Plant and Soil Science

Journal homepage: https://agriculturalscience.com.ua/en
*Plant and Soil Science, 14(4), 21-32*
Received: 29.06.2023 Revised: 29.09.2023 Accepted: 22.11.2023

UDC 712.3:911.6:477.7:634

DOI: 10.31548/plant4.2023.21

**Ihor Hrynyk**
Doctor of Agricultural Sciences, Professor
Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine
03027, 23 Sadova Str., Kyiv, Ukraine
https://orcid.org/0000-0002-3652-8152

**Tetyana Yehorova**
Doctor of Agricultural Sciences
Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine
03027, 23 Sadova Str., Kyiv, Ukraine
https://orcid.org/0000-0003-2148-7738

**Mykola Bublyk***
Doctor of Agricultural Sciences, Professor
Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine
03027, 23 Sadova Str., Kyiv, Ukraine
https://orcid.org/0000-0003-4056-791X

**Lyudmila Barabash**
PhD in Economics, Senior Researcher
Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine
03027, 23 Sadova Str., Kyiv, Ukraine
https://orcid.org/0000-0003-1243-8627

# Agricultural landscape zoning of the Forest-Steppe zone of Ukraine to develop organic gardening

**Abstract.** The relevance of this study lies in the applied use of general scientific methods of landscape ecology in organic horticulture of the Forest-Steppe of Ukraine. The purpose of the study was to develop a system of targeted agricultural landscape assessment of the territory to determine the prospects for the development of organic horticulture on the example of the right-bank part of the Western Forest-Steppe. To fulfil this purpose, the methodology of targeted agricultural landscape zoning of agricultural land was used. For this, maps and diagrams of the distribution of the main structural components and factors of the agrosphere, namely, landscapes and morphological structures of the relief, soil and vegetation cover, water chemistry, rocks, functional use of land and traditional areas of agricultural production, were used. The cartographic method and expert assessments of land suitability for organic horticulture were based on the study of 8 natural and anthropogenic factors that form the corresponding taxonomic classification of agricultural landscapes of the Forest-Steppe from 30 taxa. The spatial differentiation of the factors

**Suggested Citation**:

Hrynyk, I., Yehorova, T., Bublyk, M., & Barabash, L. (2023). Agricultural landscape zoning of the Forest-Steppe zone of Ukraine to develop organic gardening. *Plant and Soil Science,* 14(4), 21-32. doi: 10.31548/plant4.2023.21.

*Corresponding author

is determined by the relevant quantitative and qualitative parameters of orchard lands. The expert assessment of agricultural landscapes for organic horticulture is based on the percentage level of alteration of the natural structure of the land. A full-scale model of the target map of agricultural landscapes was developed to assess the prospects for the development of organic horticulture on the example of the central part of the Right Bank of the Western Forest-Steppe. The study area of 5,400 square kilometres was located at the intersection of three administrative regions, namely Zhytomyr, Kyiv, and Vinnytsia. The study identified 21 agricultural landscapes, the territories of which are homogeneous in 8 parameters. Their comprehensive regional perspectives for organic horticulture are rated from 11 to 21. It was proposed to define 5 categories of agricultural landscapes according to their suitability for organic horticulture: the highest (21 points), high (19-20 points), medium (17-18 points), low (15-16 points) levels of suitability and unsuitable (11-12 points). Half of the study area is covered by agricultural landscapes of high suitability for organic horticulture, 15% each of medium and unsuitable, and 10% each of high and low suitability. The targeted classification of land for organic horticulture on an agricultural landscape basis is the scientific and methodological basis for the widespread development of a new, environmentally sound type of agricultural activity in Ukraine

**Keywords:** agrophytocenosis; organic fruits; land categories; target zoning; full-scale model of the target map of agricultural landscapes

## INTRODUCTION

Organic agriculture is a holistic production management system that contributes to the development and strengthening of the viability of the agroecosystem, namely the maintenance of its biodiversity, biological cycles, and soil biological activity (Clark, 2020; Çakmakçı *et al.*, 2023). It is aimed at using natural resources (i.e., mineral and plant-based products) and avoiding synthetic fertilisers and pesticides.

Organic products have several advantages: they are grown without synthetic chemicals, do not contain genetically modified organisms, and are processed without preservatives and artificial colours, etc. (Paoli *et al.*, 2019). Therewith, the level of price premiums for it is much higher compared to conventional products (Pawlewicz, 2020). Global sales of organic food and drink continue to grow year on year. Furthermore, its growth in 2020 was also driven by the pandemic, which increased consumer interest in these products (Schlatter *et al.*, 2022).

Ukraine is a global supplier of agricultural products and plays a vital role in ensuring a sustainable food system and food security in the world, and organic production is still one of the priorities for the further development of its agricultural sector (Ostapenko *et al.*, 2020; Galashevskyi *et al.*, 2021). In 2021, the total volume of Ukrainian organic exports to more than 30 countries amounted to about 260.0 thousand tonnes of products, of which 82% were exported to the EU (Sahota, 2022).

Therewith, organic fruit and berry growing is becoming increasingly popular (Galashevskyi *et al.*, 2021). In 2020, the area of such plantations was about 3.9 thousand hectares (or 1.8% of all fruit and berry plantations). The leading place among other fruit crops in terms of this indicator (1,314.0 ha, or 33.3%) in Ukraine is occupied by apple trees, one of the oldest cultivated fruit plants in the temperate zone. The widespread distribution of this crop is explained by its high adaptability to different soil and climatic conditions, as well as the rich biochemical composition of the fruit, which, with the appropriate selection of varieties, can be consumed fresh almost all year round (Bublyk *et al.*, 2018). Other crops include walnuts – 1,212.8 ha (30.7%), raspberries – 585.0 ha (14.8%), blueberries – 227.3 ha (5.8%), hazelnuts – 86.9 ha (2.2%), currants – 80.8 ha (2.0%) (FiBL, 2022). The scientific and methodological basis for the further development of organic horticulture in Ukraine and new prospects in the European organic market is the targeted classification of land on an agricultural landscape basis to create environmentally sustainable agricultural landscapes.

Designing agricultural landscapes involves defining a set of desired ecosystem goals, assessing the current landscape structure considering these goals, and implementing targeted changes to achieve them (Aulia *et al*., 2020). Soil is a dynamic component of the landscape that is affected by human activity. It underlies gardening, providing space for plant growth as well as important nutrients and water (Teuber, 2021). Organic fruit cultivation usually depends on well-balanced soil with sufficient micronutrients. There is evidence that farming systems affect the level of the latter in the products grown. Researchers note that organic crops, compared to conventional crops, on average, have lower concentrations of pesticides and cadmium and higher antioxidant capacity and concentrations of a number of individual phytochemicals with antioxidant activity (e.g., phenols, minerals, other plant protection compounds) (Montgomery & Biklé, 2021).

According to experts, a fundamental component of programme research on organic horticulture areas should be the balance of soil nutrients (Pichura *et al*., 2022). This issue is one of the most important, as Ukraine's soils lack both the main plant nutrients and micronutrients. Regional biogeochemical studies over the past decade have shown differences in the balance of micronutrients in crops and outlined health risks for its consumers (Yehorova, 2018). For instance, in the Forest-Steppe of Ukraine, the authors describe agricultural landscapes with a lack of molybdenum, a complex molybdenum deficiency and an excess of zinc, as well as a predominant balance of Co, Mo, Zn, Mn, Cu, Sr (Yehorova, 2022). This substantially reduces the quality of plant materials and leads to the spread of a number of endemic diseases among the population of Ukraine, which is manifested by the increased incidence of micro-nutrient deficiencies among children (Liu-Helmersson *et al*., 2019).

Improving the soil-plant biogeochemical system by introducing certain micronutrients in certain agricultural landscapes will contribute to a substantial increase in the quality of the final product and, accordingly, a positive impact on the health of its consumers. An important aspect of the research is to increase the number of land zoning parameters by assessing the balance of key nutrients and microelements and considering radiation and industrial pollution.

Furthermore, unlike the scientific support for the cultivation of organic annual crops in fruit growing, these issues have been considered to a limited extent. Therefore, it is necessary to develop other methodological and practical approaches to agricultural landscape zoning for the further development of organic horticulture in Ukraine. The purpose of this study was to develop a system of targeted agricultural landscape assessment of the territory to determine the prospects for the development of organic horticulture on the example of the right-bank part of the Western Forest-Steppe.

## MATERIALS AND METHODS

The developed system of targeted agricultural landscape assessment of territories is based on a comprehensive mapping method of agricultural landscapes for their suitability for organic gardening. For agricultural landscape assessment of the territories, maps and schemes of distribution of the main structural components and factors of agrosphere functioning, namely, landscapes and morphological structures of relief, soil and vegetation cover, water chemistry, rocks, functional use of land and traditional areas of agricultural production, were used. All these characteristics are highlighted in the materials of the Ministry of Ecology and Natural Resources of Ukraine, which are publicly available for the territory of Ukraine (National report..., 2014; 2017; 2018; 2019). It is the information support of mapping that determines the content of the technical stages of creating a graphical model of any territorial complexes chosen by the authors of this study – ecosystems, landscapes (geographical or geochemical), biogeocenoses, agricultural landscapes, etc.

The general methodology of targeted agricultural landscape assessment of territories is determined by the following technical stages:

1. Taxonomic classification of natural and anthropogenic factors and their targeted expert ranking (in points) according to the suitability of land for organic horticulture. The taxonomic classification includes qualitative and quantitative characteristics of 8 taxonomic categories and 30 taxa of natural and anthropogenic

factors of agricultural landscape functioning within the Forest-Steppe of Ukraine. The classification categories are series, type, family, class, subclass, genus, species, and subspecies of agricultural landscapes. The content of the categories is determined by the main structural and agro-ecological factors of agricultural landscape formation. The content of taxa within the category reflects the spatial differentiation of factors, considering those quantitative (quantitative and qualitative) parameters that are important for the development of organic horticulture or product quality. The quantitative parameters were determined as follows: level of disturbance of the natural structure of land (AD, %), mineralisation (M, $dm^3/l$) and major ions of surface water, prevalence of organic and transitional crop production (OP, %), acid-base soil buffering index (pH), nutrient trace elements with deficiency (ND) and excess (E) in the soil-crop system, surface slope angles (SS, degree), depths of groundwater in soil-forming rocks (H, m), nutrient elements of high concentrations in bedrock (MS).

2. Mapping the features and distribution of agricultural landscapes, comprehensive assessment (based on the sum of points) and categorisation of the suitability of the selected agricultural landscapes for organic gardening.

The mapping methodology developed by the authors was based on a targeted taxonomic classification of agricultural landscapes and involved three technological stages (Yehorova, 2018). The first stage is mapping (map chart) of agricultural landscape features based on the target taxonomic classification and existing analytical and information support of the experimental area. The second stage is the delineation of boundaries and indexation of agricultural landscapes as territories with homogeneous taxa of factors of their formation. The third stage is drafting a target map of agricultural landscapes by calculating the total score of the target assessment and categorising the territory accordingly.

Soil samples were collected from the genetic layers of 100 soil profiles and their physical and chemical properties were analysed. The study also analysed the terrain and climate data. After calculating the land suitability classes for the two crops, they were mapped using computer modelling and conventional approaches. The maps provided by the two approaches revealed noticeable differences. For instance, in the case of rainfed wheat, the results showed higher accuracy based on land suitability maps compared to maps produced by the conventional approach. Furthermore, the results showed that the areas with classes N2 (≈ 18%↑) and S3 (≈ 28%↑) were higher, and the area with class N1 (≈ 24%↓) was less predictable in the conventional approach compared to the computer modelling approach. The study was carried out in accordance with the standards of Convention on Biological Diversity (1992).

The main limitations of the study area were the amount of precipitation at the flowering stage, strong slopes, shallow soil depth, high pH, and high gravel content. Therefore, land improvement operations are proposed to increase production and create a sustainable agricultural system. The map of features and distribution of agricultural landscapes is a graphical model of generalised factors of agricultural landscape formation and their intended use.

## RESULTS AND DISCUSSION

The targeted agricultural landscape assessment of the Forest-Steppe zone for fruit growing involved the selection of informative anthropogenic and natural factors of organic horticulture and their taxonomic classification; targeted expert assessment of taxa based on common practices; graphical modelling of areas of different levels of suitability for organic horticulture and selection of fruit crops for cultivation in relevant agro-soil and climatic conditions. This choice was limited by the information support on natural and anthropogenic factors of agricultural landscape formation in the area under study, its scale and the media of the created models (paper or electronic), as well as professional information on the existing level of organic gardening.

According to these parameters, the developed classification contains an expert assessment of taxa (in points) as natural and anthropogenic factors of organic horticulture functioning (Table 1).

**Table 1.** Targeted taxonomic classification of agricultural landscapes for regional assessment of organic horticulture conditions in the Forest-Steppe of Ukraine

| Taxonomic categories and factors of agricultural landscape formation | Level of expert assessment (first digit, points), agricultural landscape taxa and their quantitative and qualitative parameters |
|---|---|
| Row: functional zoning of land according to the level of natural structure disturbance | 2. Anthropogenic-natural (arable land, orchards and vineyards in combination with the settlement areas of villages and towns; AD = 25 ÷ 40).<br>1. Anthropogenic (industrial zones with protective strips of more than 15 km, transport motorways and railways with adjacent territories at a distance of 0.3 km; AD = 40 ÷ 60).<br>0. Natural (hayfields and grassland pastures, common water use of rivers and ponds, forests of wide use; AD ≤ 15). |
| Type: river basins according to hydrochemical composition of water | 4. Basins of the Prut and Western Buh rivers on the Left Bank and Pripyat on the Right Bank (M = 0.2 ÷ 0.6, $HCO_3$ – Ca).<br>3. The Dnipro River basins on the Right Bank (M = 0.3 ÷ 0.9, $HCO_3$ – Ca, Mg).<br>2. The Siverskyi Donets River basin (M = 0.6 ÷ 0.7, $HCO_3$, $SO_4$ – Ca, Mg).<br>1. The Southern Buh and Dniester River basins on the Left Bank (M = 0.6 ÷ 3.9, $HCO_3$, $SO_4$, Cl – Ca, Mg, Na). |
| Family: natural and anthropogenic vegetation cover according to the spread of organic farming | 5. Agrophytocenoses with a significant distribution of organic products (OP = 1.5 ÷ 7.2).<br>4. Agrophytocenoses with a low distribution of organic products (OP = 0.5 ÷ 1.0).<br>3. Agrophytocenoses with very low distribution of organic products (OP = 0.5 ÷ 0.2).<br>2. Agrocenoses and ornamental vegetation of rural and industrial areas of undetermined organic production potential (OP ≤ 0.2).<br>1. Meadow vegetation of river valleys, oak-hornbeam, and oak forests with no and uncertain organic production potential (OP ≤ 0.1). |
| Class: soil types according to acid-base index | 5. Typical deep low-humus and shallow low-humus chernozem (pH= 6.4–7.9).<br>4. Podzolised chernozem (pH 5.2 – 6.4).<br>3. Alluvial meadow and soddy gleyed soils (pH = 6 – 6.9).<br>2. Grey forest soils (pH = 4.1 – 5.6).<br>1. Technogenic soils of rural and industrial areas (pH = 4.1 – 5.6). |
| Subclass: balance of nutrients in the soil-crop system | 3. Balance (Co, Mo, Zn, Mn, Cu, Sr).<br>2. Shortage (ND – Mo) and balance (Co, Zn, Mn, Cu, Sr).<br>1. Shortage (ND – Mo), excess (E – Zn) and balance (Co, Mn, Cu, Sr). |
| Genus: terrain morphosculptures and surface angles | 3. Levelled and slightly sloping watersheds of the forest plain (SS = 2 ÷ 10).<br>2. Disaggregated slopes of the forest plain (SS = 10 ÷ 15).<br>1. Levelled surfaces of floodplains and terraces of alluvial plains (SS = 0 ÷ 3). |
| Species: aquifers by groundwater depth | 3. Sandy loam and sabulous deposits of water-glacial horizons (H = 5 ÷ 10).<br>2. Loess loams of aeolian-deluvial and eluvial horizons (H = 1 ÷ 15).<br>1. Sandy and sabulous loamy deposits of alluvial horizons (H = 1 ÷ 5). |
| Subspecies: Underlying rocks and their enrichment for nutrients | 4. Volyn-Podilska mineralogenic province (Zn, P, Cu, Pb).<br>3. Prypiat-Donetsk mineralogenic province (Zn, P, Pb).<br>2. Carpathian mineralogical province (S).<br>1. Ukrainian shield (Zr, Au). |

**Source:** compiled by the authors of this study

A full-scale model of the target map of agricultural landscapes for assessing the prospects for the development of organic horticulture was made to assess the conditions of organic horticulture on the Right Bank of the Western Forest-Steppe. Here is a medium-scale model of the northeastern part of this horticulture area. The 5.4 thousand km$^2$ of the model covers the connected part of three administrative regions of Ukraine – Kyiv, Zhytomyr, and Vinnytsia (Fig. 1).

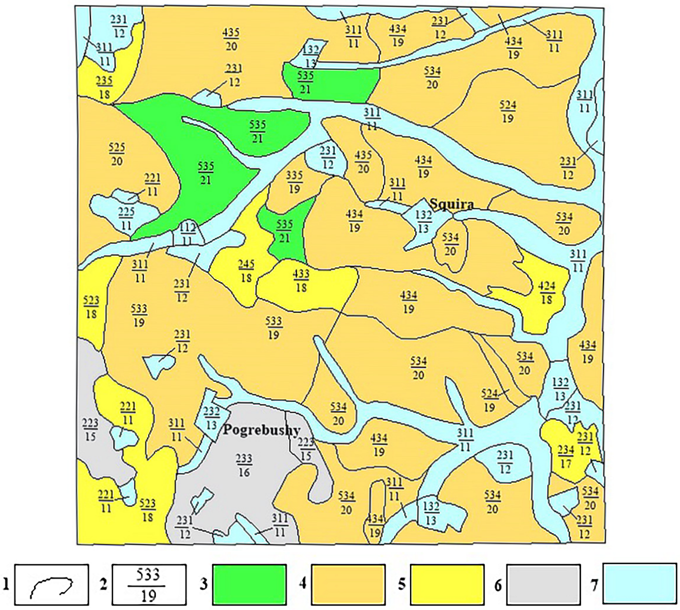


**Figure 1.** Target map of agricultural landscapes according to suitability for organic gardening on the Right Bank of the Western Forest-Steppe

**Note:** *1 – agricultural landscape boundary; 2 – agricultural landscape index in the numerator (according to Table 1: 4 – class score, 3 – genus, 5 – family) and the aggregate expert assessment score for the Forest-Steppe of Ukraine in the denominator. Categories of agricultural landscapes according to their suitability for organic horticulture: 2 – highest level (21 points), 3 – high level (19-20 points), 4 – medium level (17-18 points), 5 – low level (15-16 points), 6 – unsuitable according to regional assessments (11–12 points)*

**Source:** compiled by the authors of this study

Within the presented layout of the target map, 21 agricultural landscapes were identified, each of which has a homogeneous structure and prospects for the development of organic horticulture within the 8 taxonomic categories described by the authors of this study, which are spatially differentiated into 21 taxa (with a total of 30 in the Forest-Steppe of Ukraine). The type, subclass, and subspecies of agricultural landscapes are homogeneous across the experimental area. They define the common characteristics of a given territory. Namely, the territory belongs to the Dnipro river basin in the middle reaches with fresh hydrocarbonate calcium-magnesium waters (M = 0.3 - 0.9 $dm^3/l$); molybdenum ecological and geochemical province with a lack of Mo and a balance of Zn, Mn, Cu, Sr in the soil-plant system; distribution of underlying crystalline rocks of the Ukrainian Shield with no concentrations of the main nutrients.

The series, family, class, genus, and species of agricultural landscapes in this area were spatially differentiated and reflect the differences in the parameters of organic horticulture development. Namely: functional zoning of land (3 taxa), natural and anthropogenic vegetation cover (4 taxa), soil cover (5 taxa), terrain morphosculptures (3 taxa), aquifers (2 taxa).

According to the expert assessment of each agricultural landscape, the territory was divided into 4 categories of suitability for the development of organic horticulture and the development of transition measures. These categories of agricultural landscapes were characterised as follows. The highest level of suitability (21 points) was characterised by the agricultural landscape of levelled and slightly sloping watersheds with typical chernozems on loess loams with a groundwater table of up to 15 m within Zhytomyr Oblast, which has a relatively high percentage of arable land under organic farming and land in transition (3.5%). Agricultural landscape index 535. Clearly, these agricultural landscapes are zonally distributed in the Forest-Steppe, but they occupy about 10% of the area of the presented model. According to the acid-base index of the soil, these areas are considered the most suitable for growing apple, cherry, peach, and grape.

A high level of suitability (19-20 points) is characterised by agricultural landscapes of levelled and slightly sloping watersheds, as well as sloping slopes with typical black soil and podzolised loess loam within Zhytomyr and Kyiv Oblasts, which are characterised by relatively high percentages of arable land under organic farming and land in transition (0.6-3.5%). Agricultural landscape indices are 534, 524, 525, 434, 435; their territories cover about 50% of the map area. In terms of soil acidity, these areas are considered the most suitable for growing apple, cherry, peach, grape, pear, apricot, and red currant.

Medium and low suitability (15-18 points) is characterised by agricultural landscapes of levelled and slightly sloping watersheds, as well as sloping slopes with predominantly grey forest soils, as well as black soil podzolised on forest loam within the three oblasts with different percentages of arable land under organic farming and land in transition (0.2-3.5%). Agricultural landscape indices are 233, 234, 235, 223, 224, 225, 433, 424, 523; their territories cover about 25% of the map area. According to the acid-base index of the soil, these areas can be considered suitable for growing pears, apricots, red currants, gooseberries, bilberries, and blueberries.

According to the regional analysis, agricultural landscapes unsuitable for organic horticulture (11-12 points) are those of anthropogenic and natural series within the levelled and sloping watersheds of the forest plain, floodplains and river terraces of the alluvial plain with anthropogenic, grey forest, and alluvial meadow soils. They are common in all administrative regions of Ukraine. Agricultural landscape indices are 112, 132, 221, 231, 311, 335; their territories cover about 15% of the map area. Due to a complex of natural and anthropogenic factors, organic gardening is not feasible here.

Currently, there are five main methods of agricultural landscape assessment: geographic information systems (GIS), biodiversity analysis, soil assessment, analysis of socio-economic factors, modelling and simulation, and multi-criteria analysis. To obtain reliable results, several of these methods are often used simultaneously, or certain elements of each method are used, as was done by the authors. The authors of this study would like to emphasise that the agricultural landscape zoning of the Forest-Steppe zone of Ukraine for the development of organic horticulture was carried out for the first time.

An analogous work – "Agroecological substantiation of organic farming in the Kherson region" – was carried out by D. Breus (2018). He developed spatio-temporal models of soil fertility, which became the basis for agro-ecological substantiation of the prerequisites and prospects for organic farming in the Kherson region, improved and adapted the model of the structure of the geoinformation and analytical system of organic farming to support agricultural producers in the transition period to support their development. It was found that the lack of regular, uniform, and sufficient supply of mineral fertilisers, wind and water erosion, including irrigation, and soil deflation, as well as prolonged irrigation, led to a deterioration in the agro-ecological condition of soils. The humus content in the 0-20 cm layer of soil decreased by 16.0% on average, nitrifying nitrogen by 26.92%, mobile phosphorus by 34.84%, and exchangeable potassium by 25.52%. The author proposes a model of the structure of the geoinformation and analytical system of organic farming. The main difference between this study and the authors' study is that it was carried out under conditions of insufficient moisture and focused on field crops.

R. Taghizadeh-Mehrjardi *et al.* (2020) in Iran performed an analogous agricultural landscape assessment of land suitability for wheat and barley. However, for this development, the authors used computer modelling, which is planned for further research.

Some research papers have used certain elements of agricultural landscape assessment of territories. For instance, G.V. Titenko & V.V. Medvedev (2018) investigated the current state of the soil cover of Ukraine based on materials from the database of the Educational and Research Centre "O.N. Sokolovskyi Institute of Soil Science and Agrochemistry" – "Soil Properties of Ukraine". The materials of the last round of agrochemical certification of fields were also used, as well as generalised studies on the productive function of soils, degradation on arable land in Ukraine and the experience of 25 years of land reform in Ukraine. The study is particularly focused on the analysis of the impact of socio-economic factors on soil cover. Among other things, it was established that due to the incompleteness of land reform, almost complete irresponsibility of new land users who lease land plots, an inadequate land cadastre, ineffective legal protection of soil fertility, insufficient and practical imperfection of state control over soil fertility, the country is experiencing a chaotic type of land use with obvious negative (productive, environmental, social) consequences for future generations. Thus, soil cover and its favourable condition are an important prerequisite for the successful resolution of social issues in Ukraine.

Y.V. Rybalko & R.V. Babka (2018) considered the problem of integrated development of rural areas in terms of environmental sustainability of agricultural landscapes and anthropogenic pressure on them. The paper provides a detailed analysis of the land fund and calculates the coefficient of anthropogenic load, the level of ploughing and the coefficient of environmental stability of the territory of Chernihiv Oblast, which allow a comprehensive assessment of the rationality of the land fund structure. The ecological condition of the land was assessed, and the areas of land optimisation were identified according to the research results.

H. Davydiuk *et al*. (2022) conducted an ecological and chemical assessment of the state of agricultural landscapes in Ivano-Frankivsk Oblast, specifically in rural areas, based on monitoring studies. The condition of soils, natural waters, and crop products was investigated using the route monitoring method. It was found that some of the soil samples under study had very low acidity and a high content of nutrients, especially phosphorus and potassium. In some cases, the quality of natural water did not meet regulatory requirements. This is conditioned upon both natural factors, such as the hydrological regime, and anthropogenic factors, such as violation of sanitary rules for building up the territory, application of high doses of mineral and organic fertilisers, non-compliance with manure storage technologies, keeping of livestock and poultry, and disposal of livestock and household waste. Some samples of crop products did not meet sanitary and hygienic standards for lead, cadmium, nickel, copper, and iron. Studies show a considerable impact of the anthropogenic factor on changes in the quality of soil, natural waters, and crop products. It was found that the ecological and agrochemical assessment of the state of agricultural landscapes in the Western region, including the rural area, and the identification of the specific features of migration and accumulation of nutrients and ecotoxicants is a promising area of research for the development of measures to prevent pollution of soil, groundwater, open water bodies and crop products for the sustainable functioning of agroecosystems.

The FAO review (2020) emphasises the need to consider pollinator availability in agricultural landscape assessments and thus increase the sustainability and productivity of forestry and agriculture, which is crucial for the horticulture industry. The prevalence of forests and other natural habitats in the landscape plays a role in determining the species composition of pollinators. Agricultural landscapes adjacent to fragmented forests and natural areas benefit from the services of pollinators, and therefore crops pollinated by animals achieve greater fruit set. Hydrology and light availability can affect the composition and diversity of pollinator species and pollinator plant networks. Indigenous and local knowledge can contribute to the conservation of pollinators through conventional management practices. The review discusses the impacts of climate change and recommends measures to maintain pollinator diversity and abundance in forests.

Thus, agricultural landscape assessment is a valuable tool for investigating and analysing territories for agricultural development. The use of various methods and an integrated approach provides reliable results and allows making sound recommendations for optimising land use and preserving the environment.

## CONCLUSIONS

The system of targeted agricultural landscape zoning of the territory on the example of the Forest-Steppe fruit-growing zone consists of a taxonomic classification of natural and anthropogenic factors and their quantitative and qualitative differentiation and assessment according to the needs of organic horticulture.

Within the presented layout of the target map, 21 agricultural landscapes were identified and classified based on 8 taxonomic categories. These categories are differentiated by spatial characteristics and prospects for the development of organic horticulture. Agricultural landscapes are homogeneous in the area under study and determine the common characteristics of this zone, such as the Dnipro River basin, ecological and geochemical province, distribution of underlying crystalline rocks, etc.

Each agricultural landscape on the model has been expertly assessed and divided into 4 categories of suitability for the development of organic horticulture. The highest level of suitability (21 points) is characterised by agricultural landscapes with levelled and slightly sloping watersheds with typical black soils on loess loams, which occupy about 10% of the model area. A high level of suitability (19-20 points) is characterised by agricultural landscapes of levelled and slightly sloping watersheds with typical black soils and podzolised loess loams in Zhytomyr and Kyiv Oblasts (about 50% of the area). The average level of suitability (15-18 points) is characterised by agricultural landscapes of levelled and slightly sloping watersheds with grey forest soils and podzolised black soils on forest loams (about 25% of the area). Agricultural landscapes that are unsuitable for organic horticulture (11-12 points) are in the levelled and sloping watersheds of the forest plain, floodplains, and river terraces of the alluvial plain with anthropogenic, grey forest and alluvial meadow soils (about 15% of the area).

Such suitability assessments are most appropriate during the transition period to organic horticulture, when the principles are only being established and the products are not yet considered purely organic; during this time, organic production methods are applied gradually, usually for three years, when certain organic technologies are carefully analysed and applied. The targeted classification of land for organic horticulture on an agricultural landscape basis is the scientific and methodological framework for its further development in Ukraine and new prospects in the European organic market. The methodology and results of the presented agricultural landscape zoning guide Ukrainian organic fruit and berry producers to develop areas with the highest suitability for the production of high-quality and competitive products on most of the land in Ukraine.

Further research in this area should be carried out for all fruit-growing zones of Ukraine based on the development of spatial and temporal soil fertility models, considering the ecological stability of agricultural landscapes and anthropogenic load on them, as well as crop-specific factors.

## ACKNOWLEDGEMENTS

The authors of this study would like to acknowledge the employees of the breeding and technological department of the Institute of Horticulture of the National Academy of Agricultural Sciences of Ukraine, as well as employees of the Ukrainian Scientific and Production Centre for Geochemical Research of the SE "Ukrainian Geological Company" for their assistance in selecting information support for the research area for the mapping of agricultural landscapes.

## CONFLICT OF INTEREST

The authors of this study declare no conflict of interest.

## REFERENCES

[1] Aulia, A.F., Sandhu, H., & Millington, A.C. (2020). Quantifying the economic value of ecosystem services in oil palm dominated landscapes in riau province in Sumatra, Indonesia. *Land*, 9(6), article number 194. doi: 10.3390/land9060194.

[2] Breus, D.S. (2018). Agroecological substantiation of conducting organic farming in the Kherson region (PhD dissertation, Dnipro State Agricultural and Economic University, Dnipro, Ukraine).

[3] Bublyk, M.O., Barabash, L.O., Fryziuk, L.A., & Boldyzheva, L.D. (2018). Cultivation of apple (Malus domestica Borkh.): Main growing regions, cultivars, rootstocks, and technologies. In *Temperate Horticulture for Sustainable Development and Environment Ecological Aspects* (pp. 179-204). New York: Apple Academic Press.
[4] Çakmakçı, S., & Çakmakçı, R. (2023). Quality and nutritional parameters of foodin agri-food production systems. *Foods*, 12(2), article number 351. doi: 10.3390/foods12020351.
[5] Clark, S. (2020). Organic farming and climate change: The need for innovation. *Sustainability*, 12(17), article number 7012. doi: 10.3390/su12177012.
[6] Convention on Biological Diversity. (1992). Retrieved from https://zakon.rada.gov.ua/laws/show/995_030#Text.
[7] Davydiuk, H., Shkarivska, L., Klymenko, I., Dovbash, N., & Demyanyuk, O. (2022). Ecological and agrochemical assessment of the state of agricultural landscapes in Ivano-Frankivsk region. *Agroecological Journal*, 1, 81-90. doi: 10.33730/2077-4893.1.2022.255188.
[8] FAO. (2020). *The pollination services off orests. A review of forest and landscape interventions to enhance their cross-sectoral benefits*. Retrieved from https://www.fao.org/3/ca9433en/CA9433EN.pdf.
[9] FiBLStatistics – European and global organic farming statistics. (2023). Retrieved from https://statistics.fibl.org/world/selected-crops-world.html?tx_statisticdata_pi1%5Bcontroller%5D=Element2Item&cHash=7dc7312efa295d7a1673ae0448ead0ad.
[10] Galashevskyi, S., Manzyuk, O., Fedorchenko, I., Puzenko, M., Galashevska, Yu., Ryabtsun, G., Grokh, V., Shukalovich, V., Bondarev, S., Gavrilyuk, V., Shor, K., & Prokopchuk, N. (2021). *Research of the organic market of Ukraine 2019-2020*. Kyiv: LLC "ART OK".
[11] Liu-Helmersson, J., Brännström, Å., Sewe, M.O., Semenza J.C., & Rocklöv, J. (2019). *Estimating past, present, and future trends in the global distribution and abundance of the arbovirus vector aedesaegypti under climate change scenarios.* Retrieved from https://www.frontiersin.org/articles/10.3389/fpubh.2019.00148/full.
[12] Montgomery, D.R., & Biklé, A. (2021). *Soil health and nutrient density: Beyond organic vs. conventional farming.* Retrieved from https://www.frontiersin.org/articles/10.3389/fsufs.2021.699147/full.
[13] National report on the state of the natural environment in Ukraine in 2019. (2019). Retrieved from https://mepr.gov.ua/diyalnist/napryamky/ekologichnyj-monitoryng/natsionalni-dopovidi-pro-stan-navkolyshnogo-pryrodnogo-seredovyshha-v-ukrayini/.
[14] National report on the state of the natural environment in Ukraine in 2018. (2018). Retrieved from https://mepr.gov.ua/wp-content/uploads/2022/10/Natsionalna-dopovid-pro-stan-navkolyshnogo-pryrodnogo-seredovyshha-v-Ukrayini-u-2018-rotsi_.pdf.
[15] National report on the state of the natural environment in Ukraine in 2017. (2017). Retrieved from https://mepr.gov.ua/wp-content/uploads/2022/10/Natsionalna-dopovid-pro-stan-navkolyshnogo-pryrodnogo-seredovyshha-v-Ukrayini-u-2017-rotsi.pdf.
[16] National report on the state of the natural environment in Ukraine in 2014. (2014). Retrieved from https://mepr.gov.ua/wp-content/uploads/2023/05/U-2014-ROTSI.pdf.
[17] Ostapenko, R., Herasymenko, Y., Nitsenko, V., Koliadenko, S., Balezentis, T., & Streimikiene, D. (2020). Analysis of production and sales of organic products in ukrainian agricultural enterprises. *Sustainability,* 12(8), article number 3416. doi: 10.3390/su12083416.
[18] Paoli, A., Tinsley, G., Bianco, A., & Moro, T. (2019). The influence of meal frequency and timing on health in humans: The role of fasting. *Nutrients*, 11(4), article number 719. doi: 10.3390/nu11040719.
[19] Pawlewicz, A. (2020). Change of price premiums trend for organic food products: The example of the polish egg market. *Agriculture*, 10(2), article number 35. doi: 10.3390/agriculture10020035.
[20] Pichura, V.I., Potravka, L.O., & Breus, E.O. (2022). *Agroecological justification of organic farming in southern Ukraine*. Odesa: Oldie plus.
[21] Rybalko, Y.V., & Babka, R.V. (2018). Ecological assessment of stability and anthropogenic load of agricultural landscapes of Chernihiv region. *Agroecological Journal*, 1, 21-26. doi: 10.33730/2077-4893.1.2018.160406.

[22] Sahota, A. (2022). *The global market for organic food & drink. The world of organic agriculture. Statistics and emerging trends 2022. Research institute of organic agriculture FiBL, Frick, and IFOAM – organics international, bonn.* Retrieved from https://www.fibl.org/fileadmin/documents/shop/1344-organic-world-2022.pdf.
[23] Schlatter, B., Trávníček, J., Meier, C., & Willer, H. (2022). Current statistics on organic agriculture worldwide: Area, operators and market. In *The World of Organic Agriculture. Statistics and Emerging Trends 2022* (pp. 32-128). Bonn: Research Institute of Organic Agriculture FiBL, Frick and IFOAM – Organics International.
[24] Taghizadeh-Mehrjardi, R., Nabiollahi, K., Rasoli, L., Kerry, R., & Scholten, T. (2020). Land suitability assessment and agricultural production sustainability using machine learning models. *Agronomy*, 10(4), article number 573. doi: 10.3390/agronomy10040573.
[25] Teuber, S. (2021). A cultural ecosystem service perspective on the interactions between humans and soils in gardens. *People and Nature*, 3(5), 1025-1035. doi: 10.1002/pan3.10255.
[26] Titenko, G.V., & Medvedev, V.V. (2018). The role of soil cover in the optimization of social policy of Ukraine. *Visnyk of V.N. Karazin Kharkiv National University series "Ecology"*, 18, 14-21.
[27] Yehorova, T., Palapa, N., Nagorniuk, O., & Sobczyk, W. (2022). Biogeochemical principles of plant product quality in agrolandscapes with typical hernozems. *Jornal of Ecological Engeneering*, 23(10), 304-316. doi: 10.12911/22998993/152649.
[28] Yehorova, T.M. (2018). *Geochemical ecology of agricultural landscapes of Ukraine*. Kyiv: DIA.

**Ігор Володимирович Гриник**
Доктор сільськогосподарських наук, професор
Інститут садівництва Національної академії аграрних наук
03027, вул. Садова, 23, м. Київ, Україна
https://orcid.org/0000-0002-3652-8152
**Тетяна Михайлівна Єгорова**
Доктор сільськогосподарських наук, доцент
Інститут садівництва Національної академії аграрних наук
03027, вул. Садова, 23, м. Київ, Україна
https://orcid.org/0000-0003-2148-7738
**Микола Олександрович Бублик**
Доктор сільськогосподарських наук, професор
Інститут садівництва Національної академії аграрних наук
03027, вул. Садова, 23, м. Київ, Україна
https://orcid.org/0000-0003-4056-791X
**Людмила Олександрівна Барабаш**
Кандидат економічних наук, старший науковий співробітник
Інститут садівництва Національної академії аграрних наук
03027, вул. Садова, 23, м. Київ, Україна
https://orcid.org/0000-0003-1243-8627

# Агроландшафтне районування зони Лісостепу України для розвитку органічного садівництва

**Анотація.** Актуальність досліджень полягає у практичному використанні загальнонаукових методів ландшафтної екології в органічному садівництві Лісостепу України. Метою дослідження є розроблення системи цільового агроландшафтного оцінювання території для визначення перспектив розвитку органічного садівництва на прикладі правобережної частини Західного Лісостепу. Для досягнення цієї мети застосовувалась методологія цільового агроландшафтного районування земель сільськогосподарського призначення.

Для цього використано карти і схеми поширення основних структурних компонентів і факторів функціонування агросфери, а саме, ландшафтів і морфоструктур рельєфу, ґрунтово-рослинного покриву, хімізму вод, гірських порід, функціонального використання земель та традиційних напрямів сільськогосподарського виробництва. Картографічний метод та експертні оцінки придатності земель для органічного садівництва засновані на вивченні 8 природно-антропогенних чинників, що формують відповідну таксономічну класифікацію агроландшафтів Лісостепу з 30 таксонів. Просторову диференційованість чинників визначено за актуальними кількісно-якісними параметрами земель садів. Експертну оцінку агроландшафтів для органічного садівництва побудовано за відсотковим рівнем зрушеності природної структури земель. Розроблено натурний макет цільової карти агроландшафтів для оцінки перспектив розвитку органічного садівництва на прикладі центральної частини Правобережжя Західного Лісостепу. Досліджена площа 5 400 кв. км міститься на перетині трьох адміністративних областей, а саме Житомирської, Київської і Вінницької. Виділено 21 агроландшафт, території яких є однорідними за 8-ма параметрами. Їх комплексні регіональні перспективи для органічного садівництво оцінено у балах від 11 до 21. Запропоновано визначати 5 категорій земель агроландшафтів за їх придатністю до органічного садівництва: найвищого (21 бал), високого (19-20 балів), середнього (17-18 балів), низького (15-16 балів) рівнів придатності та непридатні (11-12 балів). Половину дослідженої території займають агроландшафти високого рівня придатності для органічного садівництва, по 15% – середнього рівня та непридатні, по 10% – найвищого і низького рівня. Цільова класифікація земель для органічного садівництва на агроландшафтній основі є науково-методичним підґрунтям для широкого розвитку в Україні нового, екологічно доцільного виду сільськогосподарської діяльності

**Ключові слова:** агрофітоценоз; органічні плоди; категорії земель цільове районування; натурний макет цільової карти агроландшафтів