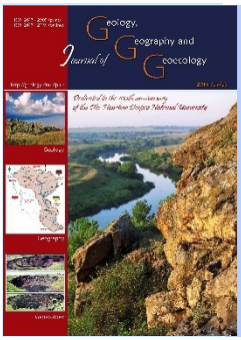

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Ecological and economic basis of anti-erosion stability of forest-agrarian landscapes

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The ecological and economic foundations of rational nature management in restoring various kinds of protective forest stands under conditions of severe damage and destruction of wood-shrubby species in the natural-climatic and economic zones of the country were developed. It was determined that using traditional methods of restoration of protective forest plantations in many cases is no longer acceptable due to different levels of damage and substantial changes to economic entities on Earth. However, the main methodological approaches remain. A new methodological approach to restoring forests on the basis of constant adaptation of the existing methodologies for the design and calculation of economic efficiency of new plantings and new ecological-economic conditions and peculiarities has been developed. Certainly ,numerousincorrectly planned forest stands have been created that do not sufficiently fulfill their ecological and economic functions and do not even have a general system of protection of the soil from negative factors. For effective regeneration of plants we have developed a formula for calculating the erosion stability of forest-agrarian landscapes for their optimal recovery through forest shelterbelts. We have developed new features of design and calculation of ecological and economic efficiency of newly created forest ameliorative spaces with new natural-economic conditions for their sustainable regeneration under modern conditions.
The transition to environmentally sustainable agriculture of European standards requires fundamentally new solutions to the problem of using forest stands as an organizational component of ameliorative complexes in the context of soil erosion control measures. Soil erosion is one of the main factors of anthropogenic impact on land resources. Intensification of erosion processes leads to substantial degradation of soils, causing great losses to agriculture and generally endangers the safe development of mankind. As long as the process of degradation of the soil continues , the agroecological condition deteriorates and the increased application of mineral and organic fertilizers fails to improve the crop volume , insofar as the crop yield is formed mainly due to the natural soil fertility. In the process of research, we discovered that the expansion of the front intake surface runoff in forestry plantings allows one to increase their effective water-regulative functions. Such an event has a certain practical value, because a large proportion of forest shelterbelts even in satisfactory condition only perform their functionsat 20-30%. Taking into account the indicators of ameliorative-hydrological stress and counter-erosion stability of landscapes in locations of planted forest stands proved to be the most effective method of strengthening the initial contact with runoff ("active") plots .This provides is a unique chance to optimize the ecological economic system of protective forest plantations , especially in newly formed agricultural enterprises under new economic conditions.

Keywords: rational environmental use, forest-agro landscape, forest ameliorative stands, erosion, soils.

Еколого-економічні основи протиерозійної стійкості лісоаграрних ландшафтів

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Розроблено еколого-економічні основи раціонального природокористування при відновленні різних видів захисних лісонасаджень за умов серйозного пошкодження та знищення деревинно-чагарникових порід для різних природно-кліматичних та економічних зон країни. Було встановлено, що існуючі традиційні методи відновлення захисних лісових насаджень у багатьох випадках вже не прийнятні через збитковість та значні зміни в системі господарювання на землі. Однак, при цьому залишаються основні методологічні підходи. Розроблено нові методичні підходи відновлення лісів на основі постійної адаптації існуючих методик для проектування і розрахунку економічної ефективності нових насаджень за нових еколого-економічних умов та особливостей. Розроблено основи коригування невірно створених лісових насаджень попередніх років, які в повній мірі враховують еколого-економічні умови та особливості раціонального природокористування за ринкових умов. Визначено високий рівень помилково створених лісових насаджень, які недостатньо виконують свої еколого-економічні функції і не сприяють загальній системі захисту ґрунтів від негативних

факторів в цілому. Для ефективного відновлення насаджень ми розробили формулу розрахунку ерозійної стабільності лісоаграрних ландшафтів для оптимального відновлення системи захисних лісових смуг. Розроблено нові особливості проектування та надано розрахунок екологічної та економічної ефективності новостворених лісоаграрних ландшафтів за сучасних еколого-економічних умов їх сталої регенерації.

Ключові слова: раціональне природокористування; лісоаграрний ландшафт; лісомеліоративні насадження, ґрунти, ерозія.

Introduction. Description of the problem. In the conditions of intense transformation towards a market economy, the aspect of rational usage of natural resourcesis becoming more and more relevant. At the same time, some ecological-economic basics of various aspects of rational use of nature require immediate definition. Recently, in Ukraine, the area of protected forest areas has significantly decreased due to relentless and uncontrolled commercial deforestation, death at the expiry of their period of exploitation, absence of necessary care and scientifically-based recovery. For recovery of the ecological-economic balance of forest-agrarian landscapes of the country, the problem of recovery of the plantations is especially relevant. At the same time, it is necessary not only to recover plantations in deforested territories, but in many cases correct their alignment in relation to newly formed agroformations in the conditions of market territorial-spatial division of land in free market conditions, taking into consideration the level of erosion of the land for further improvement of their natural-economic characteristics. As never before, we now face simultaneously the problem of urgent need and the unique opportunity of creating highly-productive agro-forest ecosystems resistant to unfavourable ecological-economic conditions, able to provide effective protection of soils from erosion and to significantly increase fertility of soils for producing economically valuable and ecologically safe agricultural products. Updating scientifically proven systems of regenerating shelterbelts would allow creation of a forest ameliorative and organisational-economic framework for developing and introducing zonal soil-protecting systems of field crop farming and components of soil-protecting complexes and also soil-protection technologies of cultivating agricultural crops production.

Soil erosion causes great losses to the agrarian economy and threatens the safe development of humanity. The most significant factors in the processes of degradation of soils are processes of water and wind erosion: 56% and 28% respectively. In our country, in the conditions of complex relief, the most ideal in anti-erosional aspect is considered to be the contour-ameliorative organisation of the territory of slope land, which, according to the main characteristics, is based on practical principles of field crop farming on slopes in many countries and best takes into account soil and relief peculiarities of each soil structure . Such territorial organisation is the most significant form of the differential approach to creating conditions for protecting soils during formation of forest-agrarian systems and landscapes. Until the early 1990s , this type of territorial organisation was undergoing scientific and technical trial in many regions of the country. But due to the formal approach, in many cases during the Soviet times, forest plantations were created in an incorrect way, not fullfilling their ecological-economic functions and even sometimes damaging the system of protecting soil from negative factors.

Therefore, currently, in conditions of severe deforestation of large tracts of forest plantations across the country, there is a unique chance of recovering the system of forest plantations regarding scientific-methodological inventories and taking into account new agrarian enterprises with new economic conditions of management.

Our study was orientated towards developing and adapting existing methods of projecting and calculating economic efficiency of new forest-ameliorative plantations to new natural-economic realities and peculiarities of their stable recovery in Ukraine in the modern conditions of deforestation of large territories of forest-agrarian landscapes. The limitations of our study were connected with the absence of full data on the real extent of deforestation of the territory of the country, both in general and forest-ameliorative component, and also the extent of elimination of particular species in plantations.

The objective of the study was to develop suggestions for an ecological-economic basis for rational usage of natural resources.

The goals of the study were as follows:

-to determine the ecological-economic basis for recovering shelterbelts as a fundamental aspect of rational usage of natural resources;

- to proposean algorithm for recovering plantations on deforested territories of forest-agrarian landscapes;

- todevelop methods of planning and calculating the natural-economic efficiency of new forest-meliorative plantations in Ukraine;

- to propose methods of increasing meliorative functions of forest plantations.

Analysis of the previous studies. The aspect of creating and recovering protecting forest plantations was studied by A. G. Ahtiamov, V. A. Bodrova, I. D. Braude, V. S. Vavina, M. I. Kalinina, E. S. Pavlovsky, O. I. Pylypenko, S. S. Soboliev, V. D. Tuniakina, U. I. Cheverdina, S. V. Sharapova, and many others. Creating an effective system of measures is one of the essential methods of applying state policy in the sphere of protecting forest-agrarian land. Therefore, already during the Soviet period, the creation and development of shelterbelts was a subject of interest for I. D. Braude, who was developing the theories of his predecessors, emphasizing that the soils in abandoned and partly destroyed plantations are too dense and become covered with thistles and steppe vegetation. Due to deforestation, neglect of the plantations and failure to apply the correctagrotechnology of their cultivation, their ameliorative value is low and continues to decrease. Neglected forest plantations should be recovered as fast as possible, so they could fulfill their ameliorative functions. At the same time, the author emphasized that the economic expenses for recovering such plantations continue to increase every year. Recovering plantations should follow their examination, for which sample plots are made. The author recommended the establishment ofplanted plots 10-12 m long in belt plantations every 200 m across the entire width, and for large plantations - in the areas where elimination of species is most characteristic. On each sample plot, the condition of the plantation and the number of destroyed plantations of each species should be determined. The obtained data then is used for developing the plan of recovering the plantation. The task of recovering the framework shelterbelts with oak as the main species cannot be approached following a standardized format. V. A. Bodrov and M. I. Kalinin in their studies determined optimum approaches for arranging systems for protecting forest plantations and selecting the best variant from the ecological-economic perspective.They determined a universal algorithm of developing optimum planning solutions for aligning shelterbelts, which is relevant even nowadays in the conditions of market transformations of the agrarian sector of the country`s economy. E. S. Pavlovsky, O. I. Pylypenko and S. S. Sobolev have determined that the economic parameters of surplus in the harvest of agricultural cropsdepend on the height of the shelterbelts, their construction, thesystematicarrangement in the farming. At the same time, in the fields surrounded by shelterbelts on all four sides, the surplus in the harvest was 6 times higher than in the fields adjacent to a woodland belt on only one side. These scientists determined that increase in the harvest of the grain crops in 100 ha areas between the belts is 1.5 times higher compared to 200 ha fields surrounded by forest. According to O. I. Pylypenko, in the chernozem zone of Steppe Ukraine, the average harvest surplus of winter wheat protected by single shelterbelts was 3.7 quintals /ha (11.8%), and 5.5 quintals/ha (17.6%) in the areas protected by shelterbelts of full optimum construction (moderate width and openness). According to collective data of many authors, within a system protected by shelterbelts, the harvest of grain crops on average is 1.6 times higher than in an open field system. In such conditions, the surplus in the grain harvest can be over 10-15 quintals/ha. All these calculations were made for shelterbelt plantations of full construction, which were practically undamaged by relentless deforestation and frequent tree falling in the plantations. The studies by I. D. Braude revealed that shelterbelts increase productivity of labour in agriculture by 12-15%, and decrease cost of plant products sold by 9-13%. The rate of return of cultivating grain crops and green mass of corn in the fields between shelterbelts increases by 30-40% and of technical crops (sugar beet, sunflower and Gossypium) - by 50-60%. U. I. Cheverdin, V. S. Vavin, A. G. Ahtiamov and V. D. Tuniakin emphasize that the woodland belts have a significant effect on regulation of moisture in agro- and natural cenoses. Their impact, especially in dry conditions, significantly decreases the duration of periods with no productive moisture in soil, the supplies of which are the most dynamic in the humus horizon. Also, an impact of climatic anomalies was found on the preservation of woodland shelterbelt plantations and their structure.

Following this analysis of research, the conclusion could be drawn that the data obtained by the abovementioned authors indicatesthe large scale ecological-economic impact of full scientifically-based systems of forest-ameliorative plantations both on the results of farming in the agrarian sector, and on creating favourable conditions for further stable development of forest-agrarian landscapes. Neglected, or partly destroyed and non-systematized remnants of the complex of forest-ameliorative plantations almost totally lose their ecological-economic significance.

Methods. The sources of the data and the empiricalbase of the study was the ecological-economic documentation on the condition of protecting forest plantations in the country and the dynamic of its spatial-qualitative changes both directly in the period of the study and over the last two decades in general. Due to the urgent character of the study`s problematics and relatively limited basis of field survey data, we mostly used methods

of interpolative analysis of data, retrospective methods of study and content analysis on the basis of a qualitative-quantitative approach and study of documentation due to objectivity of the conclusions and quantitative analysis of the data with following objective interpretation of the results of the corresponding research. The methods of the data analysis were orientated towards determining the dependencies of the calculations on the basis of the criteria of anti-erosion resistance of forest-agrarian landscapes, which was determined by a complex analysis of the main factors of decrease in fertility of the soils on the basis of the theory of similarities and physical modeling. Using methods of dimension theory and natural analogues ensures reliability of the calculation formulae for any geomorphological and soil-climatic conditions with shelterbelts of different levels of damage and incorrect positioning.Automized calculation of characteristics of erosion potential was performed using methods of structural-digital analysis of the area. This method consists of a conceptual approach to the forest-agrarian landscapes as a component of a dynamic system, functioning of which is determined mainly by its so-called framework - combined networks of thalwegs and water divides.At the same time, a logical unit of information during creating a structural model was water intake. Obtaining initial information requires preparing data using an algorithm of converting the initial data into an idealized "fluvial" form. The entire process of distinguishing and complectation of a structural model consists of the following steps: Step 1. - Transformation of the initial network function to fluvial. (This means that the developed network function has no local minimum values, and the united global minimum corresponds to the mouth of the water intake). Step 2. - Creating erosionaltree speciesstructures (A particular hydrogeographic network is distinguished in relation to forest-agrarian landscape.) Step 3. - Determining the range of elements of forest-agrarian landscape structure (for each structural element, sequence is determined, at the same time, the area of each sublandscape is calculated). Step 4. - Distinguishing and determining the borders of the elementary forest-agrarian landscape(Selection of border points and their arrangement regarding the counterclockwise orientation and relation to the mouth of a particular sublandscape were made for each forest-agrarian sublandscape). Step 5. - Determination of the zones of deviation from the fluviality and other specific points. (In the landscapes, the distinguished zones were the ones which changed as a result of the algorithm impact on the first step,we also distinguished some other peculiarities of the line and points such as depletion zones, lines of folds of slopes, etc.). Therefore, the components of structural information, which characterize the forest-agrarian landscape can be as follows: the corresponding structure and density of plantations, borders of water divides and specific points in the landscapes (for example, the most damaged areas of forested territories, erosion wash-outs, etc). The structural-digital modeling of forest-agrarian landscapes allows determination of the morphometric data of the study objects, which characterize the ecological-economic potential of the existing forest plantations and the requirements for its recovery and optimization. Analysis of anti-erosional potential of forest shelterbelt plantations was performed using the method of determining its direct impact on the factors of ruination and shifts of soil. For calculating anti-erosional potential of shelterbelts, we determined the content of the criteria by determining the balance between ameliorative environment and ameliorative loads on those plantations. The content of critera for the data analysis was determined for the plantations in different conditions of preservation, purpose, structure, construction, species composition and age; for determined plantations with different positioning on the water intake slopes; for plantations in places where they are combined with the simplest hydrotechnical constructions. Criteria for calculating anti-erosional potential of shelterbelts were determined in relation to two aspects - their ameliorative impact on the conditions of development and dynamic of surface flow on water intake slopes. During the evaluation of the first aspect, the main criteria are ameliorative hydrologic pressure and ameliorative capacity of the plantations. Quantitative expression of their direct impact was determined according to the parameters of woodland belts only on "operating" areas and using methods of recovering and strengthening combined with phyto-ameliorants and the simplest hydrotechnology on the slopes which concentrate the flow.

The volume of the flow was determined by the size of water-intake area and form of the slopes of forest-agrarian landscapes, which determine microrelief of the water-intakes. If the volume of water which flows down increases two times, its eroding impact approximately doubles. The speed of eroding flows is determined by the steepness and length of water intake slopes. If the velocity of water increases two times, its destructive force increases 4 times. During determination of the ameliorative capacity of shelterbelts with different characteristics, we took into account infiltrational properties of soils under those plantations, condition and age of plantations. At the same time, for evaluating intensity of moisture absorption

under the plantations, we used data on the intensity of moisture absorption by soils at rain intensity of 4.5 mm/min. At the same time, quantitative expression of water absorption process under the forest plantations determines their width, which provides full regulation of the surface flow. Meliorative load is the main criterion which determines the level of effectiveness of different arrangement of woodland plantations. The best variant of positioning the flow-regulating shelterbelts was selected by the criterion whose variant allows reducing the current speeds to non-washout values. During the study, we also used the parameter of level of moisture in soil in the zone of their impact on hydroclimatic factors (wind, temperature of air and soil, type of atmospheric precipitations, the extent of evaporation, etc). Ameliorative potential of water-regulating shelterbelts was determined according to the total of the factors of 4 categories: absorption of flow, erosionally safe redistribution of the flow, accumulation of solid particles washed down by the flow, general ameliorative impact. Increase in the flow front and decrease in the length of flow-withdrawal areasof the borders can be used for increasing soil-protecting efficiency of forest plantations. The calculation of anti-erosional potential of water-regulating shelterbelts was performed on the basis of determining the structure of woodland plantations on "active" areas, i.e. areas of initial contact with runoff water and using normative data, determining the ameliorative loads in these plantations, which could be neutralized. Then, we determined the species composition of the forest plantations and percentage proportion of tree-shrub communities in them. Then, we determined average coefficients of species composition of the plantations. Afterwards, we calculated acceptable ameliorative loads for each species coefficient. Insiting forest-ameliorative plantations, one should take into account the fact that in the areas of forest-agrarian landscapes which are arranged in the same range of acceptable values in relation to gradations of ameliorative loads it is necessary to project the siting of similar types of plantations .This methodological approach to recovering and projecting shelterbelts is the most suitable, for it takes into account the parameters of ameliorative loads on the entire surface of the areas of landscape, and at each point of its surface. The recommended ameliorative forest plantations are arranged on slopes with such calculation, that they not only perform their functions best, but at the same time occupy the least area of agricultural land. During calculations of width of the areas between the shelterbelts we used the parameters of modules of maximum discharges of the flow. Testing methodological instruments demonstrated their high efficiency in modern conditions of market farming, but some problems occurred for introducing forest-ameliorative measures in the entire territory of forest-agrarian landscapes due to the fact that it requires additional agreement with landlords and due to the need of explaining the practicality of the complex measures for recovering forest plantations in the entire territory of water-intakes of the first order.

Main material. Over the recent years, in Ukraine, in the conditions of massive deforestation due to the plantations being worked-out or fallen, due to logging for heating and other needs without required scientifically-based recovery and in the absence of effective punishment for cutting the plantations, the problem of ecological-economic safety of agrarian production is extremely relevant. In many cases, due to integrated privatisation and land division, the main ameliorative-organizing systems of shelterbelts both for general ecological and agroforest-ameliorative purposes are ignored. As a result, the negative impact of wind and water erosion on the ecological-economic parameters in farming have significantly increased.

For particular calculations of optimum positioning, structure and construction of shelterbelts during their recovery in the zones of eroded land and areas threatened by erosion, one should follow the calculations of anti-erosion resistance of forest-agrarian landscapes. During our study, we developed a formula for calculating anti-erosional resistance of landscapes using a complex analysis of the main factors of water erosion of the surface of landscapes. Anti-erosional resistance of forest-agrarian landscapes was understood as the ability of soil surface to resist the destructive impact of the main natural-anthropogenic factors of soil ruination. Anti-erosional stability depends on physical-chemical and mechanical properties of the surface of landscape. The main physical-climatic characteristic in the analysis of antierosional resistibility is the surface flow of melted and rain water. For full ecological-economic justification of the projects of recovering shelterbelts, all initial data can be organized in tables and graphic figures. Basic material for this justification is the material of geobotanical survey of any given area, soil maps, cartograms of slopes` steepness, extent of erosion and technical groupings of lands from the archives of Oblast branches of Research Institutes of land management institutions. Therefore, we developed a formula of calculating antierosionalstability of forest-agrarian landscapes for optimum recovery of shelterbelts in one or another area of the landscape (1), which in general looks as follows:

$$\Pi = \frac{\text{ENM}}{\text{pghc}\,[\sin\alpha]\text{s}\,\text{TF1F2dw}}\ , \qquad (1)$$

where Π – is a coefficient of anti-erosional stability of a forest-agrarian landscape; E – erosional resistibility of a forest-agrarian landscape at a particular point (in newtons); N – parameter of anti-erosional effect of a complex of ameliorative measures, M – parameter of anti-erosional stability of vegetative cover; p – water density; g – acceleration of gravity; hc – average multi-year layer of active flow, м; α – angle of the surface within a particular point, grad; s – parameter of the extent in relation to erosional stability; T – area of water divide for a particular point, square meters; F1 – coefficient of lengthwise form of slope column within a particular point; F2 – coefficient of transversal form of slope column within a particular point; d – coefficient of slope exposition; w – coefficient of complex impact of other factors on the surface flow.

Such calculations allow determination of all details of recovery and optimum planning of shelterbelts in particular areas of forest-agrarian landscapes of the country. At the same time, in relation to soils, the calculated coefficient of anti-erosional stability is an indicator of soil balance, which reflects a gain of soil or preservation of a soil layer through the soil-forming process and decrease in the layer of soil due to erosion. The ability of using the principle of selecting natural forest-ameliorative agents on the basis of the criterion of anti-erosional stabilitycan facilitate the required planning solutions using previously developed methods of forest-ameliorative planning. The main purpose of natural forest ameliorating agents is recovering the acceptable extent of anti-erosional stability which is the main limiting element in anti-erosional calculations of the corresponding plantations. Ecological-economic justification of antierosional protection of soils is made using typical erosion-soil maps. Due to diversity of ecological-economic conditions, the presence of an element of subjectivity in the process of soil-erosion cartography for each region, the borders of Π values are checked by analyzing several representative large-scale soil-erosional maps. On average, the coefficient of anti-erosional resistance should be calculated for 3-8 ha of forest-agrarian landscape, and the interpolation of the data should be made for further planning.

On the basis of analysis of the condition of damage to forest plantations in different types of landscapes, maps of ameliorative-hydrologic loads on forest plantations were developed. These materials should be used during determining the parameters of water-regulating shelterbelts in relation to those characteristics. Over the study, we determined that enlarging the front of water flow to a forest plantation allows their water-regulating functionto be increased. Such measure has a certain practical significance for most of the flow-managing shelterbelts we studied, even the ones in satisfactory condition, perform only 20-30% of their functions. Taking into account the parameters of ameliorating-hydrological loads and anti-erosional stability of landscapes in places of forest plantations, we determined methods of their strengthening on "operating" areas (Table).

Table. Methods of increasing water-regulating woodland belts on areas of initial contact with runoff water in the plantations

Ameliorative-hydrologic loads		Structure of plantation		Methods of strengthening woodland belts		
category	absolute value, m/s	width, m	number of rows	introducing species to the composition,%		hydrotechnical constructions
				trees	shrubs	
Week	15-45	3	3	100	-	-
Average	45-75	12	3-4	75	25	Level spreader
High	75-100	12	4	50	50	Same+hillside ditch
Extremely high	105-135	15	4-5	50	50	Water trapping anddiversionbars, runoff with grass cover, hillside ditch
Critical	over 135	25-30	10-12	50	50	Same+ ferroconcretestructures

Source: authors` system.

For elaborating the methods of determining the erosional potential of ameliorating objects, a study was made in the basin of the OskolRiver. At the same time, we detemined that in elementary forest-agrarian landscapes, the erosional processes take place less uniformly and more intensively than

in left-bank slopes, which must be taken into account. On the basis of the analysis of morphometric characteristics of landscapes, which were determined using the maps taking into account soil-climatic factors as specific coefficients, we developed complex maps of determining their erosional potential distinguishing zones by its extent at the same time. The extent of ameliorative-hydrologic load on linear forest plantations is significantly related to the pattern of redistribution of surface flow on the slope, which is conditioned by the extent of microrelief pattern of forest-agrarian landscape, and peculiarities of arrangement of woodland belts in relation to lines of flow on the slope areas for amelioration. Research on the basin of the OskolRiver revealed that the erosional resistance of right-bank slopes in general is 2-2.5 times lower than of left-bank slopes. Using such maps, one can determine the place and peculiarities of positioning and structure of water-regulating shelterbelts. On the slopes, it is first of all in zones with maximum levels and the highest density of isolines. When correcting the arrangement of the water-regulating shelterbelts which are being recovered, one should take into account the methods of their impact on the processes of formation and the dynamic of surface flow. At the same time, "direct" and "external" impact on these processes should be distinguished.

Direct ecological-economic impact of shelterbelts is characterized by the extent of impact of trees and shrubs and the forest environment which they form (scabrous soil surface, combination of the water-withdrawals by roots, increase in soil porosity, moisture of forest litter, etc) on the concentrated surface flow of mostly rain water which flows to their "operating" parts. The main goal of shelterbelts is preventing formation of concentrated water flows in the mouths of temporary water intakes with critical speeds of washout. External impact of shelterbelts is characterized by the extent of their washout impact on the process of forming the flow of melted water on the slopes next to them (trapping snow, snow division, temperature regime of air and soil, freezing and melting of soil, tempi of melting of snow, etc) for creating conditions for maximum absorption of melted water directly on the slopes. It was determined that the flow-regulating shelterbelts should be positioned on landscape slopes with such calculation that their erosional potential is opposed to ameliorative potential of these woodland belts to ameliorative-hydrologic loads at 20% provision of surface flow. Such ecological effect can be achieved by increasing the length of the runoffedge of shelterbelts, change in width and structure of woodland belts, density of plantations and selection of specific forest species for " active" areas of shelterbelts.

To achieve the highest ecological-economic effect of using water-regulating shelterbelts in slope crop-farming, it is very important to calculate the distance between them on slopes with different parameters of steepness, form, length and roughness. To determine such parameter one can use the following developed formula (2):

$$D = \frac{VsKm}{M^2CBXKp} \quad , \qquad (2)$$

where D is the distance between the water-regulating woodland belts on the sloping territories; Vs - non-washout speed of water flows for autumn tillage; Km - coefficient of ameliorative impact of forest plantations; M - coefficient of erosion extent of the soil surface; C - coefficient of steepness and roughness of soil surface; B - coefficient of surface flow; X - intensity of precipitations, m/s; Kp - coefficient of lengthwise-transversal form of the slope column.

We determined that it is best to position the outskirts of water-regulating shelterbelts so that the width of the front of the route of approach for the surface flow is maximal and its size is close to the length of these strips. At the same time, ameliorative-hydrologic load on “active” areas of shelterbelts can for a number of reasons be higher than their ameliorative potential. In such cases, during recovery of plantations, it is practical to increase their functions by adding more shrubs, and also using the simplest hydrotechnical constructions –level spreaders, hillside ditches, water-trapping and water-withdrawal ditches, etc. For selecting the appropriate intensifier of the plantation`s function, a particular ameliorative-hydrologic load on “active” areas is determined using the following formula (3):

$$Mp = \frac{\Sigma V}{s} \quad , \qquad (3)$$

where Mp – ameliorative-hydrological load, cubic meters/square meters; ΣV - volume of the surface flow from the water intake;S- “active” area of a shelterbelt.

On the slopes divided by deep depressions which receive a large amount of concentrated surface flow, efficient water management can be recovered by combining slope flow-regulating woodland belts with depressive-strip plantations which are created directly in the depressions as mud filters along the flow and windbreaks on their slopes.

Therefore, during recovery of forest-ameliorative plantations, one should necessarily take into account anti-erosional potential both

during determining ameliorative-hydrological loads on the shelterbelts and during selecting new forest species and their positions in particular conditions, and the economic efficiency of the plantations is calculated on the basis of comparing expenses for their creation and care with the sum of the damage avoided. The harm caused by water erosion is washout of soil, which leads to decrease of its fertility, loss of nutrients, decrease in the moisture regime , muddying of water bodies and loss of areas in cultivation due to formation of gullies. Non-favourable factors act as a complex, therefore can usually be evaluated by groups of factors in relation to the pattern of negative impact and harm. At the same time, loss from decrease in soil nutrients as a result of washout is determined by the sum of applied fertilizers. Decrease in the amount of nutrients depends on their content in the products of the washout and parameters of annual washout. For field-protecting and water-regulating shelterbelts, there are determined losses of harvest in the sum of money for the area covered with shelterbelts throughout the period of their existence and additional profit from increase in the harvest. Also, the fluid reserve of anti-erosional cuttedplantations of the age requiringsanitation harvest and their tax price should be determined. The payback period of shelterbelts significantly depends on the width of shelterbelts, structure, condition and intensity of growth. The narrower and denser the shelterbelts are, the shorter is their payback period. At the same time, they are most effective when long-growing species grow together with fast-growing species. The results of the study demonstrated that the ecological conditions of an area change in conjunction with change in microclimate in the fields next to the plantations. During recovery of full protection of the fields, the continentality of the climate, the amount of precipitations increases, the wind speed reduces, agroclimatic parameters improve, air moisture and moisture reserves in the soil increase, and the level of groundwater increases, the surface flow decreases follow increase in soil fertility and efficiency of anti-erosional measures for preserving and recovering soils. As a result of impact of recovered woodland plantations, the process of creating a stable productive forest-agrarian landscape occurs, which provides higher ecological-economic stability of crop farming in general. However, recovery of forest plantations is related to certain costs on material-technical resources. For forest plantations, a share of fertile arable land must be sacrificed. During the first years of recovery of shelterbelts, the protection properties of shelterbelts are not significantly efficient.For determining the total economic efficiency of shelterbelts, one should know all the investments required for establishing and cultivating the shelterbelts, the percentage of the land provided for recovering the forest plantations, increasing the harvest and costs of the agrarian products sold, payback period of selling the surplus harvest and the level of rate of return. We determined that the costs on creating and recovering 1 ha of oak shelterbelts of 10 m width and cost of annual losses of harvest in the area covered with shelterbelts begin to pay off 6 years after planting and fully pay off after 10 years, and for popular shelterbelts - after 2-3 years and 5-6 years respectively. Afterwards, the shelterbelts provide net profit. Until reaching the age of 15-years, net profit under the impact of 1 ha oak shelterbelt is 45 thousand grivnas, and for a poplar shelterbelt 80 thousand grivnas . At the same time, productivity of all main agrarian crops increases gradually on average by 5-10 percents every year depending on the crops and conditions of local moisture. Therefore, total harvest of crops in Kharkiv Oblast in 2017, on the 1st of November equaled, in thousand quintals: grain and pulse crops –37,502.4; sugar beet – 6,193.6; sunflower– 10,883.1; potato– 10,778.5. These indicators should significantly increase due to forest-ameliorative measures in eroded lands.

Conclusions. Thus, this article presents the developed ecological-economic basis of rational usage of natural resources for recovering different types of shelterbelts in conditions of intense damage and destruction of tree-shrub species in natural-climatic and economic zones of the country. In the process, we determined that currently, the traditional methods of recovering shelterbelts in many cases are not appropriate due to different level of damage and significant change in economic conditions of farming and land. However, the main methodological approaches remain the same. Therefore, we developed new methodological approaches for recovering plantations on the basis of stable adaptation of the existing methods of planning and calculating the economic efficiency of new plantations to new ecological-economic conditions and peculiarities. A transition to ecologically stable crop farming of a European standard requires a principally new way of using forest plantations as organisational-ameliorative component of the complex of anti-erosional measures. Erosion of soil is one of the main factors of anthropogenic impact on land resources. Intensification of erosional processes causes significant degradation of soil, significant losses in agrarian farming and jeopardizes safe development of humanity in general. It was determined that as long as the soil degradation processes have not

stopped, the agroecological condition of the soil continues to deteriorate and there is no improvement from increasing the application of mineral and organic fertilizers due to the fact that productivity of agrarian crops is formed mainly by the natural fertility of the soil.

We determined the high level of incorrectly created forest plantations which unsuccessfully performed their ecological-economic functions and even harmed the general system of protecting soils from negative factors. For effective regeneration of plantations, we developed formulae of calculating anti-erosional stability of forest-agrarian landscapes for optimum recovery of the forest-ameliorative component in a particular area of landscape and distance between water-managing shelterbelts on slopes with different parameters of slope angle, form, length and roughness. In the process of study, we determined that enlarging the front of provision of the surface flow to a forest plantation facilitates an increase in their effective water-regulating function. Such an approach has a certain practical value, for most of the flow-regulating shelterbelts we studied, even in satisfactory condition, performed only 20-30% of their functions. Taking into account the parameters of ameliorative-hydrological loads and anti-erosional stability of landscapes in the areas of shelterbelts, we determined the most efficient methods of their increase on runoff ("active") areas.

Therefore, currently, apart from the massive deforestation across the country, there is also a unique chanceof ecological-economic optimization of the system of forest plantations in relation to scientific-methodological developments taking into account new agrarian enterprises with new economic conditions of farming. We developed new peculiarities of planning and calculating the ecological-economic efficiency of new forest-ameliorative plantations in new natural-economic conditions for their stable regeneration in Ukraine in current conditions of deforestation of large territories of forest landscapes.

Further, it is necessary to develop work on of adapting shelterbelts both to new principles of planning new agrarian enterprises and to climate changes which directly affect the characteristics of new plantations.

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