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Preservation of Plant Biodiversity in National Natural Parks of Ukraine in the face of Climate Change

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ABSTRACT:
Conservation of plant biodiversity in national natural parks of Ukraine is becoming particularly relevant in the context of climate change, which transforms the temperature and humidity regime, increases the risks of droughts, fires, habitat degradation and species range shifts. The aim of the study was to theoretically substantiate the directions of adaptive conservation of phytodiversity in national natural parks of Ukraine, taking into account climate-related changes in the conditions of existence of plant species and groups and biological mechanisms of their vulnerability. The study was of a theoretical and analytical nature: analysis and systematization of sources were used to identify climate threats and vulnerable components of phytodiversity, comparative and analytical method - to compare Ukrainian and international approaches, generalization - to form directions of adaptive conservation. The analysis took into account the species composition of the flora, the state of populations, phenological processes, natural renewal and the structure of plant groups. The results showed that climate-related threats are complex and include changes in temperature and humidity, droughts, fires, phenological shifts, habitat degradation, the spread of invasive plants, population fragmentation and loss of ecological connectivity, which affects the viability of populations, reproductive processes, seed or vegetative renewal and phytocenotic structure. It was determined that the most vulnerable are rare, endemic, relict and Red Book species, steppe, grass, marsh, coastal and forest communities, as well as populations on the edge of the range. It was substantiated that the NNP of Ukraine can serve as centers of flora conservation, natural biotopes, elements of the ecological network and potential climatic refugia. The directions of adaptive conservation have been formed: flora monitoring, protection of vulnerable species, control of invasive plants, maintenance of ecological connectivity, assessment of population status, natural regeneration, phytocenotic structure and stability of biotopes. The practical significance of the results lies in the possibility of their use for updating NNP management plans, refining monitoring programs and biologically based selection of priority protection objects.

Keywords: adaptive management, ecological connectivity, invasive species, refugium, biotopes, ecosystem, flora monitoring.

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1. Introduction

Conservation of plant biodiversity is one of the priority areas of action in the field of protection of natural ecosystems. Phytodiversity determines the structure of ecosystems, affects soil and hydrological regimes, microclimate and ecosystem connections. The main areas designated for the conservation of plant biodiversity in Ukraine are national natural parks (hereinafter referred to as NNPs), within which rare, endemic, relict and Red Book plant species are protected, as well as the diversity of steppe, forest, meadow, swamp and coastal plant communities. The functional relationship between biodiversity and ecosystem stability is substantiated by Hong et al. (2022), which indicates the possibility of using phytodiversity as a biological indicator of the stability of plant communities and ecosystems.

An example of how climate change affects biodiversity is the impact on the relationships between plant species, their habitats, population structure, and the conditions for the passage of major phenological phases. In Ukraine, a change in the temperature and humidity regime has been recorded, which complicates the protection of plant biodiversity due to changes in the conditions of vegetation, flowering, fruiting, and natural renewal of plants (Vyshnevskyi, 2025). In Europe, a long-term decrease in plant diversity due to various climatic factors has been established (Eichenberg et al., 2021). The results published by Harrison (2020) demonstrated that the decrease in biodiversity occurs after the loss of plant communities due to climate change, therefore, it is necessary to assess not only the general state of ecosystems, but also the species composition, population viability, and the structure of phytocenoses.

The discrepancy between climate dynamics and the stability of protected areas boundaries is particularly complex. The spatial arrangement of species requires the placement of protected areas in accordance with the optimal conditions for their life, in particular, temperature regime, moisture availability, soil characteristics and the state of biotopes. However, redistribution of plant species is possible depending on their ability to settle (Lawlor et al., 2024). Depending on the projected climate changes, the ranges of plant species may shift, which indicates the difficulty of predicting their location in the future (Brun et al., 2020). In particular, the change of biomes and ecoregions is perceived as a threat to the operation of protected areas (Dobrowski et al., 2021). Therefore, it is necessary to assess the state of the Ukrainian NPs in relation to not only the current, but also the future value of biodiversity, taking into account the ability of the areas to support viable plant populations and stable plant communities under changed climatic conditions.

One of the main trends in modern conservation science is the transition from passive to active management of protected areas. The requirements for the status of a protected area do not automatically ensure the preservation of biodiversity. The effectiveness of the function of biodiversity protection depends on monitoring, restoration of ecosystems, regulation of the habitat of plant species, and minimizing the impact of anthropogenic pressure on ecosystems (Gillingham et al., 2024). Scientists Ranius et al. (2023) found that the effectiveness of protected areas depends on management strategies and flexibility. The concept of climatic refugia, which was revealed by Haight & Hammill (2020), can be used to solve modern problems of Ukrainian protected areas, but only if

suitable conditions for ecosystems are ensured, microhabitats, hydrological regime, and phytocenotic structure of plant communities are preserved.

Ukrainian botanical sources have established which components of phytodiversity are the most sensitive. Rare steppe communities are most vulnerable to the effects of fragmentation, degradation and certain changes in ecosystem conditions, since their species composition and coenotic structure depend on the stability of steppe biotopes (Dubuna et al., 2023). For grass biotopes, restoration is impossible without maintaining the integrity of the communities in which they exist, as well as without preserving the conditions for seed renewal, the development of generative individuals and maintaining population stability of species (Chusova et al., 2022). The regional specificity of the flora of individual NNPs of Ukraine requires specific approaches to their restoration, taking into account the species composition, rare components of the flora, the state of populations and types of plant communities (Shevchyk et al., 2025; Bezsmertna et al., 2024).

Under such conditions, approaches that simultaneously include elements of plant biodiversity, the state of the Ukrainian National Parks and the impact of climate change on ecosystems, in particular on the species composition of flora, population viability, phenological processes, natural renewal and the structure of plant communities, are insufficiently generalized. This requires systematization of research areas and adaptive management of phytodiversity: biodiversity monitoring, protection of rare species of biodiversity, study of ecosystem connectivity and control of invasive plant species. The aim of the study was to characterize the areas of plant biodiversity conservation in the Ukrainian National Parks under climate change conditions, taking into account the biological vulnerability of plant species, populations and communities. The objectives of the study were as follows: to characterize the importance of the Ukrainian National Parks for the conservation of plant biodiversity; to identify threats to plant species caused by climate change, in particular threats to their phenology, reproduction, natural renewal and population viability; to analyze the role of NNPs as centers of phytodiversity conservation, ensuring the preservation of biotopes and potential climatic refugia for plants; to determine the directions of adaptive management of plant biodiversity in NNPs of Ukraine; to formulate scientifically based recommendations for adaptive conservation of phytodiversity in NNPs of Ukraine in accordance with the biological characteristics of plant species, population structure and state of plant communities.

To ensure the measurability of adaptive management results, a system of specific ecological indicators has been proposed. Such indicators may include: the number of reproductive individuals in populations of rare species, the level of seed germination and the success of natural renewal, phenological dates of the beginning of flowering and fruiting of key species, the area and degree of fragmentation of priority biotopes, the percentage of coverage by invasive plants, vegetation activity indices (NDVI) based on remote sensing data, as well as the area of restored degraded ecosystems. The use of these biologically based indicators will allow moving from general goals of phytodiversity conservation to operational action plans adapted to the conditions of each specific national natural park.

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2. Literature Review

Science considers plant biodiversity to be the basis of ecosystem functioning. Researchers Hong et al. (2022) found that biodiversity plays a key role in performing ecosystem functions even under conditions of environmental change – the diversity of biological species ensures the ability of ecosystems to maintain their functional integrity. A similar conclusion can be drawn regarding plant biodiversity in NPPs: the loss of such diversity leads to a decrease in ecosystem functionality. The connection between plant biodiversity and soil carbon content was confirmed by Chen et al. (2020). Thus, the preservation of plant biodiversity in NPPs of Ukraine should not be considered separately, but one of the most important prerequisites that affect ecosystem functioning. At the same time, it is advisable to consider phytodiversity as a system that includes not only all known plant species, but also their breeding, ability to create communities and natural renewal.

Climate change exacerbates this problem, as it affects not only the plants themselves, but also their ability to form the plant communities they create. The biological dimension of such an impact is manifested through changes in the timing of vegetation, flowering, fruiting, seed renewal and population viability. For Ukraine, the work of Vyshnevskyi (2025) is important regarding the consequences of climate change for droughts affecting plant communities present within the country. However, the work of Eichenberg et al. (2021) indicates that in Europe plant biodiversity is decreasing over time. Phenological responses of plants to climate change may differ depending on the functional strategies of species, which is manifested in changes in the timing of flowering, fruiting and reproductive activity of plants (Pérez-Ramos et al., 2020). In turn, Harrison (2020) suggested that while climate change is transforming plant communities, it is also indicating that the number of these communities is decreasing. Therefore, climate change is affecting plant communities in a way that reduces not only biodiversity on the planet, but also the value of plant communities that exist in the region.

The literature has focused on the geographic movement of plant species. Lawlor et al. (2024) examined various factors associated with such movement, including the impact of climate change, the ability of these species to move, and the availability of suitable habitats and landscape connectivity. The response of plant species to climate change is heterogeneous due to the rejection of one direction or rate of range movement as a result of different properties of the plant species themselves (Madsen-Hepp et al., 2023). For Ukrainian NPPs, the boundaries of these areas are static, but the suitability of biotopes for plant growth can change. However, there are difficulties in predicting these changes. For example, Brun et al. (2020) studied the movement of species within NPPs based on the complexity of models built to study the movement of plant species. The findings of Rubenstein et al. (2023) also indicated that geographic movement is not equally observed in different biotopes. Therefore, within the Ukrainian NPPs, it is useful to carry out real confirmation of the presence of plant species and conduct studies that determine the suitability of biotopes for their growth in the future. Of particular importance for determining the status of each species is the assessment of the populations of this species, the number of individuals that germinate and are capable of reproduction both by seed and vegetative means.

Regarding the management of protected areas, plant diversity and biodiversity of the planet are not automatically protected by the official status of these areas. Adaptation strategies, as described by Gillingham et al. (2024), can be useful for protecting plant diversity by monitoring these areas, restoring ecosystems in them, managing their environment and reducing negative impacts on plant communities. It is not the area of the area itself, but its flexibility that determines future effectiveness, as pointed out by Ranius et al. (2023). Similar conclusions were obtained by Dobrowski et al. (2021), who showed that climate-induced shifts of ecoregions and biomes can reduce the effectiveness of achieving conservation goals. Therefore, for the NPP of Ukraine, it is necessary to determine not only the properties of the flora, but also the possibility of preserving plant species in the face of future climate change. In the biological aspect of the assessment, it is necessary to take into account the population, phytocenotic structure, the presence of appropriate micro-settlements and the ability of the flora to self-renew.

In studies of nature conservation areas, criticism of the static model is increasingly clearly reflected. Simply, the status of a territory as a protected area does not guarantee the possibility of preserving biodiversity if it loses microclimatic and biotope conditions suitable for plants. Adaptation actions, systematized by Gillingham et al. (2024), indicate the necessary elements of protecting natural areas of Ukraine. What is important is not the very existence of the territory as a zone with nature conservation status, but its potential for implementing adaptation measures that determine its effectiveness, which follows from the studies of Ranius et al. (2023). According to the study of Dobrowski et al. (2021), climate-related losses in conservation efficiency of territories due to the displacement of ecoregions and biomes were traced. Therefore, the assessment of Ukrainian NNPs should be carried out not only according to their biological value, but also according to which plant species grow there and will grow under climate change. It is also important to consider whether biotopes contain the necessary elements to complete the life cycle of plants, from disease germination to the formation of viable generative plants. Climate change can affect the ability of plants to germinate and grow, and therefore the survival of these species (Everingham et al., 2021).

The concept of climatic refugia is considered promising and provides opportunities for solving the problem of biodiversity loss due to climate change. According to research by Haight & Hammill (2020), protected areas can serve as refugia for biodiversity conservation and meet its requirements in the event of climate change. If the area maintains conditions suitable for plants, this can prevent their destruction and preserve species diversity in this area. Cases of species with high conservation status were studied by Hoveka et al. (2022): climate change can affect Red Book species in different ways, depending on the possibility of their growth in protected areas. It is necessary to determine the possibility of performing the refugium function by the relevant territories of the National Parks of Ukraine. In the biological sense, a refugium should ensure not only the temporary preservation of the species, but also the maintenance of its population viability, natural renewal and stability of microhabitats.

Ukrainian botanical research is performing differentiation of components that require priority attention for phytodiversity. Rare steppe groups, which were described by scientists Dubuna et al. (2023), can help to understand the problems that have arisen as a result of the fragmentation of steppe zones. Isolated species are not only a problem of

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preserving individual groups, but also a problem of preserving biotopes themselves. Similarly to the statements of Chusova et al. (2022), individual types of grass biotopes cannot be preserved near places that do not provide them with ecological needs.

Floristic materials studied in the context of the Beloozersky National Park and the Tsumanskaya Pushcha National Park have established a special regional flora in the National Park (Shevchyk et al., 2025; Bezsmertna et al., 2024). The characteristics of the primeval forests of the Synevyr National Park, presented in the work of Ustymenko et al. (2022), further confirms the impact of the natural ecosystem structure on the preservation of phytocenosis. Thus, Ukrainian botanical sources confirm the need to analyze phytodiversity at the species, population and phytocenotic levels, and not only through the area or legal status of the nature reserve. A number of works highlight additional risks for nature reserves in Ukraine. War, which was analyzed by Trofymchuk et al. (2023), Leal Filho et al. (2024) and Uvaieva et al. (2025), is not the central topic of this article, but it increases the vulnerability of ecosystems and the impact on the climate through fires, damage to biotopes, violation of the protection regime and restrictions on monitoring.

The issue of invasive plants requires special attention due to the possibility of their range change due to climate change. Rockwell-Postel et al. (2020) identified the need to assess plants that have the potential to shift their ranges under the influence of climate change. For the National Park of Ukraine, this means the need to study invasive plants not only as a consequence of modern climate change, but also as a biological factor in the transformation of biotopes, changes in the phytocenotic structure, and disruption of the stability of native plant communities.

Thus, the review of scientific sources has shown that the problem of preserving plant biodiversity in the National Parks of Ukraine is studied in an integrated understanding of phytodiversity, the impacts of climate change, the effectiveness of protected areas and threats to the state of plant biodiversity. The problem is considered insufficiently studied in the case of studying plant biodiversity in the National Parks of Ukraine simultaneously in the context of climatic requirements for ecosystems. In this case, there is a need to perform further analysis to reflect adaptive promotion of the preservation of plant biodiversity in the National Parks of Ukraine. Taking into account the analyzed sources, further analysis of the described research objects should concern the study of phenological reactions of plants, functional characteristics of species, the possibility of their regeneration, the state of their populations, the structure of phytocenoses, the suitability of biotopes for their development, as well as the role of invasive species in the transformation of plant communities.

3. Research goals

The aim of the study was to theoretically substantiate the directions of adaptive conservation of plant biodiversity in the National Parks of Ukraine under climate change conditions, taking into account the species, population, phytocenotic and biotopic organization of phytodiversity. To achieve this goal, it is necessary to analyze the scientific directions of phytodiversity conservation, investigate the role of National Parks as centers of plant biodiversity conservation and identify factors that affect the loss of effectiveness of territorial protection in the event of climate change. Particular attention should be paid

to the analysis of the relationships between biotope changes, temperature and humidity regime, range dynamics, population viability, phenological processes and natural renewal of plant species.

The expected result of the study is the systematization of scientifically substantiated directions of phytodiversity conservation in the National Parks of Ukraine. These areas include climate monitoring, protection of rare species, ecological connectivity, control of invasive plants, conservation of biotopes, assessment of population status, structure of plant communities and the impact of climatic factors on vegetation, reproduction and natural renewal of plants. This approach makes it possible to formulate recommendations for the conservation of plant biodiversity in conditions of climate change in accordance with the identified vulnerability of species, state of biotopes, population stability, phytocenotic structure and nature conservation role of NPP.

4. Materials and Methods

The study was of a theoretical-analytical type and was carried out as a result of the processing of scientific sources. The author searched and selected sources through a targeted analysis of publications corresponding to the topic of the study. The source database includes works published mainly in 2020–2025, which relate to plant biodiversity, flora of the National Park of Ukraine, species composition, population structure, phytocenotic organization of plant communities, climatically determined redistribution of species, effectiveness of nature reserves, climatic refugia, adaptive management and associated environmental threats.

The author searched and selected sources relevant to the topic. Search queries were formulated using keywords in Ukrainian and English: plant biodiversity conservation, climate change and plant diversity, protected areas and climate change, national nature parks of Ukraine, flora of national nature parks, species redistribution under climate change, adaptive management of protected areas, invasive plant species in protected areas, plant phenology climate change, plant functional traits, plant regeneration, seed germination, plant population dynamics, vegetation communities, plant biodiversity, NNP of Ukraine, climate change, phytodiversity, protected areas, plant phenology, plant populations, plant communities, phytocenoses, natural regeneration, invasive plants. The inclusion criteria were relevance to the topic, scientific or regulatory-informational nature of the work, relevance of the research, connection with the concept of plant biodiversity, protected areas or climate change and the possibility of using them in the theoretical justification of adaptive conservation of phytodiversity, as well as publication in 2020–2025. Preference was given to works that considered the biological reactions of plants to climatic factors: phenological shifts, changes in habitats, functional traits, seed and vegetative renewal, population status, structure of phytocenoses and spread of invasive species. Sources that did not meet these criteria were excluded from the study.

The work used general scientific methods: analysis, synthesis, generalization, induction, deduction, abstraction, comparison, systematization, classification, logical modeling, problem-oriented analysis, critical analysis of sources. The analysis method was used to isolate the components of the problem topic, in particular, climate threats, vulnerable plant groups, types of biotopes, population and phytocenotic indicators of

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phytodiversity conservation. Synthesis methods were used to integrate the results of Ukrainian and international research into a single scientific conclusion. Generalization methods were used to create general scientific conclusions regarding the change in the nature conservation role of NNPs and the biological prerequisites for the conservation of plant species and groups under climate change.

Specially used methods were also the systematization of scientific sources and the comparative-analytical method. Systematization allowed grouping scientific sources into the following blocks: on the flora and plant groups of Ukraine, on climate change and redistribution of species, on the effectiveness of protected areas, on adaptive management, invasive species and climatic refugia. Additionally, the sources were systematized by biological levels of analysis: species, population, phytocenotic and biotope. At the species level, rarity, endemism, relict status, conservation status and functional characteristics of plants were taken into account; at the population level- viability, abundance, isolation and ability to natural renewal; at the phytocenotic level- species composition, structure of groups, dominant species and invasive transformation; at the biotopic level - the state of habitats, water regime, microclimatic conditions and vulnerability of biotopes to climate change. The comparative-analytical method allowed us to identify the provisions of international studies that can be adapted to the requirements and possibilities of research in the National Parks of Ukraine, taking into account its biodiversity. Based on systematization and comparative analysis, scientifically sound and clear recommendations can be formulated for the adaptive conservation of phytodiversity in the National Parks of Ukraine.

The materials of the study were works on rare plant groups, flora of the National Parks of Ukraine, plant species in need of protection, phenological reactions of plants, functional characteristics of species, natural renewal, population viability, climatically determined redistributions of plant species, effectiveness of territories with nature conservation status, climatic refugia for plants, adaptive management and control of invasive plant species. Sources on military impacts on the flora, damage to forest ecosystems and remote monitoring of nature conservation areas of Ukraine were also taken into account.

5. Results

Systematization of climate-related threats to plant biodiversity of the National Parks of Ukraine. As a result of theoretical analysis of sources, it was determined that threats to plant biodiversity of the National Parks of Ukraine are threats that arose as a result of the impact of climate change, which involve three interrelated elements of biodiversity: abiotic conditions, plant communities and spatial integrity of populations.

Generalization of literary sources on the impact of climate change on biodiversity allowed us to recognize the main groups of threats that affect the state of rare species, the integrity of biotopes, the stability of communities and the implementation of environmental protection functions of the National Parks. A generalized characteristic of the identified groups of threats is given in Table. 1.

Table 1: Generalized climate-related threats to plant biodiversity of the National Parks of Ukraine

Threat group	Main manifestation	Potential impact on the phytodiversity of the NPP
Change in temperature and humidity	Rising temperatures, changing precipitation amounts and seasonality	Changes in vegetation conditions, water balance, biotope stability, and timing of phenological phases
Droughts	Prolonged moisture deficit in the soil and atmosphere	Water stress, reduced population viability, loss of vulnerable species, disruption of seed and vegetative renewal
Fires	Increasing fire danger in forest, steppe and meadow ecosystems	Damage to vegetation cover, seed bank, disruption of natural regeneration
Habitat degradation	Deterioration of habitat conditions and structural integrity of communities	Reduction of suitable habitat areas, reduction in the number of rare species, disruption of population stability
Phenological shifts	Change in the timing of vegetation, flowering, and fruiting	Disruption of seasonal dynamics, reproductive processes and interspecific interactions, reduction in the efficiency of generative reproduction
Shifting species ranges	Shifting climatically suitable conditions beyond the current distribution	Spatial mismatch between the boundaries of the NNP and future habitats of species, loss of suitable habitats for individual populations
Spread of invasive plants	Establishment of alien species in disturbed or weakened biotopes	Displacement of native species, transformation of communities, change in competitive relations and phytocenotic structure
Population fragmentation and loss of ecological connectivity	Isolation of populations and disruption of natural migration routes	Reduced genetic exchange, limited adaptive potential of species, increased risk of local extinction of rare populations

Source: author's summary based on the results of theoretical analysis of sources (Vyshnevskyi, 2025; Eichenberg et al., 2021; Harrison, 2020; Lawlor et al., 2024; Dubyna et al., 2023; Chusova et al., 2022; Gillingham et al., 2024; Marangi et al., 2020; Dobrowski et al., 2021; Dupuy et al., 2020; Pérez-Ramos et al., 2020; Madsen-Hepp et al., 2023; Everingham et al., 2021; Bernardo et al., 2020; Rockwell-Postel et al., 2020)

Analysis of systematized data demonstrates the interconnected nature of threats to the phytodiversity of the National Parks of Ukraine. The basic factor affecting the state of plant populations and groups is a change in the temperature and humidity regime. The following depend on temperature and humidity: the duration of the growing season, flowering and fruiting times, growth intensity, seed renewal, and the viability of generative individuals. In particular, Ukraine is considered one of the regions in which the impact of changes in climatic factors has been determined, which indicates the possibility of a decrease in the stability of natural ecosystems (Vyshnevskyi, 2025).

Swampy, meadow, coastal and other biotopes are sensitive to the impact of climatic factors. Phenological shifts under such conditions can change the timing of the main phases of plant development and disrupt reproductive processes in groups (Pérez-Ramos et al., 2020). The threats directly related to the general change in the climatic regime

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of Ukraine are droughts and fires. Droughts increase the degree of water stress for plants and reduce the viability of their populations, and can also change the relative abundance of ecological and functional groups of plant species in ecosystems.

The decline in plant diversity in Central Europe over the years, studied by Eichenberg et al. (2021), demonstrates the cumulative nature of such events. Fires damage vegetation cover, destroy seeds, and disrupt the seed bank and natural regeneration conditions. The increased risk of fires associated with climate change is one of the risks to natural ecosystems. Changes in climatic conditions can also affect the regeneration potential of plants, in particular seed germination, early growth stages and the formation of traits associated with population recovery (Everingham et al., 2021).

Since habitat degradation affects rare and stenotopic species, their conservation is impossible without the conservation of the communities in which they exist. One of the promising areas of research is an in-depth study of the dynamics of rare steppe communities and protected species of grass biotopes of Ukraine under climate change (Dubyna et al., 2023; Chusova et al., 2022).

The combined impact of several threats is particularly dangerous for rare plants, since climatic factors can enhance the effects of biotope fragmentation, population decline, and disruption of natural regeneration (Bernardo et al., 2020). Therefore, the object of protection should be not only individual species, but also the biotopes in which they exist, as well as population and phytocenotic conditions that ensure the completion of the full life cycle of plants.

In addition to their isolated effects, climatic and biotic threats often act synergistically, reinforcing each other. Prolonged droughts weaken the physiological state of plants, reduce their competitiveness and facilitate the penetration of invasive species, especially in fragmented biotopes with disrupted phytocenotic structure. Fragmentation, in turn, limits gene flow between populations, reducing their ability to adapt to new climatic conditions. Taken together, such multi-stressor effects can cause cascading changes in plant communities that are difficult to predict under passive protection. Therefore, adaptive management should assess the cumulative impact of several threats on ecosystem resilience, and not just analyze them separately.

The spatial dimension of ecosystem risks is manifested in the shift of plant species ranges and the loss of ecological connectivity, which requires consideration of the climate-induced redistribution of phytodiversity in national parks of Ukraine. Dependence on the possibility of settlement and the availability of biotopes affects the distribution of plant species (Lawlor et al., 2024). The direction and speed of such changes may differ between species, as they depend on the functional characteristics of plants, their ecological plasticity and the ability to use new climatically suitable habitats (Madsen-Hepp et al., 2023).

In NNPs, the problem of the difference between the permanent location of parks and the shift of climatically suitable conditions for the existence of plant species arises. An additional ecosystem risk is the spread of invasive plants in degraded or climatically altered biotopes, therefore, their control should be one of the components of adaptive management (Gillingham et al., 2024; Marangi et al., 2020; Rockwell-Postel et al., 2020). Having analyzed the scientific evidence, it can be concluded that the tasks of conserving phytodiversity in Ukraine should be to reduce climate-related biological risks, maintain biotope connectivity, preserve the viability of populations, control invasive plants and

prevent phytocenotic disturbances. Vulnerable components of phytodiversity of NNP under climate change. The analysis established that the main components that require assessment under the influence of climate change are different types of plant communities, populations of rare species and biotopes, since changes in their composition, structure and stability reflect the state of ecosystems and the vulnerability of biotopes. Table 2 provides a generalized description of the vulnerable components of phytodiversity of national natural parks of Ukraine and the corresponding conservation priorities.

Table 2: Priority objects of adaptive conservation of phytodiversity of the National Park of Ukraine

Phytodiversity component	The main reason for vulnerability	Priority of environmental attention
Rare species	Small population size, limited habitats, risk of disruption of natural regeneration	Population monitoring, habitat protection, assessment of the number of generative individuals
Endemic and relict species	Narrow ecological amplitude, dependence on specific conditions	Preservation of local biotopes and microhabitats
Red Book plants	High conservation status, threat of population decline	Priority protection of populations and habitats, monitoring the condition of reproductive individuals
Steppe groups	Sensitivity to drought, fragmentation and degradation, changes in the ratio of xerophytic and mesophytic species	Maintaining the integrity of steppe biotopes, preserving the phytocenotic structure
Grassy biotopes	Dependence on the hydration regime and the structure of groups	Protection of communities as habitats for species, maintaining conditions for seed renewal
Marsh and coastal communities	Dependence on a stable water regime	Preservation of hydrological conditions, protection of populations of moisture-loving species
Forest ecosystems	Risks of droughts, fires, changes in natural regeneration	Monitoring the condition of tree stands and natural structure, assessing undergrowth, herbaceous and shrub layer, and seed renewal
Populations at the edge of the range	High sensitivity to shifts in climatically suitable conditions, dependence on functional traits and ability to settle	Assessing habitat dynamics and maintaining ecological connectivity, monitoring the viability of local populations

Source: author's generalization based on the results of theoretical analysis of sources (Dubuna et al., 2023; Chusova et al., 2022; Shevchyk et al., 2025; Bezsmertna et al., 2024; Ustymenko et al., 2022; Lawlor et al., 2024; Hoveka et al., 2022; Vyshnevskyi, 2025; Gillingham et al., 2024; Madsen-Hepp et al., 2023; Everingham et al., 2021; Bernardo et al., 2020).

Analysis of the summarized data on the elements of phytodiversity indicates that the most vulnerable are the components related to rarity, endemism, relict status and high conservation status of species. Such plants often have limited habitats, small populations and specific requirements for growth factors, such as moisture, light and soil substrate. These species respond quickly and clearly to changes in the biotope and environmental

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conditions. Therefore, it is necessary to take into account not only the protection of these species in the NNP, but also maintaining the conditions for their stable growth, reproduction, seed or vegetative renewal and maintaining the viability of populations. For rare plants, the combined threat of several factors is particularly dangerous, since climate threats can intensify the impact of habitat fragmentation, population decline and reduced natural regeneration (Bernardo et al., 2020). A separate group is made up of steppe and grass communities. Studies on the state of rare steppe plant communities in Ukraine have identified their vulnerability to fragmentation, drought, habitat degradation, and changes in phytocenotic structure (Dubuna et al., 2023).

It has been established that herbaceous communities have species whose existence depends on the integrity of the corresponding biotope and the stability of coenotic relationships. Chusova et al. (2022) established that the object of protection should be the biotope itself as an integral functional system, and not just individual species. Therefore, for steppe and herbaceous biotopes, it is important to determine not only the probability of the presence of protected species, but also their species composition, the structure of ecosystem groups, dominants, the state of generative renewal and signs of xerophytization of communities.

Swamp, meadow and coastal communities have been identified as the most sensitive to changes in the water regime, since their structure and species composition directly depend on the stability of moisture. Violation of hydrological conditions can cause a reduction in populations of moisture-loving species, a change in the ratio of ecological groups of plants and the gradual degradation of the corresponding biotopes. In forest ecosystems, the main impacts on biodiversity include droughts, fires, disruption of natural regeneration or its insufficient intensity.

The value of the natural structure of forest ecosystems has been studied using the example of the Synevyr National Park (Ustymenko et al., 2022), which confirms the need to preserve little-disturbed forest biotopes as centers of maintaining phytodiversity, natural regeneration and ecosystem stability. Therefore, for forest communities, it is important to control not only the tree stand, but also the undergrowth, herbaceous and shrub layer, renewal of seed cover and places of growth of rare plants within the territory.

Floristic studies of the Biloozersky National Park and the Tsumanskaya Pushcha National Park allow us to establish the peculiarities of the flora of each of them (Shevchyk et al., 2025; Bezsmertna et al., 2024). It is believed that the determination of vulnerable components of phytodiversity should take into account the specifics of the flora of a particular National Park. An important factor is the state of populations concentrated on the border of the range, since they can be the first to react to shifts in climatically suitable conditions (Lawlor et al., 2024; Hoveka et al., 2022). The heterogeneity of such a reaction can be determined by the functional characteristics of plants, ecological plasticity and ability to settle (Madsen-Hepp et al., 2023).

Thus, the analysis of sources made it possible to determine that the priority objects of adaptive conservation in the National Park of Ukraine are not only rare species, but also biotopes, plant communities and spatially vulnerable populations. This confirms the need to transition from purely species protection to integrated phytodiversity management, aimed at preserving not only individual plant species, but also the conditions of their

existence, the viability of populations, natural renewal, and the stability of the phytocenotic structure.

5.1. The role of national natural parks of Ukraine in the conservation of phytodiversity

As a result of the analysis, it was established that the NNPs of Ukraine perform a multifunctional role in the conservation of phytodiversity. According to the results of the analysis of scientific sources, national natural parks ensure the protection of plant species, maintain the integrity of their biotopes and communities, and can also create conditions for the conservation of species vulnerable to climate-related environmental changes. Therefore, national natural parks should be considered as key territories on the basis of which a system of adaptive conservation of plant biodiversity in Ukraine can be formed, focused not only on the protection of territories, but also on maintaining the viability of populations, natural renewal and phytocenotic structure of plant communities.

First of all, NPPs serve as centers of flora conservation. They contain biologically valuable ecosystems that have high conservation value. Known materials on the flora of the Biloozersky NPP and the Tsumanskaya Pushcha NPP indicate the specificity of the plant cover, which reflects the regional flora (Shevchyk et al., 2025; Bezsmertna et al., 2024). An assessment of information on the structure, composition and state of ecosystems indicates that the NPP is not an isolated nature conservation unit. Each NPP is distinguished by a certain flora, which is determined by the local species composition, population structure of species, ecosystem groups, biotopes and climatic factors. Therefore, the importance of the NPP refers not only to the preservation of the restored list of species of these phytocenoses, but also to ensuring conditions for their growth, reproduction and existence.

The second important function of the NNP is the preservation of natural biotopes- the conditions for the existence of plant species. Analysis of sources has shown that the protection of phytodiversity cannot be effective if it ensures the preservation of only individual plant species. Rare steppe groups of Ukraine are particularly vulnerable to degradation (Dubuna et al., 2023). A similar pattern is observed in grass biotopes: the preservation of plant species requires the protection of entire groups in which they exist (Chusova et al., 2022). Biotopes should be considered as independent management objects in the NNP, since they determine the conditions for the existence of plant species and groups, ensure the passage of ontogenetic stages, seed or vegetative renewal and maintenance of coenotic relationships between species.

Of particular importance in the assessment of protected areas in Ukraine is their ability to function as potential climatic refugia. Important for climatic and biological assessment is the ability to maintain conditions in protected areas that promote the survival of vulnerable species, depending on the state and restoration potential of biotopes (Haight & Hammill, 2020). The ability of areas to perform a refugium function is determined by the extent to which they can maintain local microclimatic conditions, microhabitats, hydrological regime and the structure of plant communities. It is important to determine the state and potential of protected areas in Ukraine to determine the ability of biotopes to remain suitable for survival in the event of changes in temperature, humidity, fire regime and seasonal vegetation dynamics. In this context, NPAs can help not only maintain the

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presence of individual plant species, but also support the stability of their populations, reproduction and natural restoration of these vulnerable plant species.

Another result of the analysis is the definition of NPAs as elements of an ecological network. Due to climate change, plant species can lose suitable habitats or move to other regions. Surveying isolated NPAs is ineffective for ensuring the conservation of phytodiversity. The redistribution of plant species occurs as a result of changes in the availability of suitable biotopes, climatically suitable habitats and the presence or absence of barriers to settlement (Lawlor et al., 2024).

Thus, NPAs of Ukraine should be considered not as separate protected areas, but as parts of a common ecological network, which also includes ecological corridors and other natural areas. Such spatial combination is important for the preservation of genetic exchange between populations, as well as for settlement and the preservation of adaptive potential.

The analysis also showed that the effectiveness of phytodiversity conservation depends on the state of biotopes and their restoration capabilities. Restoration of ecosystems themselves contributes to the conservation of plant species and communities, provided that the impact of climate, degradation of biotopes, invasive plants, fires and displacement of plant species ranges are taken into account (Gillingham et al., 2024; Ranius et al., 2023). To fulfill the function of biotope restoration, it is necessary that restoration measures be aimed at maintaining natural regeneration, plant cover structure, resilience of local populations and reducing the impact of climate risks.

Therefore, restoration should take place not only in accordance with management requirements, but also in accordance with biological norms that ensure the life cycle of the plants and phytocenoses grown.

Thus, the theoretical analysis of the sources allowed us to determine that the NNPs of Ukraine play an important role in the conservation of plant biodiversity: firstly, through the protection of flora; secondly, through the preservation of natural biotopes; thirdly, through the possible performance of the function of climatic refugia; fourthly, through ensuring ecological connectivity in the regions. In particular, responding to the problem of climate change makes it possible to assess how NNPs can support the conservation of plant species, biotopes and their resilience. This emphasizes the need for adaptive management focused on monitoring the state of phytodiversity, reducing climate-related risks and maintaining the integrity of plant communities, as well as assessing population viability, natural renewal, the state of microhabitats and phytocenotic structure as key biological indicators of the conservation of plant biodiversity.

5.2. Directions of adaptive conservation of phytodiversity of the National Parks of Ukraine

Adaptive conservation of phytodiversity of the National Parks of Ukraine should include not separate, but interconnected nature conservation and biologically based directions. Such formation is determined by the very nature of the identified risks that have arisen as a result of changes in climatic regimes, degradation of biotopes, displacement of the ranges of relevant species, spread of invasive plants or increased fire danger. Generalized directions of adaptive conservation of phytodiversity of the National Parks of Ukraine are reflected in Table. 3.

Table 3. Directions of adaptive conservation of phytodiversity of the National Parks of Ukraine

Adaptive Conservation Direction	Content of the direction	Expected conservation value
Climate-oriented flora monitoring	Regular monitoring of changes in species composition, population size, phenology and biotope status	Early detection of negative changes in plant communities and populations of vulnerable species
Protection of rare and vulnerable species	Priority attention to Red Book, endemic, relict and stenotopic species	Reducing the risk of local extinction of vulnerable populations and supporting their natural renewal
Maintaining ecological connectivity	Preservation of ecological corridors, buffer zones and connections between natural areas	Ensuring species migration, genetic exchange and preserving the spatial integrity of populations
Invasive plant control	Early detection, mapping and containment of alien species	Preventing the displacement of native flora and the transformation of the phytocenotic structure of communities
Conservation and restoration of biotopes	Maintaining the integrity of steppe, meadow, swamp, coastal and forest communities	Preservation of the conditions for the existence of plant species and the completion of their life cycle
Taking into account fire and drought risks	Incorporating fire risk and water scarcity into management plans	Reduction of vegetation loss, habitat degradation and seed bank disruption
Remote monitoring	Using satellite data to assess changes in vegetation cover	Rapid detection of damage and spatial changes within biotopes and plant communities
Updating of NPP management plans	Integrating climate risks into environmental planning	Transition from static protection to adaptive management taking into account population, phytocenotic and biotopic indicators

Source: Author's summary based on the results of theoretical analysis of sources (Gillingham et al., 2024; Ranius et al., 2023; Lawlor et al., 2024; Dubyna et al., 2023; Chusova et al., 2022; Marangi et al., 2020; Dupuy et al., 2020; Drozd et al., 2025; Haight & Hammill, 2020; Hoveka et al., 2022; Pérez-Ramos et al., 2020; Everingham et al., 2021; Madsen-Hepp et al., 2023; Rockwell-Postel et al., 2020)

The analysis of the established directions indicates that one of the main directions of adaptive conservation should be the implementation of climatic monitoring of flora. The value of this direction lies in the ability not only to determine which species inhabit a certain territory, but also the number of populations of each of these species, the state of their habitats, phenology, natural renewal and changes in their communities as a result of the action of these factors in general.

This method is considered important in the modern understanding of the process of preserving natural areas (Gillingham et al., 2024; Ranius et al., 2023). Taking into account the phenological responses of plants to climate change, such monitoring should cover the periods of vegetation, flowering and fruiting of species (Pérez-Ramos et al., 2020).

Conservation of rare and endangered plant species must necessarily include the preservation of their habitats. Analysis of rare steppe plant communities in Ukraine shows that degradation of their habitats is as threatening to these species as the extinction of the

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species themselves (Dubuna et al., 2023). Such conclusions are made on the basis of studies on the conservation of endangered herbaceous plant communities, where the survival of these plant species depends on the preservation of their local plant communities (Chusova et al., 2022). Thus, conservation efforts should be directed not only at individual species under threat of extinction, but also at the preservation of their local habitats, conditions for natural renewal and population viability.

The ability to maintain ecological connectivity is an integral part of the process resulting from the movement of species' ranges and changes in their climatically favorable environment. According to Lawlor et al. (2024), the movement of species to new territories depends on the species' ability to settle, the availability of suitable sites for growth in the new environment, and the degree of landscape connectivity of this new territory.

The response of plants to such changes may be different, since the shift in their distribution ranges depends on the functional characteristics of different plant species, their ecological plasticity, and their ability to colonize new biotopes (Madsen-Hepp et al., 2023). Each of these factors can affect the development and management of protected areas in Ukraine, since NPAs should take into account both the current distribution of plant species and the possible change in their habitats in the future.

The control of invasive plant species in these protected areas, as well as the consideration of the risks of forest fires and droughts, should be included in the current management plan for these areas. Many invasive species tend to establish themselves in degraded areas of ecosystems, indicating the need to control such species (Marangi et al., 2020). Under climate change, some invasive plant species will expand their potential distribution ranges, colonizing new habitats and changing the competitive relationships between local plant communities (Rockwell-Postel et al., 2020). In addition, the risk of forest fires, droughts and damaged ecosystems in these protected areas may require the use of remote sensing methods for the management of these areas (Drozd et al., 2025).

Thus, the results of the theoretical analysis showed that for adaptive conservation of phytodiversity, a combination of different directions of action is possible: protection of plant species, protection of biotopes, preservation of ecosystem connectivity, control of invasive plants and planning of actions in the field of nature conservation. Such an arrangement of directions of action makes it possible to transition from territory protection to ecological management, which is able to respond to the emergence of problems caused by climate change, as well as take into account biological indicators of the state of phytodiversity: population viability, phenological changes, natural renewal, phytocenotic structure and stability of biotopes.

6. Discussion

The results of the theoretical analysis confirm the need to isolate and prioritize the conservation of plant biodiversity in the National Parks of Ukraine. Threats that cause the degradation of plant biodiversity are changes in temperature and humidity, drought, fires, degradation of biotopes, displacement of species ranges, spread of invasive plant species and loss of ecosystem connectivity.

These factors affect biotopes not only in terms of their area and condition, but also in terms of the viability of populations, natural renewal processes, and the structure of

biotope groups. The conclusion corresponds to the approach that assesses the effectiveness of nature conservation areas in terms of their ability to restore biodiversity, perform climatic and ecosystem functions (Arneth et al., 2023).

The generalization of threats caused by climate change indicates that they affect not only individual types of biodiversity, but also the ecosystems in which they exist. Climate change affects plant diversity in NNPs (Mina et al., 2021).

Other evidence indicating the impact of climate change on plant biodiversity in NNPs of Ukraine is provided by data on climate-induced changes in the composition of plant communities (Feeley et al., 2020). Assessment of the state of plant biodiversity in NNPs should include determining the state of their biotopes, communities, populations, reproductive activity and natural renewal of plants.

The impact of climate change is reflected not only in the reduction of species diversity, but also in the loss of ecological niches, changes in phenological rhythms and a decrease in the stability of plant communities. The scientific work of Mina et al. (2021) notes the impact of climate change on plant diversity, which is confirmed by the results of a study of Ukrainian NNPs.

This threat is confirmed by evidence of the impact of climate change on the composition of communities (Feeley et al., 2020). Phenological shifts, accompanied by changes in the timing of flowering, fruiting or reproductive processes, can distort the interaction between species and phytocenoses (Pérez-Ramos et al., 2020). The study of phytodiversity in NNPs should include information not only on the floristic composition, but also on the population and phytocenotic levels of its organization.

Threats to plant communities are droughts and fires. The impact of such factors on biotopes leads to their degradation. The threat of droughts causes water stress, reduced plant viability and impaired seed renewal, while the threat of fires leads to damage to vegetation cover, seed banks and undergrowth.

The increasing threat of fires under climate change necessitates the development of measures to reduce such impacts (Dupuy et al., 2020). Data on how seeds and plant growth traits respond to changes in climatic conditions confirm the need to take into account the regenerative potential of these plant species when planning the phytoremediation process for conservation (Everingham et al., 2021). An important conclusion is that such threats should be included in the conservation planning of NNPs as factors that directly affect plant communities.

The identification of vulnerable components of phytodiversity requires a transition from the concept of separate species protection to a population-biotope and ecosystem approach. In addition to rare, endemic, relict and Red Book species that require priority attention within conservation programs, it is important to study the ecosystem aspect of their conservation. The rare component of biota plays a role in establishing areas of high conservation value (Rizun et al., 2024).

The ecosystem component of vascular plant protection of different levels of protection was studied by Sverdlov & Karpenko (2024). For rare plant species, the combined threat is especially dangerous, since climatic factors can exacerbate the consequences of habitat fragmentation, population reduction and inability to natural recovery (Bernardo et al., 2020). The priority of the National Parks of Ukraine should be

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not only the conservation of species, but also the biotopes without which they cannot exist.

When studying the role of NPPs as centers of phytodiversity conservation, it is advisable to consider such examples as the NPP "Karmelyukovo Podillya", where the significance of the park as an element of the national ecosystem network is determined (Mudrak et al., 2024). Isolated nature conservation areas may lose their ability to support stable plant populations if climatically suitable habitats shift beyond their boundaries. The need for nature conservation areas to respond to climate change has been established in scientific studies by Elsen et al. (2020). The need for a correct analysis of climate-induced species range shifts is substantiated by Taheri et al. (2021), which confirms the importance of ecological connectivity, ecocorridors and buffer zones for adaptive conservation of phytodiversity. At the same time, the heterogeneity of range shifts depends on the functional characteristics of plants, their ecological plasticity and ability to settle (Madsen-Hepp et al., 2023).

In the current literature, there is a contradiction between the need to expand conservation objectives and their actual effectiveness. The need to expand climate policy objectives is justified by Roberts et al. (2020), but the existence of protected areas necessary to achieve such objectives does not guarantee the possibility of an appropriate response to climate change (Elsen et al., 2020). For NPAs, this means that legal status and area are necessary, but not sufficient conditions for the conservation of plant biodiversity. The condition of biotopes, the presence of microhabitats, the population viability of certain species, their ability to recover and maintain biodiversity in ecosystems are also equally important.

The developed directions of adaptive conservation can be attributed to approaches in which the quality of management and biologically based monitoring play an important role. Indications of the need to improve the quality of coordinated management of NNPs reinforce the feasibility of climate-oriented monitoring, habitat restoration, invasive plant control and updating management plans (Kearney et al., 2020). An important aspect is also the conclusions arising from the study of the experience of other countries of the world: Shershun (2024) pointed out the need to improve NNP management.

There are separate directions for the control of invasive plants. Special management tools are needed to meet the requirements for the control of invasive species in the territories of nature conservation objects (Marangi et al., 2020). In response to climate change, invasive plant species may expand their potential ranges, colonize areas not intended for their presence, and disrupt relationships between native plant species in these areas (Rockwell-Postel et al., 2020). Therefore, control of these invasive species should be considered as part of preserving the diversity of flora in the affected regions (Rockwell-Postel et al., 2020).

The Ukrainian context is further complicated by the impact of war and anthropogenic factors. Military actions create additional pressure on protected areas in Southern Ukraine, which necessitates the need to take into account military risks when assessing the state of ecosystems (Horoshkova et al., 2025). At the same time, the importance of ecosystem condition for the restoration of biodiversity in natural ecosystems of Ukraine is emphasized by Vakal et al. (2025), which confirms the feasibility

of combining climate-oriented monitoring with the assessment of habitat disturbance and the restoration potential of natural areas. Such an assessment should take into account not only the total area of restoration, but also the state of vegetation cover, undergrowth, populations of rare species that are part of the communities, as well as the ability to restore.

The results obtained are consistent with international experience in adapting protected areas to climate change. In particular, the European Union's Natura 2000 network emphasizes maintaining ecological connectivity and monitoring climate-sensitive species, which coincides with our proposed priority areas. At the same time, Ukrainian national parks face specific challenges that are not typical for most European sites: limited funding, insufficient technical equipment, and direct and indirect consequences of military operations. Compared with the experience of the United States, where significant attention is paid to modeling climate refugia and active forest management, Ukrainian parks are only beginning to integrate such approaches. Thus, the proposed adaptive conservation system combines universal principles with regional specificity, which increases its practical value for Ukraine and creates opportunities for adaptation to other countries with similar environmental and socio-economic conditions.

The practical significance of the results lies in the possibility of using the established directions to update the management plans of the NPP. The broader climate-regulating role of nature reserves is revealed by Duncanson et al. (2023), and the need for ecological analysis of forest ecosystems of the forest-steppe is substantiated by Beregniak et al. (2023). Therefore, the management of the NPP should take into account not only the floristic composition, but also the functional state of forest, steppe, meadow, swamp and coastal biotopes, in particular their ability to support plant life cycles, natural renewal and stability of plant communities.

The limitations of the study are related to its theoretical and analytical nature. The work did not conduct field surveys, statistical processing of population data or modeling of habitat changes. Therefore, the conclusions obtained are conceptual in nature and require empirical verification through field surveys in different national parks. Local manifestations of climate threats and the response of phytobiota can differ significantly depending on the natural zone (Polissya, Forest-steppe, Steppe), flora composition, types of biotopes and the level of anthropogenic load. Therefore, future studies should include a comparative quantitative analysis of population parameters, phenological changes and dynamics of the state of biotopes in a network of permanent sample plots in different parks. Only such a spatially distributed empirical basis will allow us to assess how universal or, conversely, locally specific the proposed adaptive measures are.

Further research should be directed at creating a system of long-term ecological monitoring on permanent trial plots in various national parks of Ukraine. This will allow tracking population dynamics, phenological shifts and changes in phytocenotic structure. Spatial modeling of biotope suitability under different climate scenarios will allow predicting the future distribution of rare species and identifying potential climatic refugia. Integration of remote sensing data (satellite vegetation indices, aerial photography) with ground measurements of biological indicators of populations will provide an objective assessment of the effectiveness of adaptive measures. Comparative studies between parks of different natural zones will contribute to identifying the most effective strategies for

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preserving phytodiversity and forming an evidence base for improving environmental planning.

Thus, the results of the study confirm that the preservation of plant biodiversity in the NPPs of Ukraine in the conditions of climate change requires an adaptive model of environmental management. Such a model should combine the protection of rare and vulnerable species, maintenance of biotopes, control of invasive plants, consideration of drought and fire risks, preservation of ecological connectivity and updating of management plans, as well as assessment of biological indicators of phytodiversity: population viability, phenological changes, natural renewal, functional state of biotopes, and structure of plant communities.

7. Conclusions

The theoretical analysis showed that the preservation of plant biodiversity in national natural parks of Ukraine under climate change requires not only maintaining the current protection status of the territories, but also a transition to adaptive nature conservation management focused on the species, population, phytocenotic and biotope levels of phytodiversity organization. Climatically determined threats form an interconnected system of influences: a change in the temperature and humidity regime increases the risks of droughts and fires, contributes to the degradation of biotopes, the displacement of habitats, the spread of invasive plants and the loss of ecological connectivity, and also disrupts phenological processes, natural renewal and viability of plant populations. The scientific novelty of the study is that these risks are summarized within a single analytical logic that combines phytodiversity, national natural parks of Ukraine and climate-induced transformation of the conditions of existence of plant species and groups, taking into account the biological mechanisms of their vulnerability. It was established that priority objects of protection should be not only rare, endemic, relict and Red Book plants, but also biotopes that ensure their viability, reproduction, seed or vegetative renewal, in particular steppe, grass, swamp, coastal and forest groups. National natural parks can serve as centers of phytodiversity conservation and potential climatic refugia, but the effectiveness of this role depends on the state of biotopes, spatial connectivity and the ability of management to respond to environmental risks in a timely manner, preserving population stability and phytocenotic structure of plant groups. The practical significance of the results lies in the possibility of their use when updating management plans for national natural parks, organizing climate-oriented flora monitoring, controlling invasive plants, maintaining ecological connectivity, taking into account the risks of fires and droughts, and restoring degraded biotopes, as well as for assessing the state of populations, phenological changes, natural renewal, and functional state of plant communities.

For the practical implementation of the developed directions, three priority steps are:

1) urgent creation of a unified system of climate-oriented monitoring of phytodiversity with mandatory recording of population indicators, phenological phases, spread of invasive species and the state of biotopes;

2) legal and planning consolidation of measures to maintain ecological connectivity in regional eco-network schemes and land use plans;

3) targeted strengthening of the human and technical potential of national park administrations to master modern adaptive management tools, in particular GIS analysis and remote sensing.

It is advisable to assess the effectiveness of the implemented measures according to the following criteria: annual dynamics of biodiversity indices, percentage of areas with a positive trend in vegetation cover restoration, number of localities of rare species with stable population numbers, as well as reduction of areas affected by invasive plants. These indicators will allow nature reserve management bodies to systematically assess the effectiveness of adaptive measures and timely adjust park management plans.

The limitation of the work is its theoretical and analytical nature, since the conclusions were formed without own field monitoring, statistical analysis of populations and modeling of future habitats. Therefore, further research should be directed to field verification of the proposed directions, assessment of the dynamics of rare plants, modeling of habitat shifts and identification of territories capable of performing the function of climatic refugia in the national ecological network of Ukraine.

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