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VULNERABILITY AND ADAPTATION OF PROTECTED AREAS TO CLIMATE CHANGES: CASE STUDY OF NATIONAL NATURAL PARKS IN UKRAINE

The observed trends of climate changes are strong enough to affect the living process in natural communities. This paper deals with the assessment of vulnerability and progress of National Natural Parks of Ukraine towards adaptation of their ecosystems to growing pressure of climate change. The vulnerability of the National Natural Parks to the effects of climate changes depends on their sensitivity, formed due to intrinsic attributes, like level of endemism and specific microclimate conditions at certain area. From the other side, some managerial solutions framed into the action plan for assisted climate adaptation of protected areas is also the factor of vulnerability or resilience. The assessment undertaken in the given paper addresses both components. At the first stage, the signs of climate changes at 51 parks of Ukraine (excluding those created less than 3 years ago) were studied based on the data from open sources, reports to the authorities and personal feedbacks from the staff. Then these data were summarized in terms of natural zones and generalized to define the most profound effects observed. Finally, the information about the presence and implementation of adaptation measures in the National Natural Parks was collected and evaluated as contributor to building adaptation capacity of the sites. Sensitivity and adaptation potential were rated using standard scale and the level of vulnerability was assigned to each park. The results showed varied level of vulnerability with the natural parks of the Steppe and Ukrainian Carpathians region demonstrating the highest levels. The research has also revealed generally low level of attention to the issues of climate changes on the whole and adaptation strategies implementation in particular in the activity of the National Natural Parks. However, some of the objects have already entered succession processes and diversity transformations. The most well studied issue is invasions, which are also the most covered by the countermeasures. Considering the uniqueness and high value of the ecosystems of the National Natural Parks of Ukraine, it is necessary to develop and implement action plans for the adaptation of these protected areas. At the same time, the problems typical for different natural parks are often specific due to attribution to certain natural zones, composition of communities, physical features of the territory and other properties, and therefore the creation of a universal adaptation procedure is complicated. Nevertheless, the article sets the main directions of work, which can become the basis of the corresponding adaptation plans of all parks.

Keywords: climate change sensitivity; natural zones; protected areas; resilience of ecosystems; vulnerability assessment.

Introduction / Вступ

Protected areas are foundation for the preservation of species diversity, providing them with protection from threats and overexploitation, as well preventing complete destruction of habitats. Total number of protected areas worldwide has already overcome the mark of 200.000 and cover over 15 % of the land area [21]. However, researches argue that this area must be doubled in order to keep the biosphere as diverse as it is at least at the given time frame. At the same time, protected areas and their diversity are under constant pressure of urban sprawl, expansion of agriculture and environment pollution. Given that the protected status will help with keeping these threats away, there are global issues, which protected areas cannot be protected from. And one of the most urgent among them is climate change.

The *National Natural Park* (NNP) is a category of nature reserve fund in Ukraine, which includes intact biodiverse natural ecosystems of high value. NPPs are the state owned entities and their number was gradually increasing since the Independence of Ukraine. Currently, the total number of those is 55, and their total area is over 1 1000 km^2 or 1.84 % of the country territory.

Predicting the consequences of climate changes for NPPs is factor of their thriving, which in turn is the measure of the success-failure for the whole task of nature conservation in the country [11, 19]. Since they all were created in order to preserve the most valuable and typical ecosystems, loss of such sites is an irreparable harm to the whole system of nature protection due to loss of species and breach of na-

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tural corridors integrity. However, global climate changes outlook gives minimal information about the real local and regional level effects, which calls for detailed research at the level of protected areas as focus entities [4, 9, 13].

The research works considering climate change implications for the protected areas are already available for a variety of regions, scattered around the world, including China [21], the Himalaya [1], USA and Canada [3], Thailand [18], Great Britain [6] and the whole Europe [16]. Such limited coverage of detailed studies cannot provide sufficient information for decision making process related to the improvement of the conservation efficiency at the level of other national jurisdictions and global research works like [11] cannot fill this gap. Thus, a national view of the climate change effects on individual protected areas is necessary for any country, seeking to achieve its conservation goals in the changing world.

Object of research is the interactions in the system climate change – natural ecosystems.

Subject of research is the vulnerability and assisted adaptation of protected areas to climate changes.

The *purpose of research* is to evaluate the level of the intrinsic vulnerability of ecosystems within the NPP of Ukraine to the effects of climate changes and the ongoing efforts on their adaptation from the management of these protected areas.

To achieve this purpose, the following main *research objectives* are identified:

- analyze the trends of climate changes valid for the natural zones of Ukraine and determine those, which are potentially the most threatening to the NPPs;
- define the components of vulnerability for comprehensive evaluation;
- evaluate the level of vulnerability of natural ecosystems within the NPPs;
- determine the level of adaptation policies development and implementation for the NPPs and evaluate their adaptation capacity based on the actions taken.

Analysis of recent research and publications. Vulnerability in modern research fields is a concept stemming primarily from the study of disasters [10]. But in terms of climate changes the disaster is progressing slowly and often unnoticed, and combined with the lack of analogues complicates assessments and predictions. Furthermore, vulnerability to climate changes is interpreted in a variety of ways, distinct in the scope of issues, and this affects approaches to its assessment [20].

In a landmark paper O'Brien et al. discuss that modern literature on climate changes interpret vulnerability within two distinct frameworks – 'outcome vulnerability' and 'contextual vulnerability', linked respectively to a scientific framing and a human-security framing [17]. As such they should not be considered interchangeably, rather they complement each other and yield different adaptation approaches. In order to address this imbalance on the way to adaptation, we offer to separate two components for further analysis – effects of climate change, which proceed via three stages, and the corresponding processes initiated by these effects in natural communities (Figure 1). The intensity and efficiency of these processes form the vulnerability of natural ecosystem in the face of climate change.

The simplest definition states that vulnerability is the property or predisposition to be adversely affected [5, 24]. The same definition is a starting point for all related concepts of the Intergovernmental Panel on Climate Change, according to IPCC Glossary (2014). At the same time vulnerability can be considered as a process, rather than attribute, and as such it is affected by a variety of factors, including social and economic [23].

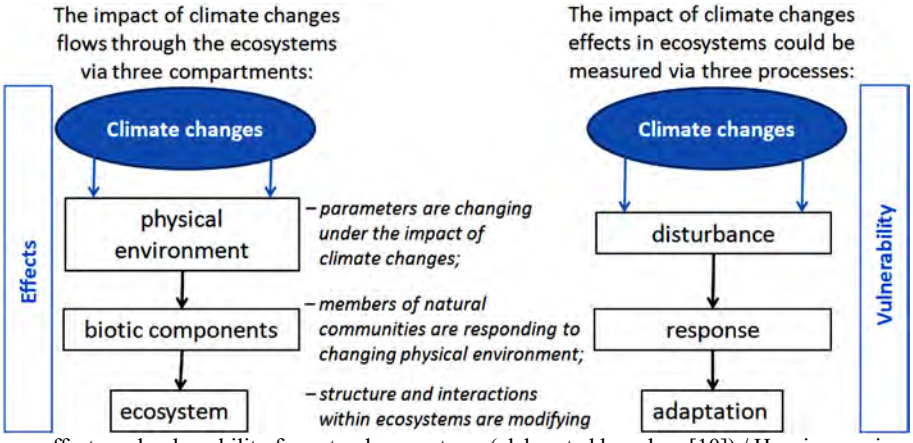

Figure 1. Climate change effects and vulnerability for natural ecosystems (elaborated based on [10]) / Наслідки зміни клімату та вразливість природних екосистем (розроблено на підставі [10])

Finally, vulnerability is seen as a function of exposure, sensitivity and adaptive capacity [12]. In other words, vulnerability appears due to inability to adapt to climate change effects. With this definition one should approach the study of vulnerability as assessing the vulnerability of selected variables to specific stressors [14]. And consequently, vulnerability is not opposite to resilience; rather it is a system in which balance could be shifted to either side [7].

After all, vulnerability assessment is an analysis that determines the nature and degree of risk through the analysis of potential threats and vulnerability assessment, which may pose a potential threat or damage to the environment on which they depend.

Since there is now widely accepted concept vulnerability, the methodology for their assessment is a separate issue. Many international agencies have developed their own assessments methods and implement them successfully. The basic methods employed in open access works include computer-based modeling, GIS, expert assessment, etc.

Some authors suggest differentiating climate impact assessment, vulnerability assessment, and adaptation policy assessment [8]. The vulnerability assessment methods are also evolving and transform towards progressive inclusion of non-climatic drivers of vulnerability to climate change and attempting to reduce the expected damages instead of purely calculating it.

Meta-analysis of the existing research results, which included methodology description, demonstrated that there are nine critical elements in vulnerability assessments: the coupled human-environment system and site-specific analysis; key components of vulnerability; multiple perturbations; scales of analysis; causal structures of vulnerability; engaging stakeholders; differential vulnerability; historical and prospective analysis; and dealing with uncertainty [22]. To certain extent they are all contributing to high quality of integrated vulnerability assessment in climate change research and help overcome traditional limitations of the given set of methods.

Methods and materials. The assessment involved the analysis of the major components of vulnerability in their application to National Natural Parks:

- *Exposure* – climate change impacts, having most prominent effect on NPP. They were defined based on the trends set for the territory of Ukraine, which have high agreement and robust evidence from the research works by major international agencies (IPCC, UNEP, etc.) and research groups.
- *Sensitivity* – responsive changes in ecosystem – expected due to attributes of NPP and observed based on the available data. The evaluation was obtained by scoring the properties of NPP, having importance for the depth of transformations induced by climate changes in natural communities. The information about observed changes was derived from open sources, websites of NPPs and their staff.
- *Adaptive capacity* – available managerial preparedness and self-regulation potential of ecosystems. The assessment was obtained by scoring the possible preconditions of adaptive capacity formation both organizational and natural.

The central idea of the assessment is that Sensitivity is mostly conditioned by intrinsic properties of ecosystems, while Adaptation potential is formed by natural preconditions, but shaped by external factors and has context character (Table 1).

At the same time adaptation potential is opposing to sensitivity, in other words greater potential mitigates sensitivity. To account this fact sensitivity and adaptation were rated in opposite directions: higher rating of sensitivity means higher vulnerability and the lower the rating of adaptation potential is the less it contributes to the NPP's vulnerability.

Table 1. Factors of assessment / Фактори оцінювання

Sensitivity factors	Adaptation potential factors
– level of endemism; – distinctive character of physical conditions due to relief or hydrology peculiarities; – level of competition and ecological niches partitioning; – amplitude of normal temperature and precipitations fluctuations and average plasticity of species; – presence and abundance of keystone species; – level of contrast to the typical communities of the area.	– total area of community; – level of biodiversity; – share of territory, transformed by human activity; – development and implementation of adaptation plan at the NNP; – survey of the display of climate change effects; – correlation between life forms of plants; – intensity of recreation and economic activity.

Thus, each parameter, given in Table 1, was rated for each NPP from 0 to 4 points, accounting the following directions:

- the higher the level of endemism and contrast to the typical communities and physical conditions of the area are, the higher the level of sensitivity is;
- the higher the abundance and diversity of species and life forms, causing increased competition and niches partitioning are, the lower the sensitivity is due to portfolio effect;
- similarly bigger areas of NPPs provide wider ranges of safe habitats and shifting opportunities, thus reducing vulnerability;
- the higher the amplitude of normal temperature and precipitations fluctuations is, the higher the sensitivity is;
- the presence of multiple species with wide tolerance range, as well as presence and stability of keystone species lowers the level of sensitivity;
- any economic activity and intervention not aimed at building resilience increases vulnerability due to possible imbalance of ecosystem: the higher the intensity of NPPs resources use and the area affected are, the higher the vulnerability is.

In the sensitivity assessment all factors were treated as those contributing to vulnerability at certain level and therefore rated with "positive" scores. While some adaptation potential factors (underlined in Table 1) are able to reduce vulnerability actively to some extent and they were rated using "negative" scale from -4 to 0, reflecting the range from the most efficient mitigation to absence of any forms of it in an NPP. Finally, the average values of the scores for the set of sensitivity and adaptation potential parameters were calculated and used in the further evaluation.

The level of climate induced changes observed in ecosystems of an NPP was also rated from 0 to 4 total points, by adding 0.5 point for each of the following phenomena observed: change of physical parameters, change of water tables, invasive species, depression of dominant species, shifting or shrinking of habitats, transformation of communities, erosion activization, and increased incidence of wild fires.

The final rating was calculated as the sum of scores by each category (sensitivity, adaptation potential and level of changes display) and rated as follows:

- 0-3 – vulnerability level 1 (low);
- 4-6 – vulnerability level 2 (moderate);
- 7-9 – vulnerability level 3 (increased);
- 10-12 – vulnerability level 4 (high).

All the components of assessment were assigned equal value and contributed to the final rating in full.

For example, Shatsk NPP was rated with mean score of 3.75 points by sensitivity factors (high level of endemism, peculiar hydrological features, narrow range of normal physical parameters fluctuations, unique wetland communities), and mean score of 2 points by adaptation potential, since its managers observe and report the climate change effects, but still don't have the adaptation plan, and the level of recreational and other economic exploitation is high. By the level of currently observed changes (invasive species, change of water tables, erosion activization, increased incidence of wild fires) is was rated with total scores of 2, thus the final rating of the Shatsk NPP vulnerability is 7.75, which corresponds to high vulnerability.

The sources of information for the assessments included: information available from official webpage, data of regular survey (major – every 5 years, and routine annual) with special focus on climate change effects, research works and staff feedbacks. However, not all parks were characterized by all the mentioned sets of data (Figure 2) and in some cases no information was found. Such cases, rated with "0" on the diagram, were assessed using indirect sources. Lack of information about climate induced changes was considered a factor of vulnerability due to poor

awareness and preparedness and additional 1 point was added to the adaptation potential.

Limitations of the assessment:

1. The assessment was based on the indirect data – not personally observed and measured, rather it was meta-analysis of information available from open sources (research projects, papers and information from web-pages of NPPs.
2. The assessment didn't include parks, which were created less than 3 years ago, because the trends of changes at these areas are not well studied yet. Excluded are: Kholodny Yar (created in 2022), Kuialnytsky (2022), Royal Beskids (2020). Charivna Havan is also not included, since it is located at the territory of Crimea and out of the Ukrainian control since 2014.
3. The sources of information were scarce in some cases and assessments were derived based on the indirect data and evidence from similar localities.

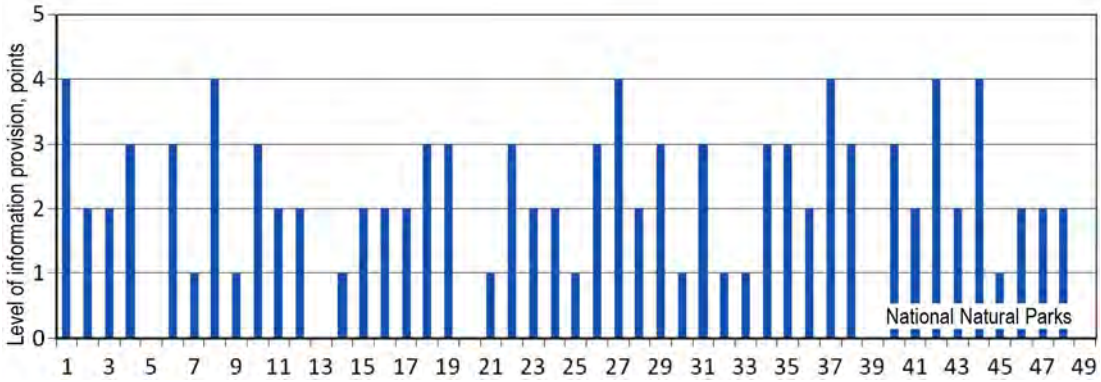

Figure 2. Information provision of the assessment rated from 0 to 4 based on the number of available sources of relevant information (numbers of NPPs correspond to the names given in tables below) / Інформаційне забезпечення процедури оцінювання в балах від 0 до 4 за кількістю доступних джерел відповідної інформації (номери НПП відповідають назвам, наведеним у таблицях нижче)

Research results and their discussion / Результати дослідження та їх обговорення

1. Mixed forest (Polissya) is characterized by extremely wet, wooded and swampy terrain, dense river network, and low population density.

The *major threats* from climate change for the given region are soil and atmospheric dryings in summer, increased precipitations in winter, increased average temperature, and more dramatic fluctuations of water tables in local water systems. The general trend is that natural objects, which include wetlands, are more affected (Table 2). After all, it is known that wetlands disappear three times faster than forests, although their economic and biological value is much higher than that of most terrestrial ecosystems. For example, conservation of swamps is the simplest and most effective measure to mitigate the effects of climate change.

Table 2. Climate change vulnerability of the Mixed forest NPPs / Вразливість НПП зони змішаних лісів до зміни клімату

National Natural Parks	Vulnerability assessment	Display of climate changes
1. Holosiivsky	3 – increased	Drying of trees
2. Derman-Ostroh	3 – increased	Relocation of natural borders between forest and forest steppe areas
3. Zalissia	2 – moderate	Acceleration of successions
4. Mezynskyi	3 – increased	Changes in hydrological regime of oxbow lakes
5. Nobelsky	2 – moderate	–
6. Prypiat-Stokhid	3 – increased	Imbalance in wetlands, drying of spruce
7. Tsumanska Puscha	2 – moderate	Establishment of new species
8. Shatsk	3 – increased	Water table fluctuations
9. Halych	2 – moderate	Depression of aquatic plants communities
10. Northern Podillia	2 – moderate	Threats to boreal plant species

Table 3. Climate change vulnerability of the Forest steppe NPPs / Вразливість НПП зони лісостепу до зміни клімату

National Natural Parks	Vulnerability assessment	Display of climate changes
11. Ichnia	2 – moderate	Change of dominating species in forest plantations
12. Yavorivskyi	2 – moderate	Relocation of natural borders between forest and forest steppe
13. Biloozerskyi	2 – moderate	–
14. Hetman	2 – moderate	Changes in hydrological regime
15. Homilsha Woods	3 – increased	Reduction of floodplain associations
16. Dvorichanskyi	2 – moderate	Intensification of erosive processes
17. Desna-Starohutskyi	3 – increased	Imbalance in wetlands
18. Karmeliukove Podillia	3 – increased	Threat to relic plants and sub-Mediterranean plant associations
19. Kremenets Mountains	3 – increased	Expansion of forest or shrub vegetation, which threatens unique rock hill plant associations
20. Male Polissia	2 – moderate	–
21. Sulynsky	2 – moderate	Imbalance in wetlands
22. Podilski Tovtry	3 – increased	Change in grasses composition
23. Pyriatyn	3 – increased	Imbalance in wetlands
24. Slobozhansky	2 – moderate	Threat to unique wetland plant communities
25. Khotyn	1 – low	–
26. Dniester Canyon	2 – moderate	Threats to unique plant formations on rocky hills

Consequently, the reduction of the area of wetlands has a detrimental effect on thousands of plant and animal species that live in these areas or depend on them. Therefore, our goal is to preserve or reduce anthropogenic impact on meadows, swamps, watercourses and water areas.

2. Forest steppe climate is temperate, usually with moderately hot summers and moderately cool winters.

The *major threats* from climate change are growing continental character of climate, increasing average temperature, change of air circulation, change of correlation between types of precipitations in favor of rains. Typically, objects, which include wooded areas, are more affected, while those with typical landscapes and more cultural importance are less threatened (Table 3).

3. Steppe is almost completely plowed; the remnants of former vegetation are preserved in reserves and partly on the slopes of beams and river valleys. Due to its flat terrain it is very hot in summer and very cold in winter.

The *major threats* from climate change for the given region are irregularity of precipitation patterns and increased rainfall, growing temperatures and intensified evaporation, causing droughts; rising sea level at the coast. The region and its NNP are potentially the most affected by climate changes (Table 4) and the signs of desertification are characteristic attribute of the region.

4. Ukrainian Carpathians are characterized by temperate continental, warm climate, with cyclonic and anticyclone invasions of Atlantic air. The Carpathians are the wettest region in Ukraine: most rain in spring and summer, snow in winter. Snow cover persists until mid-May. The forest cover of the mountains exceeds 50 %.

The *major threats* from climate change for the given region are increased temperature; reduction of precipitations; reduction of snow cover duration and capacity; changes in circulation patterns. Along with steppe ecosystems mountain areas are the most vulnerable due to distinct microclimate and endemism (Table 5). However, these NPP demonstrate higher awareness of the climate change issues. This can also be done by curbing the degradation of natural habitats and preventing the disappearance of rare species of plants and forests, as well as continuing the fight against deforestation of mountain slopes, etc.

Table 4. Climate change vulnerability of the Steppe NPPs / Вразливість НПП зони степів до зміни клімату

National Natural Parks	Vulnerability assessment	Display of climate changes
27. Azov-Syvash	4 – high	Expansion of dessert plants and xerophytes, reduction of steppe communities
28. White Coast of Sviatoslav	4 – high	Reduction of residual forested spots
29. Buzk's Gard	4 – high	Changes in hydrological regime
30. Great Meadow	4 – high	Imbalance in wetlands
31. Dzharylhak NPP	4 – high	Sea level rise
32. Kamyanska Sich	2 – moderate	Longer blooming and arrival of new species
33. Kremenetsky forest	3 – increased	Reduction of wooded area
34. Meotyda	4 – high	Increasing salinity and shrinking of floodplain swamps, estuaries
35. Nyzhniodniprovsky	2 – moderate	Reduction of floodplain forests
36. Nyzhnioosulsky	2 – moderate	–
37. Lower Dniester	2 – moderate	Reduction of estuary vegetation
38. Oleshky Sands	4 – high	Reduction of the of birch groves area
39. Tuzly Lagoons	4 – high	Reduction of estuary communities
40. Pryazovsky	3 – increased	Changes in hydrological regime, desertification

Table 5. Climate change vulnerability of the Ukrainian Carpathians NPPs / Вразливість НПП зони Українських Карпат до зміни клімату

National Natural Parks	Vulnerability assessment	Display of climate changes
41. Boikivschyna	2 – moderate	–
42. Verkhovyna	2 – moderate	Expansion of thermophilic tree species
43. Vyzhnytsia	4 – high	Reduction of meadow plant associations
44. Hutsulshchyna	4 – high	Change of dominant tree species
45. Zacharovanyi Krai	4 – high	Reduction of Primeval Beech Forests
46. Carpathian	4 – high	Reduction of river valley communities and threats to cypress association
47. Synyohora	3 – increased	–
48. Skole Beskids	3 – increased	Reduction of natural forest plantations
49. Synevyr	3 – increased	Changes of aquatic communities
50. Uzhanskyi	4 – high	Reduction of Primeval Beech Forests
51. Cheremosh	3 – increased	–

The aggregated results of the vulnerability assessment revealed that the highest level of vulnerability is set for the Steppe (average level is 3.3 of maximal 4 points) and the Ukrainian Carpathians (average level is 3.1). Forest steppe is represented with the biggest number of NPPs and is evaluated with average level of 2.31, while Mixed forest area is on average the least vulnerable. Since the most important structural elements of vulnerability opposed in Table 1 interact in the process of balancing vulnerability of a natural park, they were plotted in order to demonstrate their contribution to the final level of vulnerability (Figure 3). It is seen from the diagram that while sensitivity varies among the NPPs from the lowest to the highest level, the highest adaptation potential is attributed to none of the parks and most of them are characterized by either low or moderate levels.

A vast study of the vulnerability of protected areas within the Natura 2000 network by Nila et al. has also demonstrated that mountain regions of Europe, in particular, the Alpine area will experience novel climate conditions and pressure of disappearing habitats. At the same time they found that continental and boreal areas will probable demonstrate more consistency, compared to the other biogeographical regions [16].

Highlands and wetland regions were attributed to the high vulnerability category in the survey across England, while most grassland and woodland protected sites were rated as low to medium vulnerable [6].

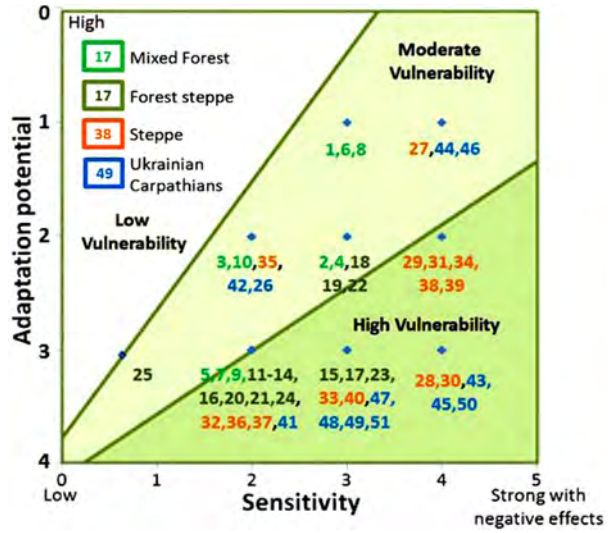

Figure 3. NPPs vulnerability to climate changes in two dimensions / Вразливість НПП до зміни клімату у двох вимірах

As it is important to shift from purely declaring vulnerability to initiating some forms of response, the assisted adaptation effectiveness in the NPPs is considered a keystone factor of NPPs resilience in the face of climate change. However, the analysis of the corresponding activity of NPPs (Figure 4) showed limited attention to the issues and minimal activity towards adaptation of ecosystems.

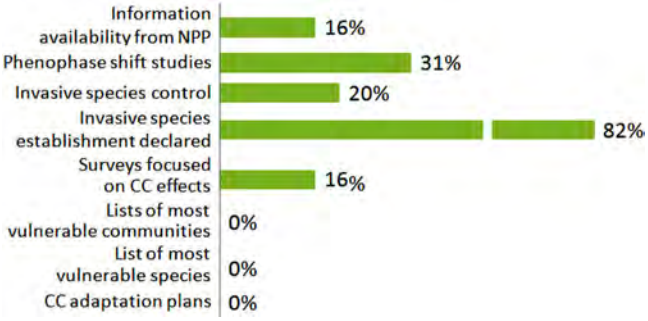

Figure 4. Share of NPPs conducting core actions for building NPPs adaptation potential to climate changes / Частка НПП, які проводять основні заходи з формування потенціалу адаптації НПП до змін клімату

This is notably different from the situation within the protected network of Great Britain, where most of 608 management responses by reserve managers of 61 National Nature Reserves demonstrated some actions implemented aiming the response to climate changes, with only 10 % just starting to consider how to respond to changes which cannot be prevented [6]. However, most of these actions are interventions that aim to build the resilience of the reserves' target features, like the complex of action against introduced species widely applied in Ukrainian NPP. The changes to ways of working and collection of the evidence base are also weak in English protected areas. At the same time adaptation plans of the NPP must look outside the current network of protected areas, since most of the protected areas might be exposed to high rates of climate displacement that could promote important shifts in species abundance or distribution [3]. Under such conditions most scientists consider planning of the refugia network for relocating species and presentation of new climate conditions in the protected network as strategic tasks [2, 15].

So, based on the results of the work performed, it is possible to formulate the following scientific novelty and practical significance of the research.

Scientific novelty of the research is that it represents the first attempt to evaluate the climate change vulnerability of Ukrainian National Natural Parks using a holistic approach to all existing parks.

Practical significance of the research results – the obtained results will help focus attention of the protected areas' managers on the current and upcoming threats to the ecosystems of the National Natural Parks and demonstrate the need to develop and implement adaptation plans specific for each site. It is also an important contribution to the decision-making process when considering the perspective areas for the expansion of the existing and creation of new natural parks in Ukraine.

Conclusions / Висновки

1. Climate change effects are valid for Ukraine as well as other countries. The most prominent effects are changing precipitation patterns, change of seasons, periodicity of weather phenomena and extreme events frequency, sea level rise and of course growing average temperatures. All this factors will have detrimental effect on plant communities.
2. The analysis of National Natural Parks of Ukraine was conducted to assess their vulnerability to climate changes and to define the already displayed effects of climate changes. The assessment of vulnerability was based on the sensitivity and adaptation potential of NPP. The parks were considered in terms of natural zones attribution, since the set of climate change impacts has zonal differences and the most prominent ones were defined for each zone.
3. It was defined that almost all parks are vulnerable to climate change impacts and demonstrate some forms of response to climate changes. Steppe and mountain regions were evaluated as the most sensitive due to natural attributes.
4. The work on building adaptation potential of the NPPS is not well developed in the studied NPPs and lacks consistent and comprehensive measures. The most actively implemented action is the control over invasive species, while other important measures, like definition and monitoring over the most vulnerable species, as well as development of full adaptation plans, haven't started yet.
5. In order to increase the resilience of NNPs in the face of climate change it is necessary to establish long-term survey programs at NNPs to trace any effects caused by this phenomenon in order to develop efficient plans for the protection of biodiversity in Ukraine.

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ВРАЗЛИВІСТЬ ТА АДАПТАЦІЯ ЗАПОВІДНИХ ТЕРИТОРІЙ ДО ЗМІН КЛІМАТУ НА ПРИКЛАДІ НАЦІОНАЛЬНИХ ПРИРОДНИХ ПАРКІВ УКРАЇНИ

Тривалі тенденції зміни клімату є досить сильними, щоб вплинути на життєвий процеси у природних угрупованнях. У цьому дослідженні оцінено вразливість і прогрес Національних природних парків України у напрямку до адаптації їхніх екосистем до зростаючого тиску змін клімату. Вразливість Національних природних парків до наслідків кліматичних змін залежить від їхньої чутливості, сформованої внаслідок внутрішніх ознак, таких як рівень ендемізму та специфічні мікрокліматичні умови на певній території. З іншого боку, чинником уразливості також є наявність або відсутність управлінських рішень, які приймають для сприяння адаптації природоохоронних територій до зміни клімату. Оцінювання стосується обох компонент. На першому етапі вивчено ознаки зміни клімату в 51 парку України (за винятком тих, які було створено менше 5 років тому) на підставі даних з відкритих джерел, звітної документації парків та особистих відгуків співробітників. Далі ці дані згруповано за природними зонами й узагальнено для визначення найбільш виражених та типових наслідків. Окремо зібрано та проаналізовано інформацію про наявність та впровадження адаптаційних заходів у Національних природних парках. Чутливість до кліматичних змін і потенціал адаптації до них оцінювали за стандартною шкалою, і за поєднанням цих оцінок визначали рівень вразливості кожного парку. За результатами оцінювання встановлено, що для природних парків степового регіону та Українських Карпат характерний найвищий рівень вразливості. Виявлено також низький рівень уваги до питань зміни клімату загалом та реалізації стратегій адаптації зокрема в діяльності Національних природних парків. Проте деякі об'єкти вже проявляють ознаки процесів сукцесії та трансформації різноманітності у відповідь на зміну температурного режиму та режиму опадів. Найбільш вивченим питанням, що має стосунок до кліматичних змін, є інвазії, які також найбільш охоплені контрзаходами. Зважаючи на унікальність і високу цінність екосистем Національних природних парків України, потрібно розробити та впровадити плани дій з адаптації цих заповідних територій. При цьому проблеми, типові для різних природних парків, мають певну специфіку, пов'язану з належністю до певних природних зон, складом угруповань, фізичними особливостями території та іншими властивостями, а отже, створення універсального порядку дій є ускладненим. Однак у цьому дослідженні сформульовано основні напрями роботи, які можуть стати основою відповідних адаптаційних планів усіх парків.

Ключові слова: чутливість до зміни клімату; природні зони; природоохоронні території; стійкість екосистем; оцінювання вразливості.