negative influence of the natural-anthropogenic factors on the change in soil fertility and promoting additional crops yields. However, the average field protective forest cover in the separate physical-geographical areas of Ukraine varies within 1.3-1.5% at the necessary optimum level of 3-4.5% (Pylypenko O.I. et al., 1998; Stadnik A.P., 2012).

Official statistics indicate that as of 01.01.2017, in Ukraine, there were recorded about 446 thousand ha of field protective forest belts (Fig. 3).

Based on the data from the State Service of Ukraine for Geodesy, Cartography and Cadastre, as of 01.07.2016 (In Ukraine, the field-protecting forest

Table 2. Agro-ecological services of protective forest belts

Indices	Territory	
	unprotected	protected by forest stands
Water reserves in the snow, mm	70–80	110–120
Flow of water into the soil, mm	58–63	100–108
Surface runoff, mm	19–20	6–7
Soil loss, m <sup>3</sup> /ha	3,0–4,0	0,5–0,7
Total evaporation of moisture during the growing season, mm	750–760	625–640
Relative humidity at 1300 in July, %	25–28	30–34
Relative humidity in dry years,%	14–15	20–22
Total number of animal species	35–60	83–149
Zoomass per 100 ha of territory, kg	180–186	358–880

strips..., 2016) a significant deviation of the actual areas of protective forest belts and the list of lands determined in the projects of denationalisation and privatization of agricultural enterprises lands (1995-1997) was detected in 12 regions.

It has been established that the total losses amount to 10.071 ha (Fig. 4) with the greatest losses of protective forest belts in the Southern regions of Ukraine, in particular, in Kherson (32.5% of the area of total losses), Zaporizhzhia (22.5%),

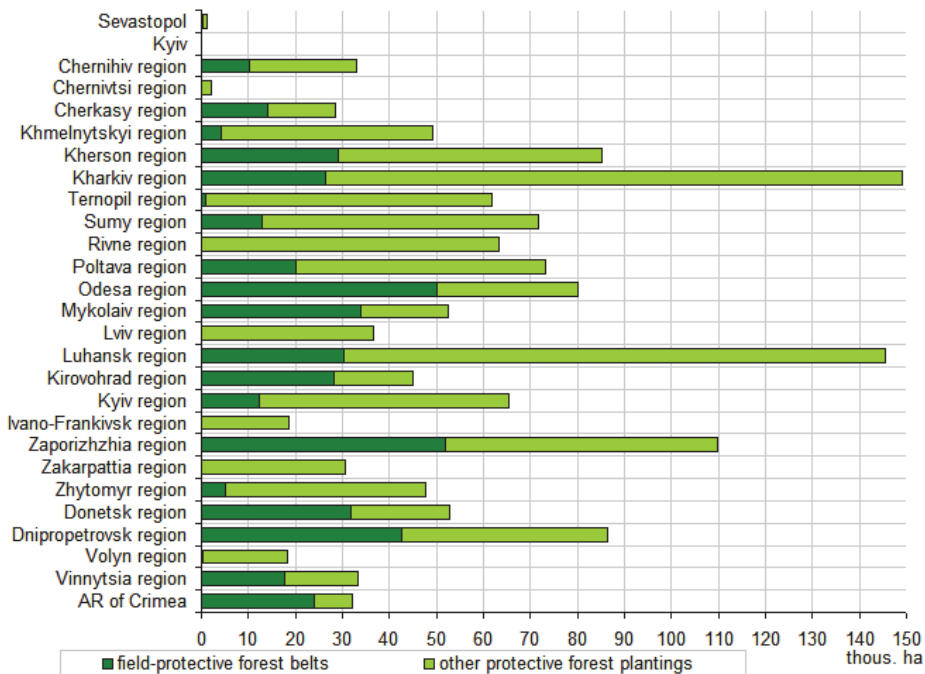
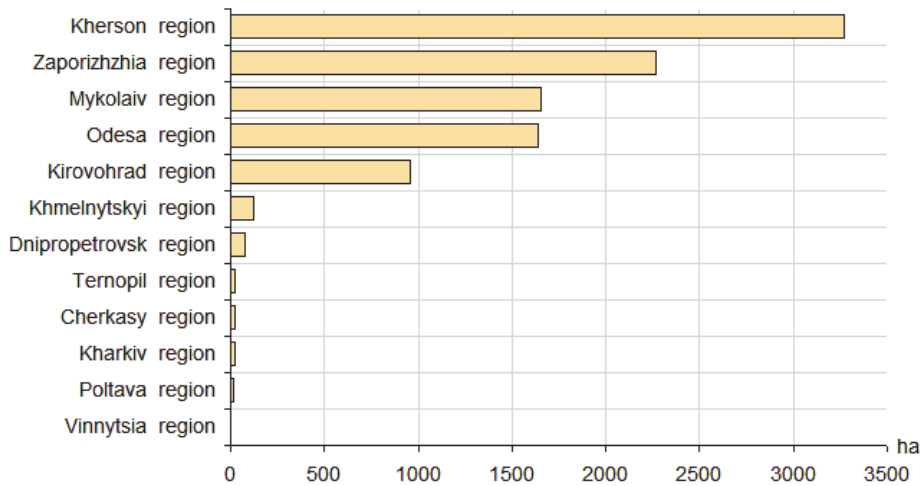


Figure 3. Distribution of protective forest stands in Ukraine as of 01.01.2015





**Figure 4. Areas of destruction of protective forest belts in Ukraine during 1995–2016**

Mykolaiv (16.4%), Odessa (16.3%) and Kirovohrad (9.5%) regions.

Therefore, based on the obtained results of study, it was determined that over the last 60 years the area of field protective belts has been reduced by 1.9-2.3 times. The actual area of the protective forest belts is 350 thousand ha, and as per the statutory indicators, there is a need for reconstruction of another 700 thousand ha. The unestablished ownership of field protective belts in the course of land reform complicates and slows down the process of their reconstruction.

It has been established that the forest cover of the Steppe zone of Ukraine (Fig. 5) in 130 administrative-territorial units (Dnipropetrovsk, Zaporizhzhia, Kirovohrad, Mykolaiv, Odessa, Kherson regions, with the total study area of 167.4 thousand km<sup>2</sup>) varies from 0 to 27%: about 36.8% of the territory of the 46 administrative-territorial units (ATUs) has a forest cover of less than 1.0%; 31.5% of the territory has from 1.0 to 3.0% of the forest cover (40 ATUs); 14.9% – within

the limits of 3.1-5.0% (18 ATUs); 7.9% of the territory has from 5.1 to 10.0% of forest cover (13 ATUs); the forest cover of 5.4% of the territory is within the limits of 10.1–15.0% (7 ATUs); the forest cover of 3.6% of the territory is more than 15% (6 ATUs). About 76.0% of the Ukrainian Steppe zone territory is characterized by insufficient forest cover level, which causes systematic negative manifestations of water and wind erosion. This situation is complicated by the high level of agricultural reclamation of the southern regions – up to 97% (Fig. 6), which induces a low degree of environmental sustainability of landscapes regarding preservation of soil fertility.

In accordance with the arable/natural land ratio, the following types of landscape conditions may be determined: 70:30 – destructive, 60:40 – unstable, 50:50 – extremely stable, 40:60 – minimum stable, 35:65 – medium stable, 30:70 – stable, 25:75 – high stable, 0:25:100–75 – ecological balance with stable increasing of soil fertility. The ploughness of the studied territories of

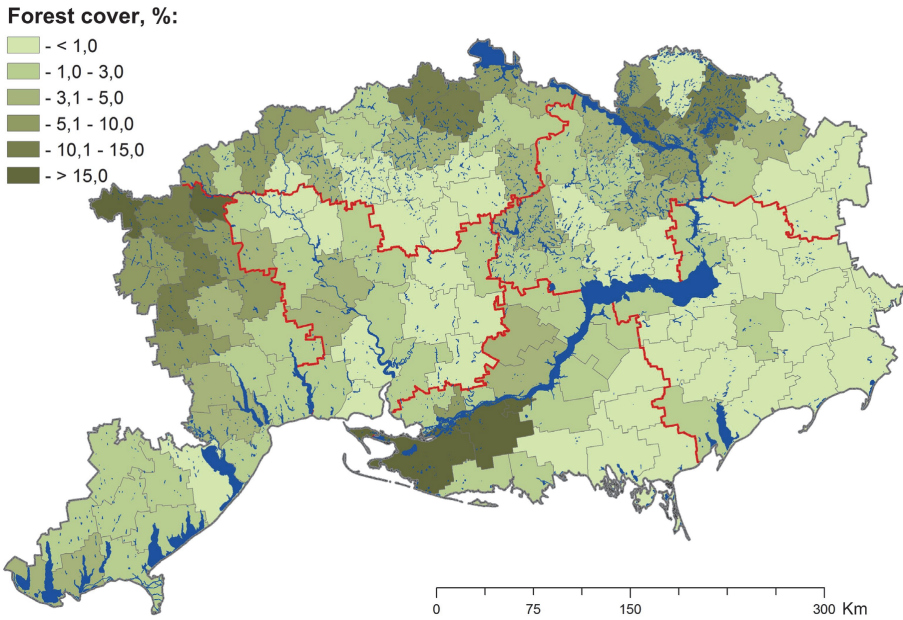


Figure 5. Spatial differentiation of the forest cover of the administrative units of the Steppe zone

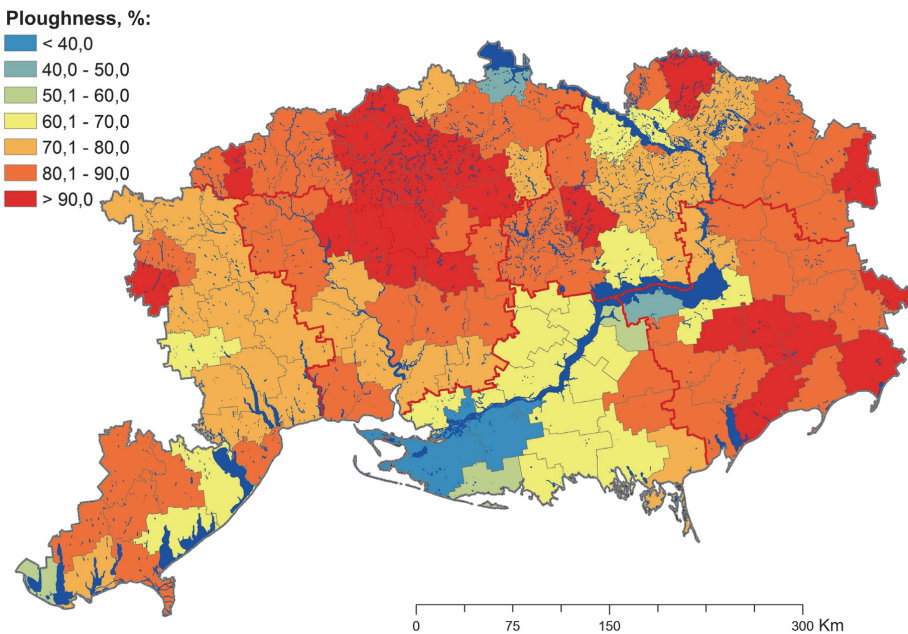


Figure 6. Ploughness of studied territories of the Ukrainian Steppe zone

the Steppe zone is 78.6%, including Dnipropetrovsk region – 80.5%, Zaporizhzhia region – 84.6%, Kirovohrad region – 86.9%, Mykolaiv region – 81.8%, Odesa region – 75.9%, Kherson region – 61.4%.

Agricultural reclamation of the Ukrainian Steppe zone varies from 20 to 97%. 3 ATUs with a total area of 0.80 thousand km<sup>2</sup> (0.5% of the area of the studied region) have high stable and stable landscapes with the ploughness of 30% and less; 2 ATUs with a total area of 4.18 thousand km<sup>2</sup> (2.5%) have medium and minimum stable landscapes (ploughness is 30-40%); 2 ATUs with a total area of 2.56 thousand km<sup>2</sup> (1.5%) have the ploughness of 40-50% and, respectively, extremely stable landscapes; 123 ATUs with a total area of 159.90 thousand km<sup>2</sup> (95.5%) have unstable and destructive landscapes (more than 50% of the territory ploughness). About 18.0% of the territories of the studied zone are plowed up by 90% or more.

One of the most important tasks for forest and forest belts protection is to develop and maintain an optimum forest cover percentage differentially for different physical-geographical areas of Ukraine. Protective forest stands are the basis of optimized ecological systems in agricultural areas, an important component of anti-erosion organization of land management territory. The productivity of optimized forest agricultural landscapes can be 1.5-2.0 times higher than that of open forestless areas, which is a reliable reserve for solving food and environmental problems. Forest stands play an important role in establishing ecological balance, harmonizing the interaction of major ecological systems of the biosphere (Yukhnovsky V.Yu. et al., 2009). The main reason of slowing down the restoration of protective forest

stands is the unresolved legal aspects of their ownership. The land of forest stands were not subject to stocking. They are considered as the undistributed lands, reserve fund lands and lands that are in general use of settlement councils. Therefore, it is necessary to resolve the issue of the adequate maintenance of the forest belts by assigning them to the owners of agricultural land. At the level of the state regulatory acts, it is necessary to anchor the order of priority of the maintenance and care for the forest belts, to improve the system of their use, and to take measures to create new field protective stands at the expense of the local government finances.

The results of studies of economic and environmental development of Ukrainian forestry indicate ecologically unbalanced forest management. There is no well-defined system of measures for forest protection, forest inventory, forest management, forest restoration, protective forest cultivation. Therefore, there is a need to scientifically justify the organization of environmentally balanced management of forestry activities with a focus on forest restoration through innovative forestry technologies and the development of forest infrastructure. The development and implementation of a system for assessing the effectiveness of forestry activities management becomes relevant, too.

### ***Conclusions***

In order to preserve and to improve the productivity, restoration, protection and defense of forests, as well as to improve the culture of forestry management, it is necessary to implement measures for forest organization, the main task of which is to determine the boundaries of the territories of forestry

enterprises, forest resources, to define species and age composition of forests; to discover the logging areas, to specify the areas of forest restoration and for-estation; to determine the ways of forests restoration; to clarify the division of for-ests into groups and categories of protec-tion. The main ways of rational use and restoration of forests are the environmen-tal and economic substantiation of forest improvement measures and the use of wood, the introduction of scientifically sound calculation and distribution of the forest fund, the application of the forest protection system against pests, diseas-es, forest fires and unauthorized log-ging, maintenance of an optimum level of forest cover at the required level of restoration of primary forest types in the process of forest exploitation. The results of the conducted study make it possible to substantiate the system of spatio-dif-ferential measures for forest restoration and implementation of specific land-and water-protective measures for optimi-zation of the land fund on the basis of adaptive-landscape principles, which is a prerequisite for rational management and rehabilitation of forest and land resourc-es of Ukraine.

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**Н.В. Дудяк, В.І. Пічуря, Л.О. Потравка  
ЕКОЛОГО-ЕКОНОМІЧНІ АСПЕКТИ  
ЛІСОРОЗВЕДЕННЯ В УКРАЇНІ В КОНТЕКСТІ  
СТАЛОГО ЗЕМЛЕКОРИСТУВАННЯ**

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**Анотація.** За останні півстоліття загальна площа лісів країн світу істотно скоротилася. Україна належить до малолісних і лісодефіцитних країн, оскільки рівень лісистості становить 15,9% за необхідного оптимального значення 25–30 %. Степові райони характеризуються 1,9–4,8 % лісистості. Сучасна загальна площа лісових ділянок, які належать до лісового фонду України, становить 10,4 млн га, в тому числі вкриті лісовою рослинністю 9,6 млн га, близько 3,5 млн га лісів мають обмеження у лісокористуванні. В період 2008–2017 рр. в Україні вирубано 4,03 млн га лісів і додатково знищено пожежею, шкідниками, буреломами і браконьєрами близько 170,7 тис. га, із них відновлено лише 16,3% цієї площі. Для забезпечення оптимальних показників лісистості потрібно диференційовано відновити площі лісів в Україні на 6,0–9,2 млн. га. Середня полезахисна лісистість у окремих фізико-географічних зонах України варіює в межах 1,3–1,5%, оптимальна повинна становити 3–4,5%. Зокрема, близько 76,0% території зони Степу України мають недостатній рівень лісистості, що обумовлює систематичні негативні прояви водної та вітрової ерозії. Дана ситуація ускладнюється високим рівнем сільськогосподарської



освоєності південних регіонів – до 97%, що обумовлює низьку ступінь екологічної стійкості ландшафтів до збереження родючості ґрунтів. Ретроспективним аналізом відзначено значне зменшення площ полезахисних лісосмуг за останні 60 років у 1,9–2,3 рази. Загальні втрати захисних лісових смуг в Україні за останні 10 років складають 10 071 га, що послабило природоохоронної функції лісонасадження та викликало масштабні прояви водної і вітрової ерозії. У дослідженнях використано дані Державної служби статистики і Держгеокадастру України за 2008–2017 рр. Дешифрування даних дистанційного зондування Землі та використання серії коректно каліброваних супутникових знімків MODIS (геометричне розрізнення 230×230 м) забезпечило можливість визначення співвідношення просторового розподілу лісного фонду та розораності сільськогосподарських угідь на території України. Із застосуванням модуля Zonal Statistics of Spatial Analyst Tools програми ArcGIS визначено лісистість і розораність угідь в межах окремих адміністративно-територіальних одиниць. Складана ситуація в Україні, за якої стан лісових екосистем не відповідає еколого-економічним вимогам, спричинена складністю прийняття управлінських рішень в галузі лісового господарства. Одержані результати дозволяють обґрунтувати необхідність просторово-диференційних заходів лісовідновлення і впровадження земле- та водоохоронних заходів щодо оптимізації земельного фонду на основі адаптивно-ландшафтних принципах, які дозволять створити передумови для раціонального використання та оздоровлення лісних і земельних ресурсів України в контексті сталого землекористування.

**Ключові слова:** еколого-економічні аспекти, лісний фонд, захисні лісові смуги, лісистість, розораність, екологічна стійкість, стале землекористування, Україна, геомодельовання.

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**ЭКОЛОГО-ЭКОНОМИЧЕСКИЕ АСПЕКТЫ ЛЕСОРАЗВЕДЕНИЯ В УКРАИНЕ В КОНТЕКСТЕ УСТОЙЧИВОГО ЗЕМЛЕПОЛЬЗОВАНИЯ**

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**Аннотация.** За последние полвека общая площадь лесов стран мира существенно сократилась. Украина принадлежит к малолесным и лесодефицитным странам, поскольку уровень лесистости составляет 15,9%, при необходимом оптимального значения 25-30%. Степные районы характеризуются 1,9-4,8% лесистости. Современная общая площадь лесных участков, принадлежащих к лесному фонду Украины, составляет 10,4 млн га, в том числе покрытые лесной растительностью 9,6 млн га, около 3,5 млн га лесов имеют ограничения в лесопользовании. В период 2008-2017 гг. в Украине вырублено 4,03 млн га лесов и дополнительно уничтожено пожарами, вредителями, буреломами и браконьерами около 170,7 тыс. га, из них восстановлено лишь 16,3% этой площади. Для обеспечения оптимальных показателей лесистости нужно дифференцированно восстановить площади лесов в Украине на 6,0-9,2 млн. га. Средняя полезащитная лесистость в отдельных физико-географических зонах Украины варьирует в пределах 1,3-1,5%, оптимальная должна составлять 3-4,5%. В частности, около 76,0% территории зоны Степи Украины имеют недостаточный уровень лесистости, что обуславливает систематические негативные проявления водной и ветровой эрозии. Данная ситуация осложняется высоким уровнем сельскохозяйственной освоенности южных регионов – до 97%, что обуславливает низкую степень экологической устойчивости ландшафтов к сохранению плодородия почв. Ретроспективным анализом отмечено значительное уменьшение площадей полезащитных лесополос за последние 60 лет в



1,9-2,3 раза. Общие потери защитных лесных полос в Украине за последние 10 лет составили 10 071 га, что ослабило природоохранные функции лесонасаждения и вызвало масштабные проявления водной и ветровой эрозии. В исследованиях использованы данные Государственной службы статистики и Дер-жгеокадастра Украины в период 2008-2017 гг. Дешифрирование данных дистанционно-го зондирования Земли и использования се-рии корректно калиброванных спутниковых снимков MODIS (геометрическое различия 230 × 230 м) обеспечило возможность определения соотношения пространственного распределения лесного фонда и распаханно-сти сельскохозяйственных угодий на терри-тории Украины. С применением модуля Zonal Statistics of Spatial Analyst Tools программы ArcGIS определено лесистость и распашка угодий в пределах отдельных административно-территориальных единиц. Сложная

ситуация в Украине, при которой состояние лесных экосистем не соответствует эколо-го-экономическим требованиям, вызванная сложностью принятия управленческих ре-шений в области лесного хозяйства. Полу-ченные результаты позволяют обосновать необходимость пространственно-диффе-ренциальных мероприятий лесовосстановле-ния и внедрение земле- и водоохраных меро-приятий оптимизации земельного фонда на основе адаптивно-ландшафтных принципах, которые позволят создать предпосылки для рационального использования и оздоровления лесных и земельных ресурсов Украины в кон-тексте устойчивого землепользования.

**Ключевые слова:** эколого-экономиче-ские аспекты, лесной фонд, защитные лесные полосы, лесистость, распашка, экологическая устойчивость, устойчи-вое землепользование, Украина, геомодель-ювання.