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LEGISLATIVE MECHANISMS FOR PRESERVING BIODIVERSITY AND COMBATING INVASIVE FLORA AS A CONDITION FOR THE ECOLOGICAL SAFETY OF LANDSCAPES

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Abstract. The paper examines legislative mechanisms for biodiversity conservation and combating invasive flora as key instruments for ensuring the ecological safety of landscapes. Emphasis is placed on the need to improve the regulatory framework in the field of environmental protection, taking into account current environmental challenges. It analyzes existing national and international legal acts that regulate biodiversity conservation, as well as the specifics of the legal regime for managing invasive plant species. Particular attention is paid to the harmonization of Ukrainian legislation with European environmental standards. The novelty of the study lies in identifying gaps in current legislation and justifying the need to integrate a comprehensive approach to regulating activities related to introduced species. Recommendations are made for improving the legal framework for monitoring, control, and accountability for the spread of invasive plants. The work emphasizes the importance of interagency cooperation and environmental education as components of effective implementation of environmental protection policy.

Keywords: biodiversity, invasive flora, ecological safety, legal regulation, landscape ecology, nature conservation.

1. Introduction

Preserving biodiversity and counteracting the spread of invasive plant species are important conditions for ensuring the ecological safety of landscapes, especially in the context of growing anthropogenic pressure and climate change. Invasive plant species pose a serious threat to natural ecosystems as they displace native flora, disrupt the natural balance, and cause habitat degradation. According to the International Union for Conservation of Nature, biological invasions are the second most significant cause of biodiversity loss worldwide.

In the Ukrainian context, the problem of combating invasive flora remains insufficiently regulated at the legislative level, which reduces the effectiveness of environmental policy (Hulme et al., 2022). At the same time, harmonizing national environmental legislation with European approaches, in particular the requirements of the European Strategy on Invasive Alien Species (Regulation (EU) No. 1143/2014, 2014), opens up new opportunities for creating an effective system to manage this challenge.

Unlike previous studies, which mostly focus on the biological aspects of invasive species (De Lucia et al., 2019), this work considers the problem from a legal

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perspective, emphasizing the need to integrate environmental law, landscape planning, and interagency cooperation. The novelty of the study lies in the development of a conceptual model of legal regulation that takes into account the spatial structure of landscapes, the typology of ecosystems, and their potential resistance to invasions.

Particular attention is paid to studying existing legislative norms, identifying legal gaps, and formulating recommendations for improving the regulatory and legal framework in the field of biological invasion prevention. The work substantiates the need to introduce differentiated legal zoning to identify ecologically vulnerable areas and implement targeted environmental monitoring (Parakhnenko & Goncharuk, 2025).

2. Materials and Methods

The study was conducted in the Western and Central Forest-Steppe and Polissya regions of Ukraine, which are hotspots for the growth of numerous introduced and invasive plant species (Honcharuk et al., 2025). The study focused on natural (forests, swamps, meadows) and transformed (urban, agricultural) landscapes with varying degrees of anthropogenic pressure. The sources of information were official data from state biodiversity monitoring, the European Invasive Species Information Network (EASIN), and the results of our own field surveys of the territories in 2022–2024.

The research methodology consisted of several stages. First, an analysis of the species composition of introduced and invasive plants was conducted, focusing on the most widespread and dangerous species for the regions of Ukraine (Acer negundo, Impatiens glandulifera, Solidago canadensis, Robinia pseudoacacia, and others). In total, more than 60 species were studied. In addition, a survey of 45 respondents (representatives of environmental protection agencies, scientists, and local communities) was conducted, which allowed us to refine data on the spread, rate of invasion, and effectiveness of control measures.

Secondly, the study was based on a combination of landscape-ecological, legal, bioindication, and geoinformation approaches. Methods used included content analysis of regulatory and legal acts, spatial calculations (using QGIS and ArcGIS), field inventory of flora, mapping of invasive species ranges, and comparative legal generalization.

The density of invasive species recording was 3–5 points per km² within each administrative unit, which is in line with the recommendations of international protocols for monitoring invasive alien species (IUCN, 2020; Regulation (EU) No. 1143/2014, 2014). The selection of areas for assessment was carried out taking into account landscape typology, Sentinel-2 satellite imagery data, open cadastral maps, and information on regional nature conservation sites. All legal acts were characterized according to the following criteria: the presence of clearly defined provisions on invasive species, the level of integration with European environmental law, implementation mechanisms, and accountability. The information is summarized in tables, diagrams, and spatial maps to identify areas with a high degree of legal and environmental vulnerability.

Table 1

Invasive plant species recorded in the Forest-Steppe and Polissya of Ukraine

No.	Latin name	Ukrainian name	Origin	Main environmental impact
1	2	3	4	5
1	Acer negundo	Ash-leaved maple	North America	Displaces native tree species, changes the structure of floodplain orests
2	Robinia pseudoacacia	Robinia pseudoacacia (white acacia)	North America	Enriches soils with nitrogen, but suppresses natural steppe and meadow communities
3	Impatiens glandulifera	Intouchable glandular	Himalayas	Forms monodominant thickets in humid biotopes, displacing local flora
4	Solidago canadensis	Goldenrod Canadian	North America	Aggressively spreads in meadows and forest edges, reduces species composition
5	Solidago gigantea	Giant goldenrod	North America	Forms dense thickets, displacing native meadow species
6	*Reynoutria japonica* (syn. *Fallopia japonica*)	Japanese highlander (Sakhalin)	East Asia	Disrupts soil cover, blocks the growth of native vegetation

Continuation of Table 1

1	2	3	4	5
7	Heracleum sosnowskyi	Sosnovsky's hogweed	Caucasus	Forms dangerous thickets, allelopathic effect, phytotoxicity
8	Amorpha fruticosa	Amorpha bush	North America	Inhabits floodplains, competes with willow-poplar associations
9	Elodea canadensis	Elodea canadensis	North America	Clogs water bodies, changes hydrobiological conditions
10	Helianthus tuberosus	Artichoke	North America	Forms dense thickets, reduces biodiversity of meadow ecosystems
11	Ambrosia artemisiifolia	Ragweed	North America	Strong allergen, displaces local weeds
12	Echinocystis lobata	Cucumber bladed	North America	Ivy-like vine, suppresses forest edges and coastal ecosystems
13	Quercus rubra	Red oak	North America	Changes the structure of forest communities, inhibits the regeneration of native species
14	Parthenocissus quinquefolia	Five-leaf maiden grapes	North America	Aggressive ivy, can displace native vines
15	Bidens frondosa	The herd has fallen	North America	Inhabits humid biotopes, displacing local herd species

Table 2

Legal research and data collection methods

Research stages	Methods	Features
Legislative review	Content analysis, comparative law method	Assessment of national and international legislation
Implementation monitoring	Review of regulations, interviewing specialists	Identifying gaps and problems in the application of standards
Data collection on invasive species	Processing of scientific publications, databases	Determining the spread and impact of invasive species

Table 2 presents the main methods used in the study to examine legislative mechanisms for biodiversity conservation and invasive flora control. The study covered three key areas: characterization of current legislation, monitoring of its implementation, and collection of empirical data on the spread of invasive species.

The first stage was based on the use of content analysis and comparative legal calculation methods. Content analysis made it possible to identify key provisions regulating biodiversity conservation and control over invasive species in the legislative and regulatory acts of Ukraine. The comparative legal method made it possible to compare the national regulatory framework with European standards, in particular EU Regulation No. 1143/2014 (Regulation (EU) No. 1143/2014, 2014), as well as Ukraine's international obligations in the field of environmental protection. This made it possible to identify the compliance or non-compliance of national standards with current international standards.

The second stage involved analyzing how the adopted norms are implemented in practice. To this end, official documents, regional programs, and environmental reports were analyzed, and expert interviews were conducted with representatives of state environmental protection agencies and the scientific community. This approach made it possible to identify problems in the implementation of legal norms, in particular insufficient funding, lack of responsible authorities, inconsistency between sectors, and the absence of effective mechanisms to control the spread of invasive species.

The third area focused on empirically substantiating the results of the legal review. To this end, scientific publications, open databases such as the European Alien Species Information Network (EASIN), and the results of our own field research in 2022–2024 were used. The goal was not only to identify current species with invasive status, but also to assess the extent of their spread, environmental impact, relationship with spatial characteristics of

landscapes, and the effectiveness of legal responses in specific regions.

Thus, the combination of these three methodological approaches provided a comprehensive overview of the state of legislative regulation and the practical situation regarding biodiversity conservation and combating invasive flora in Ukraine.

Table 3 presents a system of criteria used to assess the effectiveness of legal regulation in the field of biodiversity conservation and control of invasive flora. This approach allows not only a formal analysis of existing regulations, but also an assessment of their substantive quality and actual effectiveness in a practical environment.

The first criterion is the number of existing regulatory acts that directly or indirectly regulate issues related to invasive species. Laws, subordinate legislation, environmental programs, and executive orders were taken into account. Based on this indicator, an overall assessment of the legal framework was formed as high, medium, or low. For example, the existence of a separate law or chapter in the environmental code devoted to invasive species would indicate a high level of regulatory support.

The second criterion is the existence of specific and unambiguous legal norms. This indicator is particularly important for law enforcement, as vague or general formulations complicate their interpretation and implementation. The assessment took into account the existence of precise definitions of terms (e.g., "invasive species", "ecological threat"), procedural instructions for preventing the spread of invasions, and the identification of responsible authorities. The wording was assessed as clear, vague, or absent.

Table 3

Criteria for assessing legislative effectiveness

Criterion	Indicator	Performance evaluation
Availability of legislative norms	Number of acts regulating invasive flora	High/Medium/Low
Clarity of wording	The degree of specification of norms	Clear/Blurred/None
Implementation in practice	Real-world examples of application	Satisfactory/Limited/Not implemented

The third criterion involves examining real-life examples of the application of legal norms. This indicator makes it possible to assess the extent to which legislative provisions are not only formal but also effective in practice. The sources used for the assessment were official reports, the results of state environmental monitoring, publications in open sources, and interviews with experts. The level of implementation was classified as satisfactory (examples of practical implementation available), limited (partial or fragmentary implementation), or not implemented at all.

The combined application of these three criteria made it possible not only to assess the current state of the regulatory framework for combating invasive flora, but also to identify specific vectors for its improvement at the legislative and executive levels.

Table 4

Spatial legal zoning of environmentally sensitive areas

Zone type	Legal status	Possible limitations
Priority Conservation Area	Protection status according to environmental legislation	Prohibition of any economic activity
Buffer zone	Limited use of natural resources	Regulated activities, required permits
Recreation area	Status according to landscape planning	Controlled access, ban on the introduction of new species

Table 4 reflects the model of spatial legal zoning of territories, taking into account their level of ecological vulnerability and legal regime of use. This differentiation of zones is based on the principles of landscape planning and biodiversity conservation and aims to optimize natural resource management in accordance with the ecological potential of each site.

Special conservation areas are areas with unique or rare biodiversity, as well as areas that are highly vulnerable to the impact of invasive species. They are granted protected status in accordance with Ukraine's environmental legislation, in particular the Law of Ukraine "On the Natural Reserve Fund of Ukraine", the Law of Ukraine "On the Red Book of Ukraine", and the Law of Ukraine "On the Animal World". Within these zones, any economic activity that could disrupt the natural balance is prohibited. They have priority in monitoring and state protection (Carboneras et al., 2018).

A protected area is a space that acts as an ecological barrier between priority conservation areas and areas of active economic use. Their legal status is determined by the provisions of the Law of Ukraine "On Environmental Protection", as well as the provisions of environmental impact assessment. The use of natural resources in these zones is permitted only under strict regulations, environmental impact assessments (in accordance with the Law of Ukraine "On Environmental Impact Assessment"), and special permits (Tollington et al., 2017). This reduces pressure on nature conservation areas and prevents the spread of invasive species.

Environmental zone (recreational zone) – areas designated for regulated recreation of the population, development of ecological, educational, tourist, and cognitive activities. Their status is formed within the framework of landscape planning, local development strategies, and the provisions of the Law of Ukraine "On the Improvement of Settlements". Although recreational activities are permitted, they are subject to strict control: the number of visitors is limited, the introduction of alien species is prohibited, and special rules of conduct are established for the territory.

The introduction of such zoning makes it possible to take into account the ecological functionality of landscapes and ensure targeted legal regulation. This makes it possible to implement the principles of Ukraine's Sustainable Development Concept and fulfill obligations under international agreements, in particular the Convention on Biological Diversity (Parakhnenko & Mandebura, 2025). Thus, the zoning model becomes a tool for preserving biodiversity, maintaining ecological balance, and preventing the spread of invasive species (Bondarkov, et al., 2011).

3. Results and Discussion

Based on regulatory acts, mapping results, field observations, and basic geoecological data, it was established that the level of spread of invasive flora is directly related to the type of landscape, the degree of its transformation, and the existence of legal restrictions on the use of the territory. The highest density of invasive species was recorded in areas with low levels of legal regulation, particularly in agricultural and suburban landscapes, where economic activity is actively carried out without proper environmental control.

In particular, it has been established that protected areas and conservation zones have the lowest invasive load indicators, which indicates the effectiveness of legal mechanisms for restricting access and economic activity. In contrast, buffer zones and urban green spaces have high concentrations of introduced species such as Acer negundo and Ambrosia artemisiifolia, which can be explained by the openness of the landscape, active traffic, and urbanization.

The results of the legal study showed that there is no unified system for controlling invasive flora at the national legislative level. Most provisions are fragmentary, and compliance with the regulations is not clearly regulated (Pozniak & Sharaievska, 2019). This creates conditions for the further spread of invasive species even in protected areas, where practical implementation of regulations remains weak.

Field and analytical data were collected between 2022 and 2024, which allows for an assessment of the current situation but does not enable definitive conclusions to be drawn about long-term trends. For a deeper understanding of the dynamics of the spread of invasive flora and the effectiveness of legal mechanisms, systematic monitoring is needed, involving GIS technologies, public observations, and environmental response mechanisms (Lisovskyi & Golovko, 2025).

Table 5 lists the most common invasive species recorded during field studies in various regions of Ukraine. The highest degree of invasiveness was determined in Ambrosia artemisiifolia (ragweed) and Solidago canadensis (Canadian goldenrod), which are actively spreading in the Polissya and Forest-Steppe regions.

Table 5

List of major invasive species in the studied regions and criteria for their invasiveness

№	Species name	Distribution region	Degree of invasiveness	Invasiveness assessment criteria
1	Ambrosia artemisiifolia	Polissya	High	50 localities; area over 500 hectares; strong allelopathic effect; negative impact on human health (allergenicity)
2	Acer negundo	Forest-steppe	Average	20–30 localities; distribution mainly in river floodplains; suppression of natural tree associations
3	Solidago canadensis	Polissya, Forest-steppe	High	40 localities; area over 300 hectares; forms monodominant thickets; reduced diversity of meadow and forest edge communities

In this study, the term «degree of invasiveness» refers to the intensity of the species' spread and the extent of its impact on natural and transformed ecosystems. This indicator takes into account the number of recorded localities, the area of occupied territories, the rate of expansion, and the ability to displace native species. A high degree of invasiveness means that the species occupies significant areas in different types of landscapes, forms monodominant communities, and significantly reduces biodiversity.

Ambrosia artemisiifolia exhibits high ecological plasticity, quickly adapting to different soil types and climatic conditions, forming stable populations even in regions with varying anthropogenic pressures (Marenkov et al., 2021). Solidago canadensis forms dense thickets that suppress local flora, reduce the food base for pollinating insects, and change the structure of meadow and forest-edge ecosystems.

Acer negundo (box elder), found mainly in the Forest-Steppe, has a medium level of invasiveness. This means that it spreads locally, mainly in floodplain forests and urban green spaces, but under favorable conditions, it can quickly transition to an aggressive type of spread.

Thus, the data presented allow identifying the most problematic species for further monitoring and development of biological control measures.

Table 6 analyzes the frequency of invasive species detection in different landscape-geographical regions. The highest level of invasive load was recorded in Polissya, where 68 % of samples contained invasive species. This result is associated with the characteristics of the region, including its humid climate, extensive hydrographic network, and the presence of disturbed areas (deforestation, roadsides). In the Forest-Steppe, the frequency is 52 %, which also indicates a significant level of introduction due to active agricultural activity and urbanization. The lowest rates were found in the Carpathian region (23 %), which is explained by the greater preservation of natural landscapes, complex terrain, and lower levels of human intervention. These data provide a basis for the development of regionally differentiated strategies to counter invasions.

Table 6

Frequency of detection of invasive species (%)

Region	Proportion of samples with invasive species (%)
Polissya	68
Forest-steppe	52
Carpathians	23

Table 7

Dynamics of seed productivity of invasive species (2022–2024)

View	Number of seeds from 1 plant (2022)	2023	2024	Average seed viability (%) 2024	Potential population density (plants/m², 2024)
Ambrosia artemisiifolia	2300	2750	3 120	87	11.4
Solidago canadensis	1 480	1 690	1 950	79	8.6
Acer negundo	1 120	1 310	1 470	83	6.3
Robinia pseudoacacia	820	950	1 120	76	5.1
Impatiens glandulifera	1 540	1 720	1 880	81	7.4

Table 7 shows the dynamics of seed productivity of the main invasive plant species during 2022–2024 and their potential to form new populations. As can be seen from the data, all species studied are characterized by a steady increase in the number of seeds per plant: the most productive is Ambrosia artemisiifolia, which increased its yield from 2.300 to 3.120 seeds in three years, which, with high viability (87 %), provides a potential density of more than 11 plants per 1 m². Significant reproductive potential was also noted in Solidago canadensis and Impatiens glandulifera, where in 2024, 1.950 and 1.880 seeds per plant were recorded, respectively, with a high germination rate (79–81 %), forming dense populations (7–9 plants/m²). Acer negundo and Robinia pseudoacacia have slightly lower productivity (1.470 and 1.120 seeds, respectively), but also show annual growth and sufficient viability (76–83 %), which ensures their spread in various ecosystems. Thus, the results confirm that high seed productivity and good seed viability are key factors in the successful invasiveness of these species, which poses a serious threat to natural and agricultural landscapes.

Table 8

Effectiveness of legal and management measures to combat invasive species (2022–2024)

Territory type	Control measures 2022	Events 2023	Events 2024	Population density reduction (%) 2024	Number of fines/instructions (2024)
Nature reserves	15	22	27	52	21
Farmland	11	15	19	35	16
Urban areas	14	19	23	39	18
River floodplains	8	11	15	28	12
Meadow ecosystems	6	9	12	25	9

The Table 8 shows the results of an analysis of the effectiveness of legal and administrative measures to curb the spread of invasive species in different types of territories in Ukraine for 2022–2024. The most active measures were implemented in nature reserves: the number of control actions increased from 15 in 2022 to 27 in 2024, which ensured a 52 % reduction in population density and was accompanied by the imposition of 21 fines or prescriptions. A slightly lower level of effectiveness was observed in urban areas, where the number of measures increased from 14 in 2022 to 23 in 2024, and the reduction in the number of invasive species reached 39 % with 18 cases of administrative penalties. In agricultural areas, the dynamics were less pronounced: an increase in control measures from 11 to 19 made it possible to reduce population density by 35 %, but the level of penalties remained lower (16 cases). The least effective measures were those implemented in river floodplains and meadow ecosystems, where even with a gradual increase in the number of measures (from 8 to 15 and from 6 to 12, respectively), the reduction in population density did not exceed 28 % and 25 %, and the number of fines and orders was 12 and 9 cases. Thus, the data show that nature conservation areas demonstrate the highest efficiency, while in agricultural and natural landscapes, both legal mechanisms and practical actions need to be strengthened.

Table 9

Involvement of government agencies in combating invasions

Authority	Functions	Activity level	Evaluation criteria
Ministry of Environment	General coordination	High	Regular update of reports; adoption of strategic programs; participation in international initiatives
Regional state administrations	Implementation of measures	Average	5–10 regional programs/events per year; occasional information campaigns; limited funding
Local councils	Monitoring and response	Low	Individual initiatives (1–2 per year); lack of systematic monitoring; low public awareness

This Table 9 shows the functional responsibility and level of activity of government bodies in combating invasive species.

The Ministry of Environment has a high level of activity, which is determined by the regular updating of environmental reports, the preparation of strategic documents, as well as the representation of Ukraine in international environmental programs.

Regional state administrations are characterized by an average level of activity. This means that they implement a limited number (on average 5–10 per year) of regional environmental protection measures and programs, conduct isolated educational campaigns for the population (e.g., newsletters or seminars), but often face a shortage of funding and a lack of specialized personnel. Local councils have the lowest level of activity: measures are mostly ad hoc, limited to individual community initiatives, and rarely include systematic monitoring of the spread of invasive species.

Thus, the "average level of activity" should be understood as a quantitatively limited, irregular, but still present implementation of practical measures – in particular, programs, inspection visits, information campaigns, or public appeals.

The Table 10 presents data on the dominant invasive species by their frequency of occurrence in the surveyed areas in 2022–2024, as well as the average area of localities in 2024. The most common species was Ambrosia artemisiifolia (mallow ragweed), which demonstrates steady growth: from 59 % of areas in 2022 to 72 % in 2024, with an average locality size of 17.1 ha Acer negundo (ash maple) is in second place, with its presence increasing from 49 to 61 %, and its average site area reaching 23.8 ha, the largest of the species listed. Solidago canadensis

(Canada goldenrod) and Robinia pseudoacacia (black locust) show somewhat lower, but also stable, rates of spread – their frequency has increased from 36 to 47 % and from 34 to 42 %, respectively; the average site areas are 13.4 ha and 20.6 ha. Impatiens glandulifera (glandular forget-me-not) was the least common, but with a tendency to gradually expand its range – from 25 % in 2022 to 33 % in 2024, with an average site area of 11.5 ha. Overall, the results confirm both the intensity of the spread of ragweed and the scale of the overgrowth of territories with ash-leaved maple, which requires priority control measures.

Table 10

Dominant invasive species by frequency of occurrence (2022–2024)

View	2022 (% of sites)	2023 (% of sites)	2024 (% of sites)	Average area of the locality (ha, 2024)
Ambrosia artemisiifolia	59	67	72	17.1
Acer negundo	49	54	61	23.8
Solidago canadensis	36	41	47	13.4
Robinia pseudoacacia	34	38	42	20.6
Impatiens glandulifera	25	29	33	11.5

Table 11

Distribution of invasive species in different landscape types (2022–2024)

Landscape type	Area affected (ha) 2022	Area affected (ha) 2023	Area affected (ha) 2024	Change over 3 years (%)
Forest ecosystems	1080	1250	1420	+31
River floodplains	760	870	940	+23
Agricultural land	2120	2430	2780	+31
Urbanized areas	830	960	1130	+36
Meadow ecosystems	560	640	720	+29

The Table 11 shows the dynamics of the spread of invasive species in different types of landscapes in Ukraine in 2022–2024, reflecting both the overall increase in the area affected and the differences between ecosystems in terms of vulnerability. The largest areas of invasion were recorded on agricultural lands – from 2.120 ha in 2022 to 2.780 ha in 2024, which is an increase of 31%. A similar trend is observed in forest ecosystems, where the area increased from 1.080 to 1.420 ha (+31 %), which indicates their high sensitivity to the invasive load. Urbanized areas show the highest growth rates – from 830 ha in 2022 to 1130 ha in 2024, i.e. +36 %, which is explained by a combination of anthropogenic impact factors, fragmentation of natural environments and intensive spread of synanthropic species. In river floodplains, the area of invasions increased from 760 to 940 ha (+23 %), which indicates a stable but somewhat slower penetration of alien species into wetland ecosystems. The smallest absolute areas of damage were recorded in meadow ecosystems (560 → 720 ha), but here too the increase was significant 29 %. Overall, the results demonstrate that invasive species are actively spreading in all types of landscapes, with agrocenoses and urban areas remaining the most affected, which requires priority control and management measures.

Table 12

Effectiveness of legal measures by type of territory

Territory type	Availability of legislative norms	Effectiveness of measures
Nature reserves	Yes	High – regular environmental monitoring (5+ inspections per year), availability of environmental inspections, effective mechanisms for punishing violations
Farmland	No	Low – lack of special standards, isolated inspection activities (2 per year), low level of control over the use of pesticides
Urban areas	Part	Medium – availability of development rules and local council decisions, 3–5 campaigns/inspections per year, but lack of centralized policy

The Table 12 reflects the effectiveness of legal measures for different types of territories and allows us to see the difference in the level of regulatory support and the effectiveness of the implemented actions. Using the example of the objects of the nature reserve fund, it is clear that this category of territories has the clearest system of legal regulation. Regular environmental monitoring is provided here, which on average amounts to more than five inspections per year, special environmental inspections and mechanisms for punishment for violations are in place. As a result, we can speak of a high level of effectiveness of legal measures, because thanks to constant control, it is possible to restrain the spread of invasive species.

In contrast, agricultural lands are characterized by the lowest efficiency. There are practically no specialized legal acts for them, and inspection activities are carried out episodically, on average twice a year. This means a weak level of state control, especially in the field of agrochemical use, which makes such territories vulnerable to the introduction and spread of dangerous weeds (Lisovsky & Holovko, 2025).

Urban areas occupy an intermediate position. Here there are local regulations in the form of development rules and individual decisions of local governments. Practical measures are implemented in the form of 3–5 campaigns or inspections per year, which include explanatory work with residents, sending out information letters, periodic actions to monitor the condition of green spaces. It is this frequency and content of actions that allows us to attribute them to the average level of activity. The average level in this case means the presence of certain measures (visits, inspections, information campaigns), but their frequency and scale do not provide a comprehensive solution to the problem. That is, the authorities fulfill their duties, but not systematically and not at a level that would allow achieving high performance.

Thus, "medium level of activity" means the implementation of three to five activities per year, including inspections, consultations and information actions, but without a national strategy and systematic approach. This indicates the need for a more integrated policy, which takes into account the specificities of different types of territories and ensures coherence of actions at the local and regional levels.

The presented bar Fig. 1 demonstrates the frequency of detection of invasive flora species (%) in the three main landscape and geographical regions of Ukraine – Polissya, Forest-Steppe and Carpathians. The Fig. 1 is based on the results of field monitoring and statistical processing of random samples during 2022–2024.

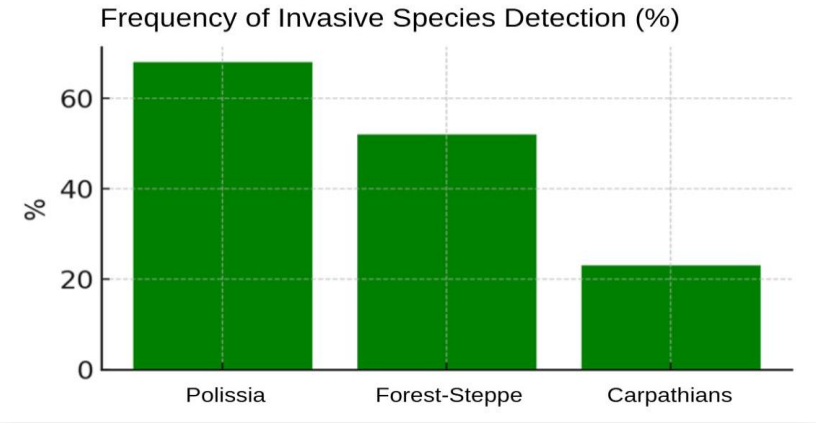

Fig. 1. Frequency of detection of invasive species

Main results

Polesie ranks first in terms of the frequency of detection of invasive species – over 67 % of samples contained one or more introduced aggressive species. Such a high frequency is explained by a combination of natural (humidity, loose soils, extensive water supply network) and anthropogenic factors (presence of disturbed areas, logging operations, transport corridors).

The forest-steppe region shows a share of about 52 %, which also indicates a significant level of invasive load. The main sources of spread in this region are agricultural fields, roadsides and urban areas. In the forest-steppe, there is an active increase in the number of invasive species such as Acer negundo and Solidago canadensis.

The Carpathians have the lowest rate – 23 %. This is explained by the preserved natural

environment, lower anthropogenic load, lack of intensive agricultural activity and natural barriers (relief, climate) that prevent the spread of invasive species.

This graph is a visual confirmation of regional differences in the impact of invasive flora on biodiversity. The data indicate the need for a differentiated approach to legal regulation and environmental monitoring, since different regions have different risk factors. A correlation was also found between the degree of anthropogenic transformation of the landscape and the frequency of invasions, which confirms the hypothesis of a close connection between human activity and the spread of alien species. Therefore, an effective environmental policy should take into account the spatial heterogeneity of invasive pressure when planning environmental protection measures.

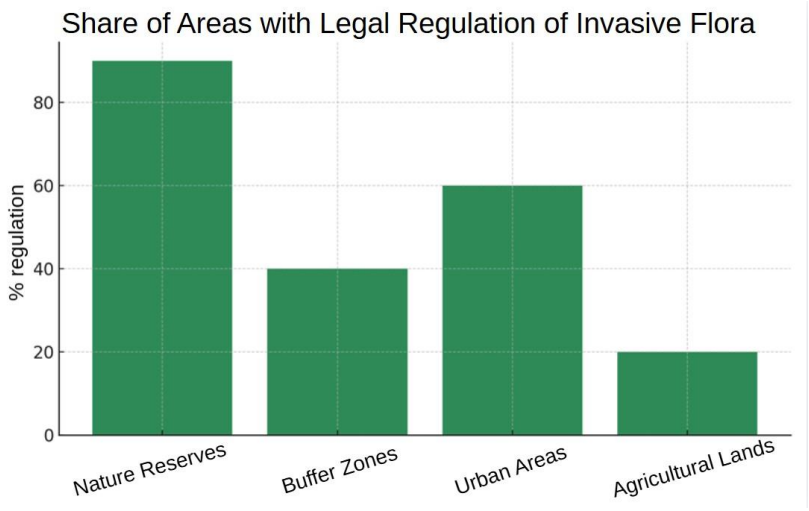

Fig. 2. Share of territories with legal regulation of invasive flora

The Fig. 2 illustrates the proportion of areas with legal regulation of invasive flora by four key land use types: reserves, buffer zones, urban areas and agricultural lands. The data is presented in percentages, reflecting the level of coverage of each category of areas with regulatory acts for the control and prevention of the spread of invasive species.

Reserves have the highest share of legal regulation – over 90 %. This is explained by the effect of the laws of Ukraine "On the Nature Reserve Fund", "On Environmental Protection", "On the Red Book of Ukraine", as well as the internal regulations of national parks and reserves. Such zones provide for special protection regimes, environmental monitoring and a ban on the introduction of alien species without expert assessment.

Urban areas demonstrate coverage of approximately 60 %. In some communities, landscaping regulations are in force that restrict the use of certain ornamental plants or provide for their control. However, as practice shows, these regulations are often declarative in nature and are rarely accompanied by effective implementation mechanisms.

Buffer zones, which serve as a transition zone between protected and exploited areas, have only 40 % legal coverage. The reason is that in many cases such zones are not legally distinguished as a separate category of land and therefore do not have a clearly established use regime, despite their strategic role in containing biological invasion.

Agricultural lands have the lowest level of legal regulation – only 20 %. This is especially critical as these areas are often a source of invasive flora, in particular weeds (e.g. Ambrosia artemisiifolia), due to the lack of proper control, sanitary zones, inspection supervision and monitoring.

The presented graph shows a disproportion in the legal provision of counteraction to invasive flora, which has important consequences for the ecological safety of landscapes. The best protection is provided where there is a clear legal framework and institutional responsibility. At the same time, agricultural lands and buffer zones remain the most vulnerable to biological invasion, which poses risks to the environment and public health.

Thus, the results of the graph highlight the need to reform the legal regime of landscape management, in particular by introducing a national register of invasive species, mandatory risk assessment at the land use stage, and the integration of international environmental law (e.g. the Convention on Biological Diversity and EU Regulation No. 1143/2014) into national legislation.

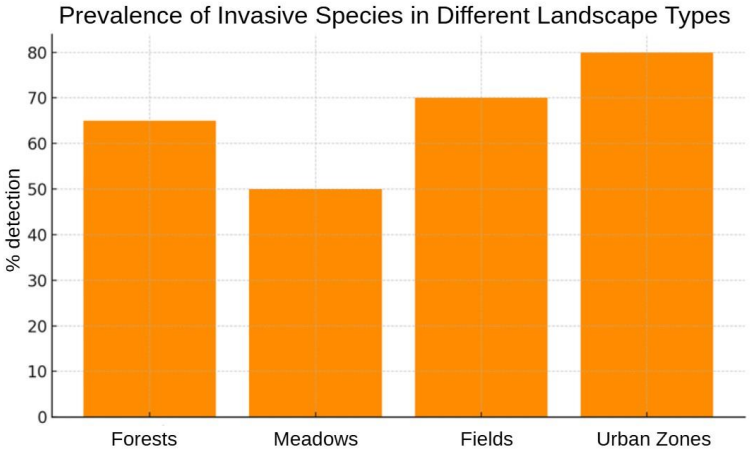

Fig. 3. Prevalence of invasive species in different types of landscapes

The Fig. 3 reflects the prevalence of invasive flora species in different types of landscapes, presented as a percentage of detected cases based on monitoring results in 2022–2024. Four types of landscapes were included in the review: forests, meadows, agricultural fields, and urban areas – the most typical for different regions of Ukraine.

Key findings

Urban areas show the highest prevalence of invasive species – 80 % of samples showed the presence of at least one invasive species. This high prevalence is explained by a combination of several factors: high population density, active landscaping using non-adapted introduced species, transport corridors as migration vectors, and insufficient control by municipalities. For example, Acer negundo and Solidago canadensis have become dominant in many urban ecosystems.

Fields (agricultural lands) are in second place with 70 % of detections. Here, a massive spread of weeds such as Ambrosia artemisiifolia, Erigeron annuus, Xanthium strumarium is recorded, which quickly colonize arable land, especially under conditions of irrational land use, intensive agricultural cultivation and lack of phytosanitary control. Prohibited seed treatment, import of uncertified seed material also contribute to invasions.

Forests show 65 % prevalence of invasive species. Despite the natural barrier potential of forest ecosystems, their peripheral parts are actively invaded, especially near roads and clearings. In humid conditions of Polissya and Northern Forest-Steppe, the density of Impatiens glandulifera and Reynoutria japonica increases (Vasiliuk et al., 2022).

Meadows have the lowest recorded prevalence – 50 %, which is associated with less anthropogenic interference with natural dynamics. However, typical meadow invasive species – in particular, Lepidium latifolium and Bidens frondosa – are also spreading here. Their impact is exacerbated by non-compliance with haymaking regimes and grazing without ecological monitoring (Geng et al., 2024).

This graph is a visualization of the ecological and legal vulnerability of different types of landscapes to invasive flora, which is of great importance for the formation of territorial-specific biodiversity protection policies. A relationship has been established between the degree of anthropogenic load and the level of spread of alien species, which confirms the hypothesis of the need for stricter control in urban areas and agricultural lands.

Scientifically based risk zoning and implementation of landscape-oriented countermeasures (creation of buffer zones, phytocenotic displacement of invasive species, strengthening regulatory oversight) should become part of the state strategy. In addition, the specifics of each landscape should be taken into account when developing regulatory documents to combat invasive flora.

4. Conclusions

Thus, the results of the study allow us to formulate a number of scientific and practical conclusions that are important for improving environmental policy, preserving biodiversity, and forming an effective legal framework in the field of combating invasive flora.

The practical application of the results is possible in the following areas:

Formation of a comprehensive system for monitoring invasive flora, taking into account the typology of landscapes and indicating quantitative parameters (number of localities, percentage of affected areas, frequency of inspections, etc.).

Preparation of regional management plans for territories affected by invasive species, taking into account ecological risk and absolute distribution

indicators (thousands of hectares, % of the region's territory, number of species).

Integration of zoning maps and databases of invasive species into the structure of local land use and natural resource management plans with the provision of digital data for GIS analysis.

Development of information and educational programs for communities aimed at preventing the inadvertent introduction of new invasive species, specifying the number of campaigns, seminars, and information materials conducted.

The scientific novelty of the work creates the basis for further research, in particular:

Modeling the risk of the spread of invasive species in connection with climate change and urbanization using quantitative scenarios (forecast of changes in distribution areas for 10–20 years, number of new species).

Assessment of the ability of different landscape types to biological self-regulation under invasive load based on statistics on species composition, population density and affected areas.

Development of mechanisms for implementing European environmental standards into the national legislation of Ukraine (European Strategy on Invasive Alien Species, 2014) with a comparison of specific regulatory provisions and quantitative indicators of their implementation.

The results obtained can be used in the formation of modern environmental policy that meets the requirements of biosecurity and preservation of the natural stability of landscapes. However, in the conclusions, tables and diagrams it is necessary to present absolute numerical data (for example, the number of recorded invasive species in the regions, their distribution area in hectares, the number of inspections and measures per year), which will make the generalizations more convincing and practically meaningful.

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