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Soil degradation in Volyn region: current state, dynamics, ways of reduction

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Abstract. Recently, the problem of decrease in soil fertility has become more serious, posing a threat to food safety of the country. The main cause is violation of technologies of rational arable farming, which leads to deterioration of the qualitative condition of soils, their degradation. Therefore, development of protective measures for soils against degradation

processes is a relevant problem nowadays, solving which would preserve soils and improve their condition. The article evaluates the current condition of degradation of soils in Volyn Oblast. We determined the main aspect of degradation processes, their scales and territorial distribution. We determined that in the structure of the land fund of the Oblast, 52% is occupied by agricultural land, indicating high level of agrarian cultivation of lands. For the last 15 years, the structure of the land fund of Volyn Oblast had undergone insignificant changes, and the most of the area of the land remains unaltered. The area of agricultural lands has somewhat decreased, whereas the area of forests and forest-covered territory has increased. The area of open lands with no vegetative cover has decreased by 0.15%. Ploughed fields in the southern districts of Volyn Oblast exceed the allowable limits, accounting for over 60%. We analyzed the dynamics of the degradation process of soils in the Oblast. We determined that the degradation of soils was to the greatest degree caused by manifestations of erosion and deflation. Water erosion manifested in the territory of Volodymyr-Volynskyi, Ivanychi, Lokachi, Horohiv, Lutsk and Kivertsia districts. Deflatable soils in the Oblast account for 258.2 thousand ha, most of which are in Kovel, Turisk, Rozhyshche, Stara Vyzhivka districts. Measures for improving low-productive lands, and also land conservation, are being implemented in the Oblast. However, their scale is insufficient. We propose a complex of measures for protecting soils and preventing their degradation.

Key words: land use, degraded soils, disturbed lands, exhausted lands, low-productive lands, protection of soils, protection of soils against degradation processes

Деградація ґрунтів у Волинській області: сучасний стан, динаміка, шляхи зменшення

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Анотація. Проблема зниження родючості ґрунтів в світі та в Україні є однією з найгостріших екологічних проблем. Споживацький підхід у землекористуванні приводить до погіршення якісного стану українських ґрунтів, їх деградації. Тому розробка заходів охорони ґрунтів та захисту від деградаційних процесів на сьогодні є пріоритетним завданням. Вирішення його дозволить зберегти ґрунти і поліпшити їх стан. Метою статті є оцінка сучасного стану деградованості ґрунтів Волинської області, територіального розподілу та динаміки деградаційних процесів, розробка комплексу заходів охорони ґрунтів та захисту їх від деградації. Під час дослідження застосовано: методи збору матеріалів, методи статистичної обробки результатів, картографічні методи, метод експертних оцінок. Встановлено, що в структурі земельного фонду області 52% займають сільськогосподарські угіддя. Це високий рівень аграрної освоєності земель. За останні 15 років у структурі земельного фонду Волинської області відбулися незначні зміни. Площа сільськогосподарських угідь дещо зменшилася, натомість дещо збільшилася площа лісів і лісовкритої території. На 0,15% зменшилася площа відкритих земель без рослинного покриву. Розораність в південних районах Волинської області перевищує допустимі межі і становить понад 60%. Найбільшою мірою

деградація ґрунтів викликана проявами ерозії та дефляції. Водна ерозія проявляється на території південних районів області, а дефляція – північних районів. В області недостатньо здійснюються заходи поліпшення малопродуктивних угідь та консервації земель. Першочерговими заходами запобігання деградації ґрунтів та відновлення порушених ґрунтів є: відновлення боліт, заболочених і перезволожених земель, обмеження використання торфовищ для добування торфу, обводнення їх та захист від торфових пожеж, збільшення лісистості регіону, створення ландшафтно-адаптивних систем землеробства із контурно-меліоративною організацією території, екологічно обґрунтоване використання органічних та мінеральних добрив, отрутохімікатів, засобів захисту рослин, впровадження органічного землеробства, заохочення і стимулювання традиційного землекористування як фактору стійкого розвитку місцевих громад, проведення ефективного ґрунтового моніторингу.

Ключові слова: використання земель, деградовані ґрунти, порушені землі, відпрацьовані землі, малопродуктивні землі, деградовані землі, охорона ґрунтів, захист ґрунтів від деградаційних процесів

Introduction

The agrarian sector is extremely important for the development of economy of our country, its export potential and filling of the budget. Decrease in fertility of soils, their degradation cause significant economic losses for Ukraine. For example, according to the research of the State Institution Soil Protection Institute of Ukraine (Derzhgruntohorona), during this century, fertility of the soils is decreasing. This manifests through decrease in humus content in soils. Particularly, during the last 20 years, its losses are assessed 0.4-0.8 T/ha, which at the level of the state causes losses amounting to 453.4 B hryvnias (Baliuk et al., 2010).

The main cause of decrease in the fertility of soils is violation of the technologies of rational arable farming. The condition of soils, increase or decrease in their fertility, depend on following the rules of using these technologies. Most land users take no required measures oriented at preservation of soils and increasing their fertility. Organic fertilizers are introduced in insufficient amounts – to 1 T/ha, while scientifically substantiated requirements are 8-14 T/ha. Structure of cultivated areas does not correspond to scientifically substantiated requirements. Monocultures dominate. At the same time, agricultural crops significantly exhaust the soil (sunflower, rapeseed, maize). The modern approach to land use in our country may be called the consumer's approach. It causes deterioration of the qualitative condition of Ukrainian soils, manifestation of various processes of their degradation. Therefore, development of measures for protection of soils and prevention of degradation processes is a relevant problem of nowadays, solving which would allow a preservation of soils as means of production and an improvement of their condition. The aspect of agroecological condition of soils and evaluation of degree of their degradation is closely related to the analysis of the contemporary ecological condition of the territory, determining acute ecological problems, development of local ecological programs and programmes of the development of the agrarian production, implementation of public ecological initiatives.

Review of previous research. There is a large amount of scientific studies in the sphere of soil degradation. Most of them focus on regional problems of use of soils and their degradation: decrease of the area of agricultural lands and degradation of soils in Sri Lanka (Nayakekorale, 2020), impact of intensity of degradation of loess and parameters of functioning of soils in North Iran (Kooch et al., 2020), erosion of soils in Russia (Tsymbarovich et al., 2020), evaluation of degradation of lands in Argentina (García et al., 2018), degradation of soils in South Africa (Maltitz et al., 2019), experimental measures against degradation of lands in Germany (Wunder et al., 2019). Many studies focused on soil-science aspects: changes in fractions of organic compound and structural resistance of the soil as a result of degradation and restoration of soils (Jensen et al., 2020), ability of soils to function and provide ecosystem services (Fine et al., 2017), study of dynamics of soil-active organic carbon of Gahai Wetland in north-west China (Wu et al., 2020). A generalizing pattern was determined in the works by the International Collective of Scientists (Núñez-Delgado et al., 2020), and also articles about implementation of the concept of neutral degradation of lands (Akhtar-Schuster et al., 2017), minimization of erosion of organic carbon (Chappell et al., 2019) and many others.

In Ukraine, degradation of soils and development of measures for its reduction were analyzed in numerous scientific works: ecological condition of soils in Ukraine was evaluated in the article (Baliuk et al., 2014) and national reports about the condition of fertility of soils in Ukraine (Baliuk et al., 2010), scientific and practical basics of protection soils against erosion in Ukraine (Baliuk et al., 2010), the condition of soils and peatlands of Ukraine (Truskavecky et al., 2010), the main directions of solving problems of degradation and desertification of lands in Ukraine (Movchan, 2017), measures of decreasing the degradation of lands by revitalizing them (Budzjak, 2014) and many others.

In the scientific literature, the aspects of evaluating the condition of extent of degradation of soils in

Volyn Oblast are described quite well. Nonetheless, the condition of soils intensely changes over time, and therefore needs timely monitoring. The first and the most important scientific work in the sphere of studying ecological condition of soils in Volyn Oblast is the monograph (Molchak et al., 1998). Soils in Volyn Oblast, and also partially their current condition and peculiarities of anthropogenic transformation, were analyzed in the monograph (Shevchuk et al., 1999). Deflation processes in soils of Volyn Oblast were studied (Polanskyj, 2015). Impact of drainage reclamation on soils of Volyn Oblast was analyzed in the monograph (Zuzuk et al., 2012). Among the recent studies reporting issues of degradation of soils in Volyn Oblast and measures for its decrease, there is a collective monograph of scientists of the Department of Physical Geography of Lesya Ukrainka Volyn National University (Fesyuk et al., 2016).

The objective of the article

The objectives of the article were evaluation of degradation extent of soils in Volyn Oblast, territorial distribution and dynamics of degradation processes, development of a complex of measures for protection of soils and their protection against degradation.

Materials and methods of research. To prepare the article, we used the materials of Polesia Research Station of the Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky, Volyn Oblast State Project-Technological Center of Protection of Fertility of Soils and Quality of Production, the Main Management of State GeoCadastre in Volyn Oblast, and also materials of our own studies. During the research, we used a broad arsenal of methods of scientific research: methods of collecting materials (work with fund materials, reconnaissance, expedition method), methods of statistical analysis of the results, cartographic methods (development of analytical maps, work with electronic cartographic services), methods of expert assessments (for development of measures for protection of soils and protecting them against degradation processes).

Results and their analysis

The land fund of the Oblast as of 2019 accounted for 2,014.4 thousand ha, including 1,047.6 thousand ha or 52% comprising agricultural lands, which indicates the high level of cultivation of lands. Over the past 15 years, the structure of the land fund of Volyn Oblast has undergone insignificant changes, while the total area of the lands remained the same. The area of agricultural lands somewhat decreased, whereas the area of forests and forest-covered territory slightly increased. A decrease measuring 0.15% occurred in the

area of open lands without vegetative cover, which is a positive point from the ecological perspective. Practically unchanged also remained the area of waterlogged lands and aquatic objects.

Two types of landscapes may be distinguished in the structure of natural complexes of the territory of Volyn Oblast, field and forest-steppe types. Use of lands of the region is to a large extent due to soil-climatic conditions that are favourable for agriculture. In the structure of agricultural lands of Volyn Oblast, the leading role is played by tilled lands (tilling). Their share in the structure of the Land Fund is greatest in southern forest-steppe districts. The greatest share of agricultural lands is concentrated in the southern part of the Oblast and is associated with lowland terrain, distribution of podzolized and chernozem soils, sufficient amount of heat and moisture. Podzolized soils dominate in the forest-steppe part of the Oblast. Among them, the following are distinguished: bright grey and grey podzolized; dark grey podzolized; podzolized chernozems (Shevchuk et al., 1999).

In the territory of the Oblast, for a long time, there agriculture has been actively developing. The ploughed area in the southern districts of Volyn Oblast is above the allowable limits, equaling over 60% (Fig. 1): Horohiv (67%), Lokachi (61%), Lutsk (65%), Ivanychi (60%). The lowest degree of agrarian cultivation is in the northern districts of the Oblast, where the share of ploughed lands in their structure accounts for no more than 20%. When analyzing agricultural use of lands, it is important to evaluate the shares and location of the main constituents of agricultural lands, such as ploughing, multi-year planting, hay fields and pastures. Their area within the Oblast is divided unequally. The greatest share in ploughing was observed in the southern districts, and smaller in the northern districts, the area there has more pastures, hay fields, and also a significant share of lands is occupied by self-sown forests.

The study (Fesyuk et al., 2016) determined integral ecological stability of the soils in Volyn Oblast. Soils with high stability comprise 819.84 km² (4.05%). Those are mainly deep chernozem and shallow low-humus soils, characterized by comparatively high content of humus, heavy granulometric composition, neutral reaction of soil solution, which occur exclusively in the forest-steppe part of the Oblast. Stable soils are distributed over an area of 743.04 km² (3.6% of the territory of the Oblast). There are meadow-marshy soils, which are distributed in the territory as small plots. Turf carbonate, grey, dark grey podzolized soils were evaluated as averagely stable, distributed mostly in the transitional and forest-steppe zones of the Oblast in the area of 2,001.92 km² (9.81 %).

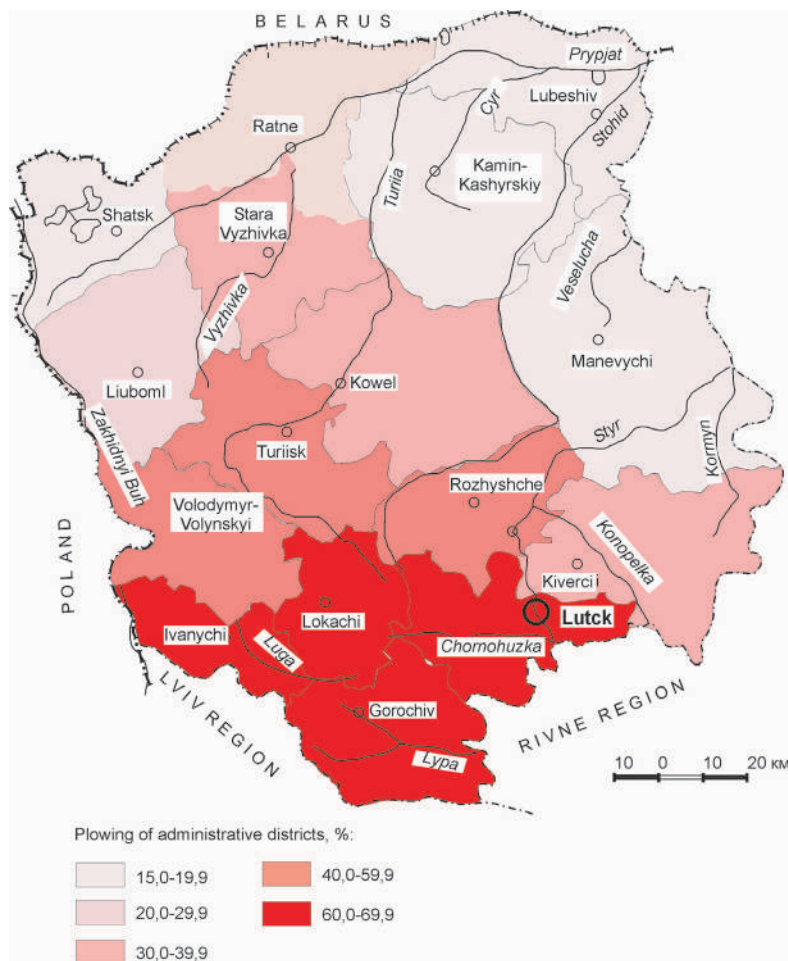


Fig. 1. Ploughing of the administrative units in Volyn Oblast (Fesyuk et al., 2016)

The least stable soils are low-humus, poorly saturated and acidic soils of the Polesia: turfy-podzolized, sandy, loamy sandy and clayey-sandy, and also peat-marshy and peatland types. They comprise large areas, accounting for 14,768.00 km² (73.1% of the territory of the Oblast). Also unstable were sandy and clayey-sandy types of turfy-podzolized gley soils. They are approximately distributed over an area of 1,955.84 km² (9.5% of the territory of the Oblast).

Active and ecologically irrational use, coupled with low integral ecological stability of soils within the Oblast, lead to degradation processes.

Degradation of soils is deterioration of beneficial properties and fertility of soil as a result of impact of environmental or anthropogenic factors (Molchak et al., 1998).

The main types of soil degradation are (Bridges, et al., 1979):

- physical degradation (over-compaction, de-segregation, compressor erosion, etc);
- erosion (soil dislodging, washout, alluviation) and deflation;
- waterlogging, groundwater flooding, flooding;
- exhaustion (de-humification, acidification, al-

kalization, trophic impoverishment, secondary salinization, sodification);

- contamination with heavy metals, pesticides, oil products, other organic and biological pollutants, radionuclides.

As for over-densification, according to the materials (Baliuk et al., 2010), there is a slight threat of over-compaction to soils of the Polesia part of the Oblast, which may be explained by lower intensity of use and light mechanical composition. Soils of the southern (forest-steppe) part of the Oblast were observed to be under moderate and high threats of over-compaction.

An unfavourable situation is also observed for the content of humus in the soils of Volyn Oblast. Over the recent decades, there a tendency has been observed toward decrease in humus content in soils, explained by both natural processes (first of all, erosion-deflation) and compression of humus in the process of intense agricultural activities. According to the materials of the National Report on the condition of soil fertility (Baliuk et al., 2010), for the recent 40 years, average annual losses of humus in Polesia accounted for 0.1–0.2 T/ha, in the forest-steppe – 0.8–1.0 T/ha, in the steppe – 0.4–0.5 T/ha. Average content of humus

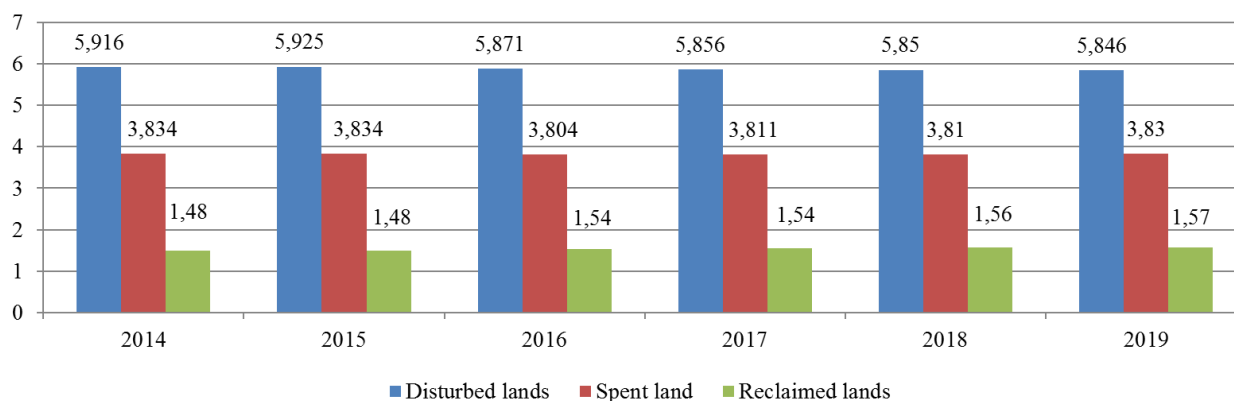


Fig. 2. Dynamics of the area of disturbed, exhausted and recultivated lands in Volyn Oblast, thous ha (according to the materials of the Main Management of State Cadaster in Volyn Oblast)

in soils of the Oblast equals 1.56%. This places Volyn on the bottom rank for humus content in our country. According to the research (Baliuk et al., 2010), Volyn Oblast is the only Oblast in the gradation of the lowest level of humus (less than 2%).

According to the materials of the National Report on the condition of soil fertility, by acidity, the soils of the greater part of Volyn Oblast are in the gradation of pH = 4.5-5.5, i.e. acidic soils (Baliuk et al., 2010).

An important indicator that characterizes the territory from the ecological perspective is presence of open areas without vegetative cover, including gullies, rocky places and sands. Based on multitemporal analysis of the structure of land use, certain specifics were determined: within the Polesia part of Volyn Oblast, there prevail territories that have been preserved in their natural condition, particularly forests and forest-covered territories, meadows and pastures; in southern forest-steppe districts, there dominate anthropogenically altered lands – lands of agricultural allocation. The greatest share of open lands with no vegetative cover (over 1%) is in Volodymyr-Volynskyi and Kamin-Kashyr districts.

Soil degradation in Volyn Oblast was to the highest degree caused by manifestations of erosion and deflation. The territory with manifestations of water erosion comprises Volodymyr-Volynskyi, Ivanychi, Lokachi, Horohiv, Lutsk and Kivertsi districts. The amount of eroded agricultural lands in each district by 1991 has greatly increased since 1968. For example, it was 14.8 against 7.3 thousand ha in Volodymyr-Volynskyi, 13.8 against 4.4 thousand ha in Ivanychi, 21.5 against 9.9 thousand ha in Lokachi, 42.2 against 21.8 thousand ha in Horohiv, 32.8 against 21.4 thousand ha in Lutsk, and 10.2 against 7.1 thousand ha in Kivertsi. The percentage of eroded soils of the total area of arable land within Volyn Oblast varies. Therefore, partially, in Volodymyr-Volynskyi and Lokachi districts, it ranges 11-30 %, in Ivanychi and, partially, Horohiv

– 1-10 %, and ultimately, partially, Horohiv, Lutsk and Kivertsi – 31-50% (Fesyuk et al., 2016).

Annually, 5 T of soil is dislodged from 1 ha in the Polesia zone, 15-20 T/ha in Volodymyr-Volynskyi, Ivanuchi, and Kivertsi districts, and 30-40 T/ha in Lokachi, Lutsk and Horohiv districts (Shevchuk et al., 1999).

Deflatable soils in the Oblast accounted for 258.2 thousand ha, including 33.2 thousand ha in Kovel district, 27.7 thousand ha in Turiisk, 21.9 thousand ha in Rozhyshe, 20.1 thousand ha in Stara Vyzhivka, 19.9 thousand ha in Liuboml, 19.4 thousand ha in Ratne, 19.2 thousand ha in Kamin-Kashyrskyi, 16.5 thousand ha in Manevychi, 17.0 thousand ha in Liubeshiv, 16.4 thousand ha in Volodymyr-Volynskyi, 4.6 thousand ha in Ivanychi, 6.7 thousand ha in Lutsk, 7.2 thousand ha in Horohiv and 7.8 thousand ha in Lokachi district (Polanskyj, 2015).

Since then, the situation has obviously changed. No monitoring of eroded and deflated lands is currently being performed in the Oblast. Statistical reports about the condition of lands contain terms such as disturbed, exhausted, low-productive and degraded lands.

As of 2019, there were 5,846.51 hectares of disturbed lands in Volyn Oblast (Fig. 2). The greatest areas are in Horohiv district – 20% of the overall parameter for the Oblast, Kovel – 18%, Turiisk – 12%, Manevychi – 9%, Stara Vyzhivka – 8%, Kamin-Kashyrskyi and Ivanychi – 7% in each. Reasons for disturbance of the lands are different (Rehionalna dopovid, 2019).

It would also be interesting to compare the areas of degrading soils in the Oblast in 1996 and 2019 in terms of administrative districts. According to the materials of the Main Management of the State Cadaster in Volyn Oblast, in 2019, compared with 1996, the area of the degraded soils (including eroded and deflated) in Volyn Oblast decreased 376-fold (116 thousand ha to 308 ha). Areas of degraded soils decreased the

most in Horohiv district – 1,356 times (40,570 ha in 1996 and 29.9 ha in 2019) and Lutsk district – 1,335 times (24,030 ha in 1996 and 18 ha in 2019). In other districts, the decrease equaled 37–357 times. Such difference between the areas is obviously due not to the successes of recultivating and ameliorative measures, but rather the fact that the reports about the condition of land resources stopped reflecting degraded (mostly eroded) soils. In order to evaluate the structure of disturbed and degraded soils, it is necessary to perform scientific research on soil, assessing the degree of soil dislodgement or deflation of soils, etc. Such studies in the Oblast have not been carried out since 1996. Until then, there was a program of monitoring degraded soils, measures of which have been implemented by the Volyn Institute of Land Management and Oblast Soil Fertility.

The level of waterlogging of soils in Volyn is one of the highest across our country. Therefore, in particular, 41.9% of the territory of the Oblast is occupied by marshes, waterlogged and overwet lands (Table 1).

Within the Oblast, there are large amounts of peat (Fig. 3). Therefore, those engaged in agriculture have an interest in its extraction. There is an especially strong interest in industrial peat and production of peat-bricks, which is increasing due to the necessity of diversification of use of energy sources and maximum replacement of gas in the structure of the oil-energy balance.

The consequences of peat extraction and drainage reclamation are the reasons for the emergence of peat fires, which have a catastrophic impact in Volyn Oblast. The main cause of the fires is burning of dry areas in pastures and hay fields against the background of decrease in the level of groundwater and dry climate over the recent years. The mass media and social network have started an active campaign against burning dry grass and leaves, which unfortunately is not that effective so far.

Over the period of 2015–19, the State Emergency Service of Ukraine in Volyn Oblast recorded 219 cases of peat fires. A total area of 280.43 ha has been burnt. The largest areas of burned peat lands were observed

Table 1. Specific weight of waterlogged lands and land in the marshland fund (Zinchuk et al., 2019)

Region	Total area, thous ha					Area of the marshland fund, thous ha			
	lands in total		including marshes, overwet lands		%	overall	including drained gross	including drained net	% of use
	in total	in agriculture	in total	in agriculture					
Polisia	1,450.3	726.3	786.3	635.3	46.3	675.9	396.1	379.2	58
Overall in the Oblast	2,014.4	1,058.7	845.2	690.8	41.9	731.8	435.0	416.6	59

Also, within the Oblast, 191 ameliorative systems operate. The area of dried lands equals 416.6 thou ha (Table 2). The area of ameliorative agricultural lands is 346.7 thous ha. Ceramic drainage pipes dry 236.6 thou ha. The area of polder system is 47.9 thou ha. Length of the open network of the canals equals 18.5 thous km (inter-agricultural – 4.6 thous km and intra-agricultural – 13.9 thous km) (Zuzuk et al., 2012).

The main problems of dried territories are: over-drying of sites, pyrogenic formations (burning out of peatlands), secondary waterlogging, karst development, emission of CO₂, erosion, overgrowing and siltification of ameliorative channels, ploughing of soils immediately adjacent to the canals (Shevchuk et al., 1999).

Another anthropogenic factor of disturbance and degradation of soils in Volyn Oblast is peat extraction.

in Kamin-Kashyrskiy – 137.9 ha (49.17% of the overall parameter for the Oblast), Liubeshiv – 26.72 ha (9.53%), Manevychi – 20.35 ha (7.26%), Rozhyshche – 16.22 ha (5.78%), Stara Vyzhivka – 19.7 ha (7%), Kovel – 12.47 ha (4.45%), Shatsk – 11.9 ha (4.24%),

Table 2. Drained lands in Volyn Oblast and their distribution (ha) (Zuzuk et al., 2012)

Region	Overall area, net	Of net area		
		mineral soils	peat-marshy	
			Всього overall	Area with depth of peat over 1 m
Polisia	374.648	262.426	112.222	22.033
In total across the Oblast	416.541	291.501	125.040	24.463

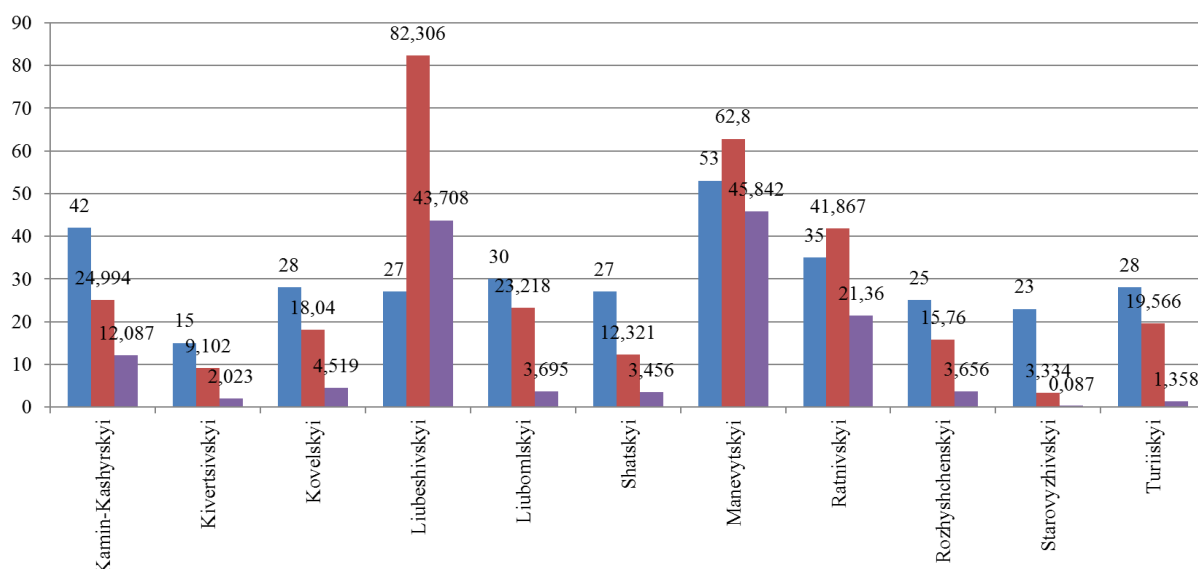


Fig. 3. Peat reserves in districts of Volyn Oblast (Rehionalna dopovid, 2019)

Volodymyr-Volynskyi – 9.67 ha (3.45%), Liuboml – 6.74 ha (2.4%), Ratne – 10.71 ha (3.82%), and other districts – less than 1% (Fesyuk et al., 2020).

Peat fires are becoming a significant ecological problem that threatens not only the ecological condition of soils but also safety of life of the population. Pyrogenic formations occupy large areas, worsening conditions for agriculture, sometimes posing a threat to territories and objects of the nature reserve fund. Climatic tendencies of the recent years lead to increase in the number of peat fires and their negative consequences, including destruction of fertile soils, decrease in biodiversity, degradation of landscapes, deterioration of the health of the population, impairment of the carbon cycle and decrease in emission of greenhouse gases. Therefore, it is necessary to prevent peat fires and reduce their negative impacts in the future, as well as to use, restore and recultivate burned peatlands.

Prevention of peat fires requires bilateral regulation of the water regime within the ameliorative system, alkalization of peat soils, increasing their fertility, sanding of dried peat soils. Also, it is important to carry out such measures as monitoring of burned peatlands and prevention of ignitions in the natural ecosystems.

For the purpose of further use, restoration and recultivation of burned peatlands, it is important to make a timely inventory-check the burned peatlands, assess economic and ecological damage, develop a plan of further use of the territory, determine the priorities of development and propose agricultural and nature-protection measures (Fesyuk et al., 2020).

Peat extraction damages soils and requires their recultivation. No such recultivation is taking place in the Oblast (Fig. 4).

Nonetheless, measures for improvement of low-productive lands in Volyn Oblast are being implemented. Those measures are called ameliorative and include hydrotechnical, biological, forest, agrotechnical, chemical amelioration. As of 2019, the leading lands according to improved areas are (Fig. 5): Turiisk district – 18% of the overall parameter for the Oblast, Kamin-Kashyrskyi – 10%, Liuboml, Stara Vyzhivka – 9% in each, Lokachi – 8%, Lutsk – 7%, Manevychi, Ratne district – 6% in each (Rehionalna dopovid, 2019).

At the same time, the extent of soil improvements do not satisfy the existing need. Therefore, the area of the lands that need improvement in the administrative districts of Volyn Oblast is much larger than the areas where the ameliorative land improvement has been made (Fig. 5). The largest areas of the lands that need to be improved are in the following districts: Turiisk (3,170 ha, 33% of the overall area in the Oblast), Ratne (2,801 ha, 30% of the overall area in the Oblast), Kamin-Kashyrskyi (2,030 ha, 21% of the overall area in the Oblast). Together with Lutsk district (541 ha, 6% of the overall area in the Oblast), these districts make up 90% of the area of the lands that need improvement. Unfortunately, statistical reports on the condition of lands made by the Service for the State Cadaster in Volyn Oblast describe no structure of causes of deterioration of the lands, disturbed lands and measures for their improvement.

Therefore, in the conditions of extensive agricultural land use, agrochemical and agrophysical or agricultural degradation of soils take place. Agrochemical degradation is characteristic of acidification of soil, decrease in phosphorus, potassium, and humus. Studies of agrochemical condition of soils, performed in the Oblast, allow monitoring of the contents of those

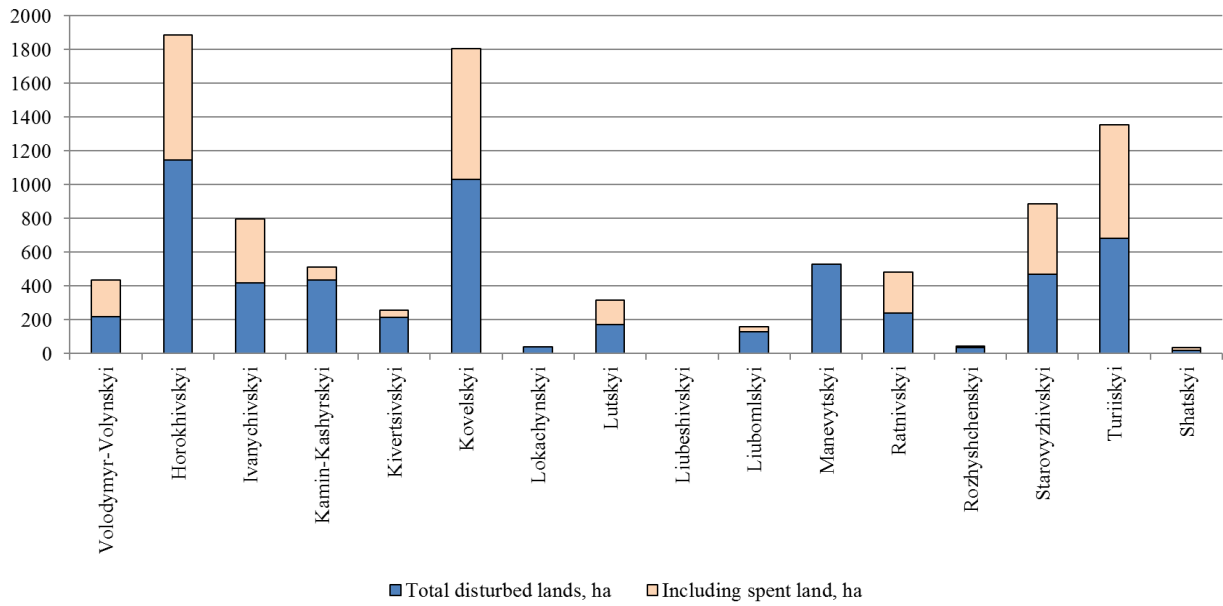


Fig. 4. Areas of disturbed lands in administrative districts of Volyn Oblast as of 2019 (according to the materials of the Main Management of State Cadaster in Volyn Oblast)

elements of fertility. Because the soil cover in the Oblast has been developed mostly by low-humus soils of light granulometric composition, which determined their low capacity of absorption and buffer

property, transformation of the fertility parameters may occur in short periods. Agricultural degradation leads to deterioration in the composition of soil layer, deterioration of water-air regime, physical conditions

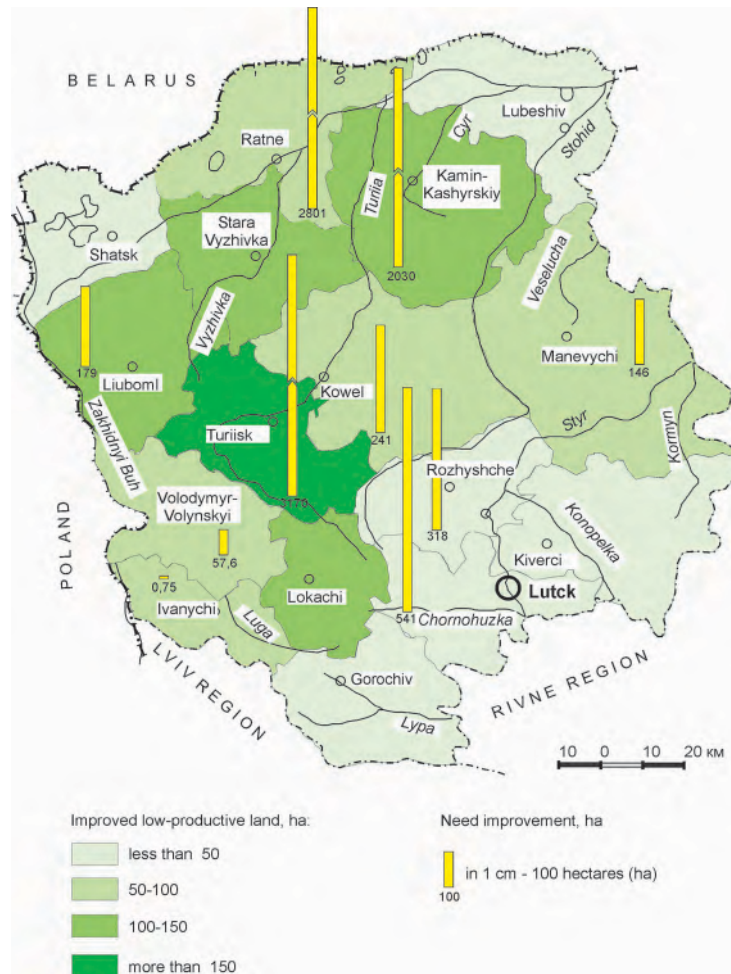


Fig. 5. Improvement of low-productive lands in Volyn Oblast as of 2019 (according to the materials of the Main Management of State Cadaster in Volyn Oblast)

Table 3. Summarised data on conservation of lands in Volyn Oblast as of 2019 (according to the materials of the Main Management of the State Cadaster in Volyn Oblast)

№	Administrative district	Lands taken under conservation since 2002	Lands that need conservation	Including		
				Those in private ownership	In state ownership	Degraded lands
1	Volodymyr-Volynskiy	88.14	544.60	0.00	544.60	307.85
2	Horohiv	104.8	132.52	0	132.52	29.9
3	Ivanychi	106.9	287.26	90.76	196.5	28.1
4	Kamin-Kashyrskiy	88.45	380.7	0	380.7	0
5	Kivertsi	316.32	511.9	0	511.9	57.4
6	Kovel	284.1	1,146.52	0	1,146.52	0
7	Lokachi	108.932	630	0	630	170
8	Lutsk	334.05	356.4	0	356.4	18
9	Liubeshiv	108.4	101.15	0	101.15	18
10	Liuboml	161.3	435.1	0	435.1	0
11	Manevychi	191.2	486.2	264.9	221.3	0
12	Ratne	89.5	291.2	0	291.2	0
13	Rozhyshche	179.3	244	0	244	16
14	Stara Vyzhivka	42	277.8	0	277.8	0
15	Turiisk	399.01	857.43	2.4	855.03	0
16	Shatsk	10	356.9	142	214.9	142
	In the Oblast	2,612.402	7,039.6807	500.06	6,539.603	787.25

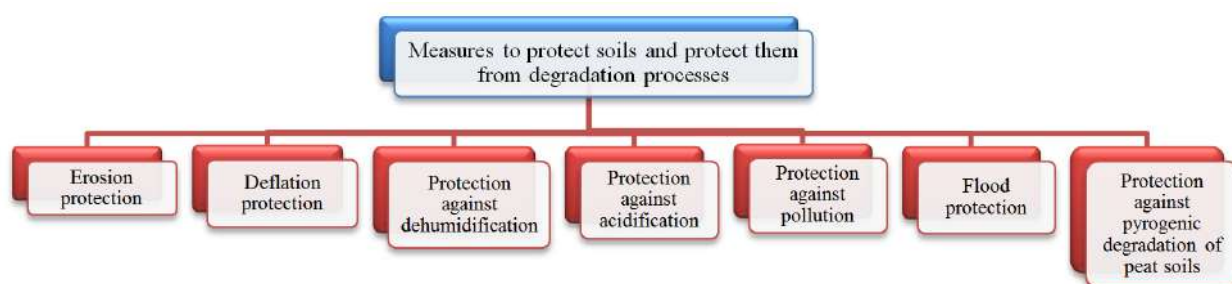
of existing of soil biota and plants. All of this leads to erosive processes.

Agroecological monitoring of soils in Volyn Oblast was conducted by the Volyn Office of State Institution Soils Protection Institute of Ukraine (Derzhgruntohorona), State Institution Volyn Oblast Laboratory Center of Ministry of Healthcare of Ukraine and State Ecological Inspection in Volyn Oblast. Density of ^{137}Cs contamination in the agricultural lands is within $1 \text{ Ci}/\text{km}^2$, content of ^{90}Sr – up to $0.02 \text{ Ci}/\text{km}^2$. In the territory of the Oblast, during 2019, 411 samples of soil were collected for the monitoring of contamination of agricultural lands with residual amounts of stable starch-organic pesticides (DDT, HCH and 2,4-D). Out of 131 analyzed samples, no excess of TLV according to the residual content of DDT was found. Maximum content equaled $0.0027 \text{ mg}/\text{kg}$ at the threshold limit value of $0.1 \text{ mg}/\text{kg}$. As for DDT

preparation, there remains a general tendency toward decrease in the level of contamination of soils and decrease in the amount of excesses in limit threshold values. According to the content of HCH (total amount of isomers), out of 98 analyzed samples, no excesses of limit threshold values were found. Maximum content was $0.001 \text{ mg}/\text{kg}$ at TLV of $0.1 \text{ mg}/\text{kg}$. Regarding HCH, no changes in detection of isomers were found over the recent years. No contamination of soils with 2,4-D (amine salt) was recorded during 2019. Content of each preparation in soils for the recent years have rapidly decreased (Rehionalna dopovid, 2019).

Conclusions

Analysis of geographic distribution of the main types of soils in Volyn Oblast reveals that a threat of physical degradation (over-compaction, desegregation, compressor erosion, etc) is insignificant.

**Fig. 6.** Complex of measures for protection of soils in Volyn Oblast and protection of them against degradation

The reasons for this are light mechanical composition of soils in the most part of the Oblast, and also improvement of soil-processing machines, which are having less impact on soils.

Other types of soil degradation are manifested to a lesser extent. Therefore, it is necessary to develop a complex of measures of protection of soils and their protection against degradation processes. The protection should include the following groups of measures (Fig. 6).

The priority measures of preventing degradation of soils and restoration of disturbed soils are:

- restoration of marshes, waterlogged and overwet lands in order to preserve biodiversity, reduce the effects of climate change, increase moisture in the territory, improve the hydrologic regime of the surface waters and their quality;

- limiting the use of peatlands for extraction of peat, flooding and protection against peat fires;

- increasing the extent of forest areas in the region in order to improve the moisture balance in the territories, prevent the development of degradation processes in soils (erosion, deflation), increasing the efficiency of protection of forests against fires and pests;

- creating a landscape-adaptive system of arable farming with contour-ameliorative organization of the territory in the districts of developed water erosion and stimulating traditional horticulture as a factor of sustainable development of local communities;

- ecologically substantiating the use of organic and mineral fertilizers, poisonous chemicals, preparations for protecting plants;

- implementing organic farming so as to improve food safety, protect soils against chemical contamination;

- conducting soil monitoring, including not only agrochemical monitoring, but also monitoring of the condition of soils, especially degraded soils.

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