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METHODOLOGY FOR ANALYZING THE TERRITORY OF A NATURE RESERVE AREA FOR THE NEEDS OF ORIENTEERING

Background. Contemporary geographical science is increasingly focused on applied research with practical significance for natural resource management and spatial planning. In this context, analyzing the potential of Nature Reserve Fund (NRF) territories, also known as Protected Areas, for active cognitive and recreational use gains particular urgency and relevance. An increasingly popular activity connected with the geographical environment is Orienteering – a sport that requires participants to navigate an unfamiliar terrain using only a map and compass to complete a course marked by control points in the shortest possible time. Successful and sustainable orienteering activities necessitate several key territorial attributes: diverse and accessible terrain (topography), the availability of accurate cartographic materials, sufficient territory size/area, high natural diversity (vegetation, landscape features), and, crucially, strict adherence to the conservation limitations imposed by the protected status of the area.

Methods. The developed methodology for assessing NRF territories for orienteering suitability comprises the following principal stages: defining specific selection criteria and spatial requirements for suitable territories, balancing sports needs with conservation mandates; comprehensive gathering and analysis of geospatial data on relief (topography), vegetation (forest cover, types), soils, climate, and anthropogenic load (existing recreational pressure); evaluating and mapping environmental limitations and conservation restrictions to identify sensitive zones (e.g., nesting sites, rare plant habitats); developing and updating specialized Orienteering Maps using Geographic Information Systems (GIS), integrating all collected spatial data; and establishing a database of suitable plots and formulating evidence-based recommendations for the optimal organization and design of courses/distances of varying complexity.

Results. A methodology was successfully developed and tested to analyze NRF territories to determine their suitability for orienteering activities. The proposed approach was applied to the Dendrological Park "Oleksandriia" (Bila Tserkva, Ukraine). The analysis highlighted several favorable conditions for this site: convenient geographical location and accessibility, rolling-hilly relief with diverse landscape elements, varied landscape components (forests, meadows, water bodies), well-developed infrastructure, and an extensive trail network. However, the assessment also identified critical constraints related to the park's protected status, including the presence of rare and protected species, a high existing recreational load in certain areas, and the overall NRF status, which demands minimal impact. Based on these findings, specific recommendations were formulated for establishing orienteering courses of varying technical and physical difficulty (e.g., novice, intermediate, and expert). These recommendations emphasize utilizing existing trails where possible and strictly avoiding ecologically sensitive zones.

Conclusions. The methodology has proven its effectiveness in assessing the suitability of NRF territories for orienteering. The territories can be used provided that environmental requirements are met, anthropogenic impact is minimized, and proper planning is carried out. The approach can be applied for further research and practical organization of competitions within the NRF.

Keywords: territory analysis, protected areas, orienteering.

Background

Geographical science is increasingly oriented toward applied research that has practical significance for environmental management and spatial planning. In this context, the analysis of the potential of protected areas as sites for active educational and recreational use is becoming particularly relevant. Orienteering is a sport where participants must navigate unfamiliar terrain as quickly as possible using a map and compass to visit control points – is becoming increasingly connected with the geographical environment (Klapoushchak, 2022). Orienteering requires diverse and accessible terrain, suitable cartographic materials, sufficiently large areas, natural diversity, and compliance with restrictions related to the protected status of the territory.

The aim of the study is to develop a scientifically grounded methodology for analyzing protected areas in order to determine their spatial suitability for the needs of orienteering. The analysis of protected areas for orienteering involves examining the spatial features of the landscape, the morphometric characteristics of the terrain, the land-use structure, the recreational load, accessibility,

and the protection regime. A geoinformation-based approach, combined with landscape analysis methods, enables the comprehensive assessment of areas' suitability for various forms of recreational activity without disrupting ecological balance.

Methods

The use of natural areas for recreational and sports purposes, including orienteering, is interdisciplinary and has been examined in studies across geography, physical education, tourism, and nature conservation. Issues of environmental management, nature protection, and tourism-related and conservation cartography have been addressed by Petryna (2007, 2018) and Popovych (2023). Orienteering as a form of active recreation has been studied primarily in an applied context: Klapoushchak (2022), Hryniuk (2024), Holovashchenko (2023), and Voitovych (2024) analyzed its impact on physical development and health, competition organization, and its role as a recreational activity. The use of protected areas for recreation and tourism was studied by Khshanovska (2023), Nazaruk (2022), and Pavliuk (2023).

Regarding the direct use of protected areas for orienteering, scientific works are limited. Studies by Zihunov

(2015), Kolotukha (2018), and Zarubina (2024) examine issues of organizing competitions in natural environments, particularly in recreational zones and forest areas, and partly within protected areas. These works emphasize the importance of environmental assessment and spatial analysis prior to allowing participants access to conservation landscapes. International research (Celestino, 2015; Lazendorf et al., 2023) focuses on the experience of Scandinavian countries, where orienteering is actively developed in national parks and forest reserves, utilising zoning and restrictions.

However, most studies lack a systematic geographical approach to analyzing the suitability of protected areas, specifically in the context of orienteering. The development of a clear methodology that includes a step-by-step geoinformation-based analysis of physical-geographical characteristics, landscape structure, territorial accessibility, and legal protection regimes remains an important task.

The methodological framework of the study encompasses cartographic methods, geoinformation analysis, morphometric analysis, field research, landscape-geographical analysis, and an examination of nature conservation restrictions.

Results

To determine the suitability of protected areas for orienteering, we developed a research framework that includes the following steps: identifying selection criteria for the territory, collecting and analyzing data, applying the methodology for analyzing protected areas, and obtaining results. The research framework is presented in more detail below (Fig. 1).

The first stage involves identifying the criteria for selecting a suitable territory. One of the key conditions for the effective organization of sports events is the logistical accessibility of the area. This primarily includes convenient transport connections that ensure the arrival of participants, organizers, and technical staff. Priority is given to areas located near road networks. Another important component is the availability of basic infrastructure required for competitions, such as designated start and finish zones, rest and medical assistance areas, water supply, and sanitary facilities.

The geographical characteristics of the territory directly influence the quality and diversity of orienteering courses. One of the fundamental factors is the diversity of relief and vegetation cover. Areas that combine forested sections, open spaces, slopes, and water bodies create favorable conditions for designing dynamic courses. At the same time, the ability to create courses of varying difficulty helps engage a wide range of participants (from schoolchildren and amateurs to professional athletes), contributing to the development of both technically challenging and educationally rich routes.

Given the protected status of PAs, ecological responsibility is a mandatory criterion. First, it is essential to ensure the preservation of natural complexes, prevent disturbance to the habitats of rare and endemic species, and avoid interference with ecosystem processes. Second, minimizing anthropogenic impact is critical. This requires clear zoning of the courses and avoiding areas with special conservation status. Environmental monitoring can serve as a mechanism for assessing the impact of competitions. Its purpose is to ensure the preservation of natural complexes, prevent ecosystem degradation, and minimize human impact on valuable areas. Environmental monitoring makes the process of organizing orienteering more responsible and aligned with sustainable development principles.

The criterion of participant safety is particularly important – an integral component of organizing orienteering in natural

conditions. Potential hazards must be identified, such as swampy areas, impassable or difficult vegetation, poisonous plants, polluted territories, or unexploded ordnance. A detailed analysis of possible evacuation routes and methods for delivering medical aid is required. Planning additional evacuation routes is essential. The quality of mobile network coverage across the territory must be assessed to ensure rapid communication in emergencies. Considering the martial law in Ukraine and possible air-raid alerts, the availability of a shelter within walking distance is a necessary requirement for holding orienteering competitions.

The next stage involves the comprehensive collection and analysis of information about the territory under evaluation – its characteristics, legal status, and suitability for orienteering use. To ensure high accuracy of spatial analysis and cartographic modelling, it is necessary to collect and process topographic maps of various scales (1 : 10,000; 1 : 25,000; 1 : 50,000), aerial photographs, and satellite data (e.g., Google Earth). Remote sensing data help update information about the spatial structure of the area, including types of land cover (forests, water bodies, open spaces). The next step involves digitizing, georeferencing, and vectorizing cartographic materials to create digital terrain models.

For a preliminary assessment of whether PAs can be used for orienteering – considering existing ecological restrictions and protection regimes – it is important to analyze cadastral maps and land-use schemes to identify boundaries, determine legal status, and establish zoning in accordance with conservation legislation. Additionally, boundaries of protected areas must be identified using state registries and cadastral documents, and legal norms governing the use of such territories for sports events must be examined. If a prohibition on holding sports events within a PA is identified, the area is classified as "unsuitable" in the list of potential locations.

A key stage in selecting a territory for competitions is conducting a scientific field expedition, as it enables direct examination of the area, verification of cartographic data, and assessment of both natural and anthropogenic factors that affect route safety and passability. During fieldwork, researchers examine relief features, vegetation types, water obstacles, forest density, and passability, among other factors. Alongside natural factors, the expedition allows for the assessment of regional infrastructure, the accessibility of transport routes, the feasibility of arranging start and finish zones, and suitable locations for judges and spectators. Ecological restrictions associated with PAs are also visually assessed, including the presence of strictly protected zones, areas prohibited for visitation, or habitats of Red List species that may be affected by the event.

Landscape analysis serves as the basis for identifying the physical and geographical characteristics of the area in relation to orienteering competitions. Relief determines the morphometric complexity of the terrain and greatly affects tactical decisions during orienteering. Complex relief, featuring hills, ravines, and valleys, provides natural reference points and enhances cognitive engagement, while also increasing the physical demands of the course. The optimal terrain for orienteering is rolling or dissected relief with significant elevation changes.

The presence of water bodies (rivers, streams, swamps, lakes, ponds) is an important spatial reference, but must be considered carefully from a safety perspective. The hydrographic network affects route passability and creates natural barriers; swampy areas or flood zones can complicate movement and require the design of alternative routes.

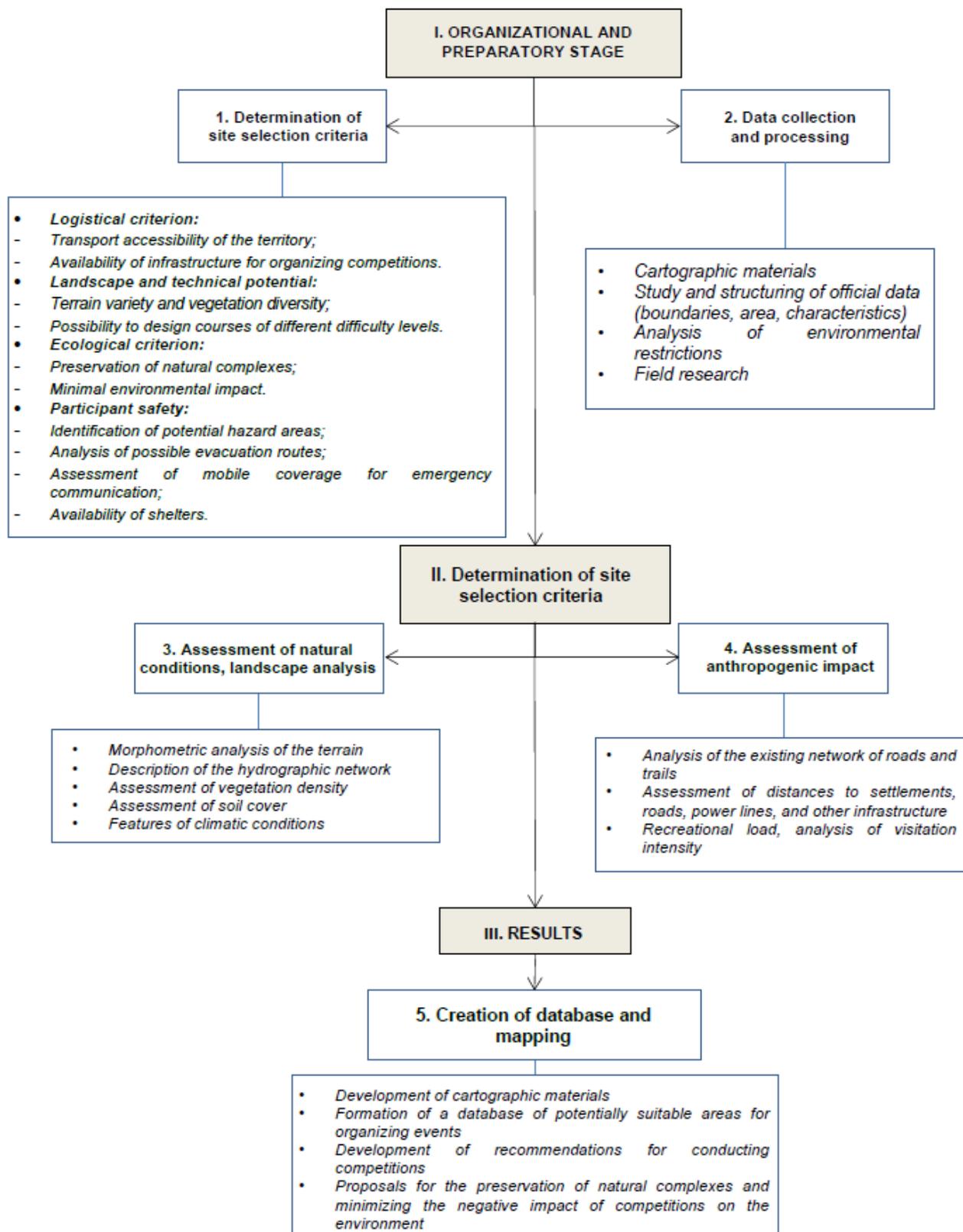


Fig. 1. Diagram of the methodology for analyzing the territory of a nature reserve area for orienteering purposes

Regarding vegetation, the type and density of plant cover significantly influence the terrain's passability. The vegetation of protected areas plays a dual role in the context of orienteering. On the one hand, it determines passability, visibility of reference points, and the physical load on

participants; on the other hand, it represents a component of conservation value that requires special attention when planning the course. Areas with dense undergrowth, thick shrubs, or young tree plantations substantially reduce movement speed, create obstacles for navigation, and

hinder visual contact with natural landmarks. Ideal areas include mixed or deciduous open forests with moderate canopy density, as well as glades and open spaces.

However, a particular challenge is the need to preserve rare plant species characteristic of many protected areas. Such territories may contain species listed in the Red Book of Ukraine or regional lists of rare plants. Therefore, any intervention in natural complexes containing rare species must be minimized. In this context, it is advisable to conduct preliminary botanical surveys, coordinate activities with PA administration, and use non-invasive forms of course marking that do not damage vegetation.

Soil type analysis enables the prediction of an area's resistance to mechanical impact and the identification of any necessary access restrictions. Generally favorable are sod-podzolic and chernozem soils with well-drained structures that provide stable surface traction. Peatlands, sandy soils, waterlogged areas, or slopes with loose material present potential hazards.

Climate determines the seasonal suitability of an area for sporting events. The main criteria include average temperature, precipitation levels, air humidity, and the likelihood of extreme weather events such as storms, fog, or thunderstorms. Analyzing meteorological conditions makes it possible to forecast the physical load on participants and develop safety and logistics measures.

Assessing anthropogenic pressure on protected areas is a crucial step in selecting sites for competitions. Existing networks of roads, tourist trails, or former service routes can serve as the basis for a portion of the course or logistical infrastructure (start/finish zones, access roads). It is recommended to use existing paths with minimal disturbance to new natural areas. Evaluating the distance to settlements, roads, power lines, and other infrastructure significantly simplifies event logistics. However, a balanced approach is necessary – between accessibility and maintaining the isolation regime of PAs. For example, a high concentration of infrastructure objects such as warehouses, farms, or power lines may reduce recreational attractiveness and increase risks, whereas a complete absence of infrastructure may limit access.

Assessing the intensity of recreational use helps determine the level of existing anthropogenic pressure and whether a sporting event might exceed acceptable limits. This assessment should include data on visitor numbers, the presence of campsites, previously established trails, etc.

The final stage is creating a database and performing cartographic visualization, integrating cartographic, statistical, and analytical data to provide a basis for decision-making, planning, and organizing events in accordance with conservation regulations. Mapping should be performed using GIS technologies that integrate data on relief, vegetation, hydrography, soil cover, and other natural components. Specialized maps of various scales are developed, from overview maps to detailed orienteering maps. Special attention should be given to accurately depicting small features critical for orienteers, such as paths, ravines, fences, and point objects.

To systematize information about areas suitable for orienteering, a database should be developed that includes geographic coordinates, physical-geographical characteristics, levels of anthropogenic impact, protection status, recreational potential, accessibility, and cartographic materials. Based on database analysis and cartographic outputs, scientifically grounded recommendations are developed for organizing competitions. These concerns include selecting optimal areas, determining courses of

various difficulty levels, positioning start/finish zones, planning access logistics, and ensuring participant safety.

Additionally, it is necessary to consider conservation regulations governing permitted activities in protected areas. All sports events within PAs must comply with ecological safety principles. Therefore, during event preparation, measures are proposed to preserve natural complexes, including limiting the use of areas with rare plants and vulnerable ecosystems, as well as controlling recreational loads. In this way, orienteering can combine recreational functions with educational and conservation objectives.

Using the proposed methodology, we consider the state Dendrological park "Oleksandriya" of the NAS of Ukraine (Table 1).

Recommendations for Organizing Orienteering Competitions in the Oleksandriya Dendrological Park:

1. Design courses that avoid, as much as possible, areas containing rare and ornamental plant species.
2. Exclude territories with dense vegetation and areas of high ecological value.
3. Use open park areas and alleys for beginner-level courses and children's competitions.
4. Include zones with denser vegetation and slopes leading to water bodies for intermediate-level courses.
5. Utilize the mosaic structure of the landscape to create diverse orienteering challenges for experienced participants.
6. Ensure the marking of hazardous areas (steep slopes, marshy sections, water bodies).
7. Develop evacuation routes with consideration of the existing trail network.
8. Install communication points at key sections of the course.
9. Use the park's location within the city to provide convenient access for participants and spectators.
10. Set up the start/finish area on open sites that will not harm the natural environment.
11. Monitor recreational load during competition events.
12. Implement temporary restrictions on visiting certain parts of the park after events to allow natural complexes to recover.
13. Use only temporary and environmentally safe course markings.

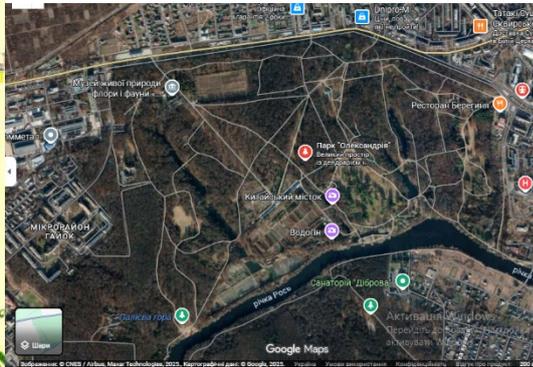
Discussion and conclusions

Thus, the Oleksandriya Dendrological Park has significant potential for use in orienteering activities. The combination of a relatively flat relief with local slopes toward the Ros River and artificial ponds creates optimal conditions for designing courses of various difficulty levels. The mosaic variation in terrain passability provides route diversity, which is an essential prerequisite for conducting training and competitions of different categories. At the same time, the territory is subject to environmental restrictions due to its status as a protected area. The presence of rare plant species requires that course design account for ecological criteria and minimize anthropogenic impact. A positive factor is the developed network of roads and paths, as well as the park's location within a populated area, which simplifies logistics and ensures the necessary level of safety.

The results of the conducted study confirm the feasibility of applying a comprehensive methodology for analyzing protected areas for the purposes of orienteering. The proposed approach integrates geographical, ecological, and sport-practical aspects to provide an objective assessment of the suitability of territories for organizing competitions.

Table 1

Example of Applying the Proposed Methodology to the Dendrological Park "Oleksandriya"

1	<p>Criteria for site selection</p>
	<ul style="list-style-type: none"> • The park is located in Bila Tserkva, 80 km from Kyiv, and has convenient transport accessibility (highways, railway). The infrastructure is well developed: there are entrances, ticket offices, tourist routes, and the territory is maintained by the administration. There is a possibility to organize and conduct orienteering events. • The relief of the dendrological park is characterized by general flatness with slight undulation and gentle slopes descending toward the valley of the Ros River and a system of artificial ponds. This surface morphology creates favorable conditions for designing courses of varying complexity, providing both accessibility and a variety of terrain features. Tree plantations are structured in alleys, forming areas with different densities and levels of passability. The area of the park (400.67 ha) allows for the design of courses of various lengths and difficulty levels. Courses can be set both in park zones and in more densely vegetated parts of the territory. • The park has the status of a protected area, with rare and exotic plant species preserved within its boundaries. Therefore, organizing competitions requires clear zoning – the courses should avoid areas containing vulnerable species. • The territory has a well-developed network of alleys and paths, which makes it possible to plan evacuation routes. Mobile coverage is stable. The dendrological park does not contain basic shelters or specially equipped protective structures. However, its location within the city ensures relative accessibility to civil protection facilities. In particular, near the park, in the Haiok residential area, at a distance of 200–500 m, there are basic shelters located in multi-story residential buildings.
2	<p>Data collection and processing</p>
	<div style="display: flex; justify-content: space-around;"> <div data-bbox="331 703 778 1070">  <p style="text-align: center;">Fig. 2 Park layout</p> </div> <div data-bbox="778 703 1311 1070">  <p style="text-align: center;">Fig. 3 Satellite image of the park</p> </div> </div> <p>The dendrological park spans an area of 400.67 hectares, situated in the southern part of Bila Tserkva, on the right bank of the Ros River, which influences its topography and hydrographic network. The territory represents the second floodplain terrace of the river.</p> <p>As a protected area, the "Oleksandriya" park is subject to the requirements of the Law of Ukraine "On the Nature Reserve Fund of Ukraine" and has a defined regime of protection and use. Any actions that may lead to the degradation of natural complexes are prohibited: unauthorized logging, disturbance of soil cover, littering, or alteration of the hydrological regime. Sporting events are allowed only under the condition of minimizing recreational pressure and complying with established regulations. In particular, orienteering courses should avoid areas with rare and valuable plant species, zones with high vegetation density, and territories designated for the conservation of genetic diversity.</p> <p>Regular ecological monitoring and scientific observation of the dendrological collections are conducted within the park, with a research laboratory operating on-site. For orienteering purposes, additional monitoring of recreational load is needed to assess whether it exceeds acceptable norms (especially in spring and summer).</p>
3	<p>Assessment of natural conditions, landscape analysis</p>
	<p>The relief is suitable for setting courses of varying complexity: a gently undulating plain with access to the river valley. The hydrography includes the Ros River, a cascade of ponds, springs, and canals that can be used as navigational features. Floral diversity is high (the species list includes 2,240 taxa), which is advantageous for educational routes but also a limitation for mass events. The soil cover consists of chernozems and meadow soils, which are resistant to recreational use; however, areas with clay subsoils become slippery after rain. The climate is temperate continental, optimal for competitions from April to October. Passability varies from open lawns to dense shrub thickets; zoning is needed for different competition categories.</p>
4	<p>Assessment of anthropogenic impact</p>
	<p>The park features a well-developed system of alleys and walking paths, totalling over 20 km in length. The main routes have a hard surface, while secondary paths are mostly dirt roads; their density provides favorable conditions for visitor movement.</p> <p>Regarding the assessment of distance to settlements, roads, power lines, and other infrastructure objects, the park is located within the city of Bila Tserkva, in close proximity to residential areas (200–500 m). Major transport routes run near the eastern and northern boundaries. Engineering infrastructure (power lines, water supply networks) passes through or near the park, contributing to additional anthropogenic pressure.</p> <p>"Oleksandriya" is one of the most visited cultural heritage and protected natural areas in the Kyiv region. Tens of thousands of tourists and residents visit it annually. The highest recreational intensity occurs in the spring-summer period and on weekends. High recreational load is manifested in lawn trampling, localized soil compaction, formation of unauthorized paths, and increased noise pollution.</p> <p>Overall, the dendrological park experiences significant anthropogenic pressure, but its territory retains high landscape value and holds strong potential for organizing sporting events, including orienteering, provided that recreational use is regulated and anthropogenic load is controlled.</p>

The use of protected areas is possible only when several criteria are taken into account, including natural conditions, anthropogenic impacts, safety, ecological restrictions, and logistical factors. The developed methodology can serve as a tool for the rational use of protected areas and contribute to integrating sports and recreational activities with nature conservation functions.

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МЕТОДИКА АНАЛІЗУ ТЕРИТОРІЙ ПРИРОДНО-ЗАПОВІДНОГО ФОНДУ ДЛЯ ПОТРЕБ СПОРТИВНОГО ОРІЄНТУВАННЯ

Вступ. Географічна наука все більше орієнтується на прикладні дослідження, що мають практичне значення для природокористування та просторового планування територій. У цьому контексті особливої актуальності набуває аналіз потенціалу територій природно-заповідного фонду (ПЗФ) як об'єктів активного пізнавально-рекреаційного використання. З географічним середовищем все більше стає пов'язаним спортивне орієнтування – вид спорту, суть якого полягає в тому, щоб на незнайомій місцевості за допомогою карти та компаса якнайшвидше подолати дистанцію, відвідавши контрольні пункти. Спортивне орієнтування потребує наявності різноманітного та доступного рельєфу, картографічних матеріалів, достатньої площі території, природної різноманітності, а також дотримання обмежень щодо охоронного статусу території.

Методи. Методика включає такі етапи: визначення критеріїв відбору територій; збір та аналіз даних про рельєф, рослинність, ґрунти, клімат і антропогенне навантаження; оцінка екологічних обмежень; створення картографічних матеріалів у ГІС; формування бази даних придатних ділянок та рекомендацій щодо організації дистанцій.

Результати. Розроблено методику аналізу територій природно-заповідного фонду для визначення їх придатності до використання під час спортивного орієнтування. Проаналізовано умови дендрологічного парку "Олександрія": зручне розташування, рівнинно-хвилястий рельєф, різноманітні ландшафтні елементи, розвинена інфраструктура та мережа стежок. Визначено обмеження, пов'язані з наявністю рідкісних видів, високим рекреаційним навантаженням і статусом ПЗФ. Сформовано рекомендації щодо прокладання дистанцій різної складності.

Висновки. Методика підтвердила свою ефективність для оцінювання придатності територій ПЗФ до спортивного орієнтування. Території можуть використовуватися за умови дотримання екологічних вимог, мінімізації антропогенного впливу та грамотного планування. Підхід може бути застосований для подальших досліджень і практичної організації змагань у межах ПЗФ.

Ключові слова: аналіз території, охоронні зони, орієнтування.

Автори заявляють про відсутність конфлікту інтересів. Спонсори не брали участі в розробленні дослідження; у зборі, аналізі чи інтерпретації даних; у написанні рукопису; в рішенні про публікацію результатів.

The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript; in the decision to publish the results.