BALANCED AND PROTECTIVE FOREST MELIORATION IN SOUTH-EASTERN UKRAINE (LUGANSK REGION)

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Abstract. Today in Ukraine, both in forestry and agriculture, the problem of preservation, reproduction, and expansion of protective forest plantations has become acute. Productivity and protective afforestation conditions have significantly deteriorated due to unauthorized felling; their deaths from fires, littering with household waste. The issue of acquiring ownership of protective forest plantations is acute. In the conditions of uncertainty of owners of field protective forest belts and mismanagement, in the corresponding plantings, fellings of care, formation, and support of a necessary design are not carried out. All this leads to an increase in erosion processes, a significant reduction in soil fertility, and a reduction in crop yields. The experience of using ecological-landscape approaches to forest-reclamation arrangement of agricultural landscapes in the historical and spatial aspect is analyzed. Conceptual approaches to the design of protective afforestation in an ecological-landscape system of agriculture are considered. The general problems of modern agroforestry in the context of reforming land relations are outlined, and the experience of their solution in the Luhansk region (Ukraine) is presented.

Keywords: agro landscape, ecological, landscape, system of agriculture, protection.

In the context of the crisis of agricultural production and radical changes in the structure of agricultural land use, the issues of preservation, reproduction, and expansion of field-protective afforestation have unfortunately receded into the background. An unauthorized cutting of trees in the protective forest plantation (PFP) and their destruction from fires due to illegal mass burning of stubble and littering with household waste became significant problems on a national scale. In the conditions of uncertainty of owners of field protective forest belts and mismanagement, there is no question of intermediate cutting, formation, and maintenance of their necessary design for a long time. There is a paradoxical situation in which the protective forest belts themselves need protection. At the same

time, neither wind nor water erosion has become less threatening for the arable lands of Ukraine; on the contrary, the adverse climatic phenomena such as prolonged droughts and heavy rains cause not only a significant reduction in yield capacity but also significantly increase the erosion processes and lead to significant soil losses. The results of the analysis of 200 years of experience on the impact of field-protective afforestation on agricultural landscapes show that it is possible to cease the erosion, stabilize soil fertility and crop capacity only with the introduction of a comprehensive system of agriculture based on ecological and landscape principles, the structural framework of which is the system of field-protective afforestation.

Because the natural and climatic conditions of the Luhansk region are difficult for farming and its territory is exposed to almost the most intensive erosion processes in Ukraine. The development of forest reclamation measures on an ecological and landscape basis is relevant and needs further research. Our article aimed at the analysis of domestic and foreign experience, introduction of effective systems of farming and arrangement of the territory on ecological and landscape principles, studying of works and conceptual approaches for further development and introduction of optimum systems of protective forest plantation in Luhansk region. It is well known that the South-East of Ukraine is a zone of risky agriculture. The agricultural landscapes of Donbas, where the huge technogenic load on the environment is combined with the highest intensity of erosion processes in Ukraine, are especially vulnerable. Thus, according to the Luhansk Institute of Land Management, at the time of compiling the latest reports on land quality (1996), the agricultural lands in the Luhansk region were eroded by 67%, and arable lands – by 68%, which is almost twice as high as in Ukraine in the whole. Simultaneously, the actual woodiness of the region is 12,7%, which is quite a low index compared to the normative optimum woodiness for this region (16,0%). Luhansk region is characterized by high development and plowing of the agricultural lands (74 and 71%, respectively). This indicates an irrational and largely unbalanced land structure, which causes and exacerbates the region's soil degradation.

Scientific research and practical experience have shown that a set of soil protection measures against erosion in water catchment areas is necessary to stop and successfully prevent the erosion processes (Goroshko et al., 2010; Goroshko et al., 2010). This conclusion was substantiated in the 30-40-ies of the twentieth century according to the results of the Novosylsk ravine-research station under the leadership of A.S. Kozmenko. He was the first who identified the main components of the anti-erosion complex, which include organizational and economic, agro-technical, forest reclamation, meadow reclamation, and hydrotechnical measures (Kozmenko, 1954). One of the main elements of this complex is protective forest plantation (PFP) of different categories. They cause the absorption of surface runoff, improving the land by silt deposition of washed away fine soil particles and enhance these functions in the most superficial hydraulic structures, which are combined with the forest plantation.

It was in Ukraine that 200 years later, a set of forest reclamation measures was first introduced, most of which corresponded to the concept of a modern landscape approach. In 1809-1837 V.Ya. Lomykovskyi, in his estate in the village of Trudoliub in Myrhorod district, Poltava province, for the first time, created a wood-sawing (according to the author) farming system. Soboliev S.S. called the edition of 1837 "Afforestation in the village of Trudoliube", which V.Ya. Lomykovskyi published for the wide dissemination of his experience, and for which he was awarded the gold medal of the "Society of Forestry Encouragement", a classic work (Sobolev, 1948). Now it can be considered strange that two centuries later, our countryman created an original holistic theory and used almost modern methods of agricultural forest reclamation for its implementation, in which each field was protected from the adverse weather conditions by forest, orchard, and shrub plantation in the form of strips, curtains, and tracts in the fields and on the unsuitable lands. High agricultural machinery was used in the fields; soil mulching was used in the gardens, and separate hydrotechnical structures (log-paths and wide dams) were built in the wetlands and valleys. The attention was also paid to the hayfields in the valleys and the pastures on the slopes. The impassable swamps were drained by wide canals and placed lined with the grove. In today's context, the most important thing is that Lomykovskyi V.Ya. "tilled each place separately in such a way as required by the most natural property of the place…". This quotation, which Soboliev S.S. highlighted, emphasizes the ecological and landscape approach in today's interpretation (Sobolev, 1948). In general, regarding the efficiency of the wood-sawing system of Lomykovskyi V.Ya., it allowed obtaining stable high yields even in the arid crop unproductive years of 1834 and 1835 (Sobolev, 1948; Koptyev & Lishenko, 1989).

A modern example of the relevant system implementation into production is the former collective farm "Druzhba" (now agricultural artel "Druzhba") in Kantemyriv district of Voronezh region), in which you can still watch the 30 years of experience in implementing the ecological and landscape farming under the leadership of Professor M.I. Lopyrev (1997, 1999, 2002). He developed and implemented a set of measures, ranging from the territory arrangement to crop rotations, agricultural machinery, and micro-reserves for the beneficial insects. In terms of forest reclamation, the author proposed the field-protective woodiness at the level of 5-6%, the total woodiness of the territory should be 16-20% (in the conditions of the Central Chernozem district); he also proposed the contour-parallel drainage-regulating forest belts (at a distance of 200-350 m, which was calculated in each case depending on the erosion situation), and the introduction of 1-2 shrubby coulisses of trees between the contour-parallel drainage-regulating forest belts, which divided the field into landscape strips and fixed the direction of soil tillage. At the same time, the forest belts, and coulisses of trees on the slopes were combined with the most straightforward hydrotechnical constructions. The afforestation of beams and ravines, economic centers, ponds and rivers and installation of mule filters near the tops of ponds and the cones of removal of ravines and beams, carried out (Lopyrev, 1997, 1999).

On the farm, according to Lopyrev M.I.: “Soil erosion has been stopped, ravines are not growing, the impact of droughts has been significantly reduced, there are more birds and wild animals, the productivity of pastures and hayfields has increased. The results of the soil cover survey show that the degradation of lands has been stopped, humus has been stabilized, water, nutrient and thermal regimes of the soil have improved during 25 years”. The efficiency of such a farming system and territory arrangement is proved by the fact that now the agricultural artel “Druzhba” consistently receives 30-40% higher yields than other farms in similar natural conditions (Lopyrev, 2002). The result of the catastrophically arid year of 2010, which was marked by the powerful steppe and forest fires and large-scale crop failures, is especially significant. Thus, O. Bogdanova in the article “Landscape strips are a guarantee of harvests” from 01.10.2010, gives the following data: in the Luhansk region from 30 to 70% of winter crops have been lost, while in the fields of the former collective farm “Druzhba” they have survived completely and yielded 32.5 centners per hectare (in Kantemyriv district – 11 centners per hectare, and in the Voronezh region – 13 centners per hectare on the average). In the good year of 2008, the yield capacity of winter crops in the fields was 60 centners/ha, while the regional average yield capacity was 32 centners/ha.

Another example is given by the well-known popularizer of ecological (natural) agriculture M.I. Kurdiumov in his book “Peace instead of protection. Practice of natural farming”. We cite a book published a quarter of a century ago by A.P. Aidaka “And the seeds will germinate”, in which the head of the former collective farm “Leninskaia Iskra” in the village of Achaky in Chuvashia shares the experience of transforming the dry ravine steppe into a picturesque and fertile area (Kurdyumov, 2010). Here is also implemented a whole set of measures in their classic combination – the ratio of land, land management, forest reclamation, and alkaline slope erosion-hazardous lands, regulation, and in most cases – the cessation of cattle grazing by creating soil-protective legumes and grass crops on the slopes, and also – the compliance with crop rotations, special agricultural techniques, plant protection systems (mostly biological), the creation of ecotopes for valuable plants and insects, as well as entomological micro-reserves. The result is the same, i.e., the soils and yields on the farm are stable, livestock is provided with fodder and summer pastures created on alkaline arable lands by sowing legumes and grasses near each village (Kurdyumov, 2010).

Analyzing the experience of many practical workers of natural farming, M.I.Kurdiumov summed up their result as follows: “Stable fertility exists in nature free of charge. Its size is optimum, and it gives the optimum yield. It is not the largest, but it is stable, high quality and the cheapest one (highlighted by the author)”. He also defines the role of the agricultural landscape for farming in general: “The health of any agrocenosis covers three levels of biodiversity: rich biocenosis of soils below, mosaic of crops and varieties in the middle, and rich agro-landscape are around” (Kurdyumov, 2010).

These examples, given for 200 years, show that the role of protective forest plantations in the agro-landscape is significant and of frame nature, because they form a system of different types of plantations and comprehensively combine all other components of the agro-landscape. Unfortunately, these examples are the achievements of the individual enthusiasts, starting with M.Ya. Lomykovskyi and ending with the separate modern farms. Such system character and complexity have not become an example and a mass phenomenon; moreover, modern agrarian and land transformations have destroyed and continue to destroy even what was created in the previous decades.

As for modern views on forest reclamation measures in the agro-landscape, we should begin their review with the contour-ameliorative system of agriculture, which was actively implemented in Ukraine in the late 80's and early 90's. It allowed to slow down the erosion processes and partially solve the problem of soil degradation. Simultaneously, in the previous socio-economic conditions, it was impossible to radically change the structure of agricultural land, land categories, and crop rotations, which were strictly determined by the nature of extensive land use and plans for agricultural production. Though the advantages of contour-ameliorative agriculture were undoubted, the main reasons that led to the current ecological crisis in agriculture remained as a consequence of the previous rectangular arrangement of the territory; they are the excessive plowing and irrational ratio of land on the one hand, and on the other – the priority of economic and technological factors over the environmental ones (Dzhos, 2002).

Hladun H.B and Poroshyn O.M. give the typification of forest reclamation measures depending on different types of terrain in terms of the relief and other natural conditions, highlighting some priorities for flat conditions (like the Stone Steppe in Voronezh region) and others – for the areas with complex relief and potential severe danger of erosion processes (Gladun & Poroshin, 2002).

Further development of soil protection systems of agriculture with the contour arrangement of the territory began in the 80-the 90s of the last century, but was significantly detailed and widely supported at the beginning of the XXI century based on ecological-landscape (landscape-adaptive) orientation of land management, which provides for the creation of sustainable ecologically balanced agricultural landscapes with a harmonious combination of socio-economic, environmental and aesthetic functions. The embodiment of these principles today is the ecological and landscape system of agriculture (Lopyrev, 1997, 1999; Belolipskij et al., 1999; Kashtanov, 2001; Gladun & Poroshin, 2002;), which is based on two main principles:

– landscape arrangement of the territory is the framework on which the system of agriculture is formed, regardless of the categories of land users and forms of ownership. It is based on the optimization of the ratio of land and land categories, the contour arrangement of the territory, the optimum and mutually agreed location of the system of protective forest plantations, hydrotechnical structures, and the areas alkaline due to the perennial grasses and nature reserves. This principle is a priority;

An agrotechnical block includes the structure of sown areas, crop rotation, tillage system, fertilizer application. This block provides for comprehensive restoration of soil fertility on the principles of biological and ecological agriculture; it is the second one and subordinated to the interests of landscape arrangement of the territory.

It is the subordination of the territory arrangement to the technological block of agriculture (in which the forest belts were created sporadically within the existing fields of crop rotations, and the fields themselves were allocated without taking into account the relief and soil conditions, but solely guided by the convenience of soil tillage with heavy tractors having large agricultural implements) was and remains the main disadvantage of all previously created concepts of agriculture.

In 1999-2000 the Concept and Program of the ecological and landscape system of agriculture in the Luhansk region for the period up to 2010 were developed (Belolipskij et al., 1999; Dzhos et al., 2000). Several necessary and reasonable measures was envisaged, which at that time (the beginning of mass registration of state acts on land ownership to holders of certificates on shares) could prevent the development of erosion processes and improve the environmental situation at the expense of optimizing the composition and ratio of different types of land plots by increasing the environment of their stabilizing species (forest plantations, hayfields and pastures, water, and swamps) while reducing the area of arable land due to the withdrawal of eroded and other types of degraded lands. It was planned to remove 313 thousand hectares of eroded and unproductive lands from the arable land in the region (mainly on the slopes > 3–5 degrees) and thus reduce the plowing of agricultural lands erosion and ecological zone from 72% to 48–68%. This would make it possible to create an additional almost 92 thousand hectares of PFP, including almost 10 thousand hectares of field-protective ones. The woodiness of the region should increase from 12.6 to 16.2%, and field-protective territory – from 1.9 to 3.6% (Dzhos et al., 2000).

Unfortunately, most of the planned measures remained only on paper. The regional initiative was not supported at the level of either the State Land Committee or the leadership of the agricultural department. Instead, the authorities called for the accelerated consolidation of shares by the State Acts on land ownership, which in most cases led to the accelerated development of land management projects not only without the planned ecological and landscape arrangement of the territory, but also without designing protective and drainage-regulating forest belts in the places where they were essential considering the provisions of the contour and reclamation arrangement of the territory.

The only farm where the ecological and landscape arrangement of the territory was designed in a more or less complete volume was the former collective agricultural enterprise named after Kirov within the Prosianka Village Soviet in Markiv district of Luhansk region. The arrangement of its territory was carried out in a complex with the registration of the State Acts on the shared arable lands and hayfields. The distribution of land shares was carried out considering the ecological

and landscape arrangement of the territory with an integrated system of drainage-regulating forest belts and shrub coulisses, located at the distance of 100-120 m, which fixed the longitudinal boundaries of land plots shares across the slope (Milehin et al., 2003) (Figure 1).

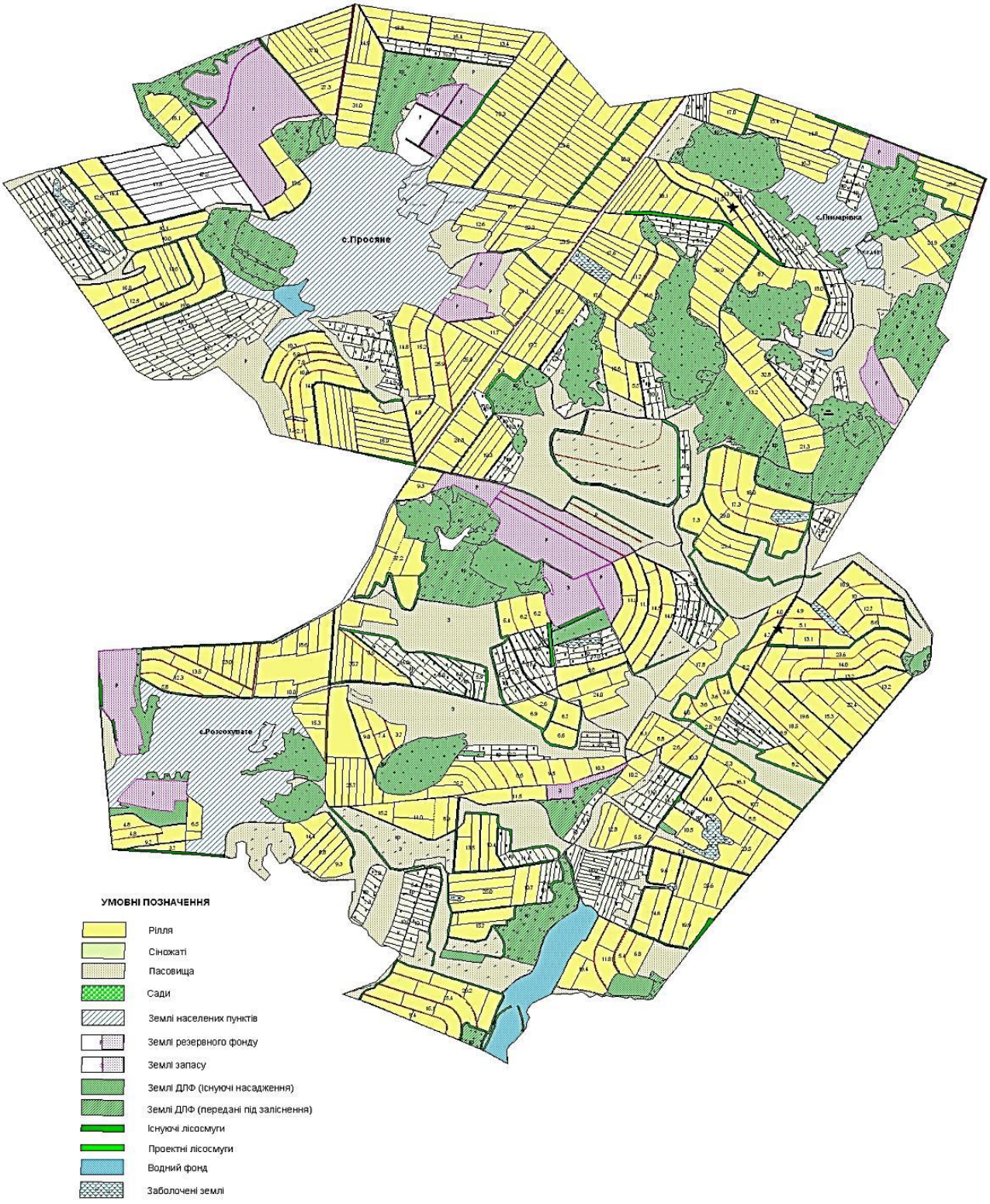

Fig. 1. Scheme of ecological and landscape territory arrangement of the collective agricultural enterprise named after Kirov in Markiv district, Luhansk region (the arable lands are marked with the yellow, horticulture lands – by the green)

The project envisaged a reduction of plowed territory from 56 to 45.7%, an increase in total woodiness from 10.8 to 19.,0% and, accordingly, an increase in the field-protective territory from 2.5 to 4.0%.

The ecological and landscape approaches during the design of the territory arrangement have their peculiarities in creating a system of protective afforestation as a spatial and temporal framework of the agro-landscape.

Their ecological impact on both separate elements and the whole agro-landscape is exceptionally diverse; it is intensified over time and takes on an irreversible, consistently positive character with a synergistic and emergent effect (Jørgensen, 2009; Nerlich, Graeff-Hönninge & Claupein, 2013). Thus, forest reclamation as part of ecological and landscape farming systems should be only comprehensive (cover all spatial elements of the agro-landscape), be based on the water catchment design principle, and have the most prolonged duration (Bila, Goroshko & Gordiyashenko, 2020). Regarding the anti-erosion forest plantations on the sloping arable lands, the ecological and landscape arrangement of the territory provides for significant volumes of creation of drainage-regulating forest belts and shrub coulisses, which should divide the fields into contour landscape strips about 100 m wide. During their design, it is necessary to consider several recommendations:

– drainage-regulating forest belts 10–12 m wide are placed mainly at a distance of 200–300 m on a calculated basis depending on the slopes and their exposure, the wind load at different times of the year, and soil conditions. 1-2 lines of shrub coulisses are arranged between them at a distance of about 100 m. In the hollows, if possible, they are combined with the hydrotechnical structures;

– the main, accompanying, and shrub species are determined according to agricultural forest reclamation and forest typological zoning, considering the ecological and landscape requirements as for the inclusion of the species that are fodder base and habitat of beneficial insects, birds, and animals, and have officinal, phytoncide and melliferous value into the composition of bred plantations.

– structural and technological parameters of the field-protective, drainage-regulating forest belts and those located near the beams and ravines can be variable (width and number of lines, rock composition, scheme and type of mixing, combination with hydrotechnical structures, and width of inter-line spacing) (Lopyrev, M.I. & Petrov, 1982). For example, at the intersection with hollows, you can plant wood species that require more moisture, as the water regime is better here (in the case of oak forest in the hollows, you can plant such species as a shrubby birch tree, Norway maple, etc.);

The simplest hydraulic structures reinforce–drainage-regulating forest belts and shrub coulisses at their intersections with the hollows to increase the working areas for retention and absorption of runoff (Zykov, 2002), i.e., to increase the anti-erosion arrangement of forest belts (Holupyak, 1993);

– drainage-regulating forest belts can sometimes be designed not along the entire contour but replace with a shrub coulisse on the inter-hollow watershed, or break the coulisse and move its part below or above the slope so as not to cross the horizontals (Tyshkovec, 1988). Depending on whether the horizontals are converging or moving away, M.I. Lopyriev (Lopyrev, 1999) and N.H. Petrov (Lopyrev, M.I. & Petrov, 1982) allow the arrangement of forest belts of variable width, and in some cases, they can be supplemented with the decorative borders of perennial grasses.

In general, forest reclamation is an effective anti-erosion measure, but outside the system of agrotechnical, forest reclamation, and hydrotechnical measures, their effectiveness is much lower (Abdalla & Fangama, 2015).

Because the protective forest plantations in the steppe and forest-steppe zone in many cases perform a recreational function and are part of the environment in which the rural population lives permanently, it is necessary to take into account the landscape approaches proposed by German scientist H. Poiker in his monograph "Cultural Landscape: Formation and Care" (Pojker, 1987). The main principles of this approach are as follows:

1. Land management should create an optimum structure of agricultural land and the creation of a cultural landscape. The requirements for the cultural landscape provide for the maintenance or development of natural components diversity in the areas included in the agricultural circulation at the appropriate level.

2. The agricultural landscape should be considered not only as a production space. It is also a place for people's recreation and needs the proper design. This area must meet the technological needs of agricultural production and perform an aesthetic function.

3. On the other hand, an area affected by the intensive agricultural use must include a certain number of natural areas to maintain the ecological stability and balance in nature and the processes of natural resources restoration. These natural areas are a permanent habitat for plants and animals and have a compensatory effect on the neighboring agricultural lands.

4. It is desirable that the agro-landscapes should be located evenly and fan-shaped throughout the space in natural areas. Moreover, the area of separate plots of such an ecological network should be not less than 250 m², and the area of each plot of agricultural land interspersed into this network – not more than 10 hectares, and the similar compensating plots should be approximately not less than 5% of the valuable area of agricultural land.

Conclusions. 1. The ecological and landscape system of agriculture solves the problems of soil protection from water and wind erosion and other types of soil degradation most comprehensively and systematically while ensuring the stable yield capacity and high quality of agricultural products at low cost.

2. The ecological framework of the agro-landscapes structure in the ecological-landscape system of agriculture is the protective forest plantations of different species

and categories. They provide the maximum ecological result only under the condition of a complex combination of different species and categories and their systematic spatial arrangement on the territory, providing a synergetic effect.

3. The ecological and landscape arrangement of the territory makes specific demands and restrictions to the design of protective and drainage-regulating forest belts and other categories of protective forest plantations, which must be considered during the development and implementation of such projects. Simultaneously, their design requires considering the local conditions, creative and original approach, and environmental thinking.

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