Interreg CENTRAL EUROPE

Co-funded by the European Union

HUMANITA

Local Action Plan to monitor and resolve human-nature conflicts in pilot sites

D.3.4.1.

Partner: Bükk National Park Directorate

Version 1

11 2025

Table of contents

Introduction

Interreg CE Humanita project and the framework of Action Plans for human-nature interactions in Protected Areas

Within the framework of the Interreg CE Humanita project, involved natural parks and protected areas are required to develop, for each pilot site, the Local Action Plan (D.3.4.1) to monitor and resolve human-nature conflicts in respective sites.

Action plan is the operational plan of the park/protected area's strategy for managing tourism impacts. The Action plan document showcases the actions needed to achieve sustainable management of tourism according to the defined objectives of optimizing human activities with biodiversity and nature protection.

It provides practical guidance on the implementation and monitoring of actions that the organization is committed to achieving upon approval.

The document begins by outlining the context of the park/protected area and displaying the main issues and criticalities that currently threaten the biodiversity and health of the areas' habitats. It describes the current impacts' mitigation measures in place, featuring the main gaps and weaknesses that still exist.

It highlights challenges and potential room for strengthening the strategies in force by combining integrative measures and tools resulting from the monitoring activities performed and knowledge exchange that occurred along the project progress. It illustrates how the action plan will be included in a wider framework of strategies in effect, within which administrative and legislative structures at local, regional, and national levels will be part, and how it will reinforce them as well.

The action plan includes a Zone plan to designate areas of the parks/protected areas for different recreational use other than their current use.

The document also includes actions specifically aimed at developing new narratives of the park/protected area to foster human responsibility and awareness about environmental values.

The Action plan contributes with concrete actions to achieving policy changes and real-world impacts.

1. Introduction to the Protected Area

1.1. Administrative Framework and Geographical Scope

A clear distinction must be made between the **Bükk National Park Directorate (BNPD)** and the **Bükk National Park (BNP)**. The BNPD is a regional public administration body responsible for nature conservation, with an operational mandate that extends beyond the Bükk National Park to a wider ecological network in Northern Hungary. This administrative scope encompasses 9 landscape protection areas – including the **Mátra Landscape Protection Area** – as well as 14 nature conservation areas, numerous Natura 2000 sites, and several "ex lege" protected natural assets such as caves and springs. While the Directorate acts as management authority, the Bükk National Park and the Mátra Landscape Protection Area constitute discrete, high-value territories with distinct geological, ecological and landscape characteristics.

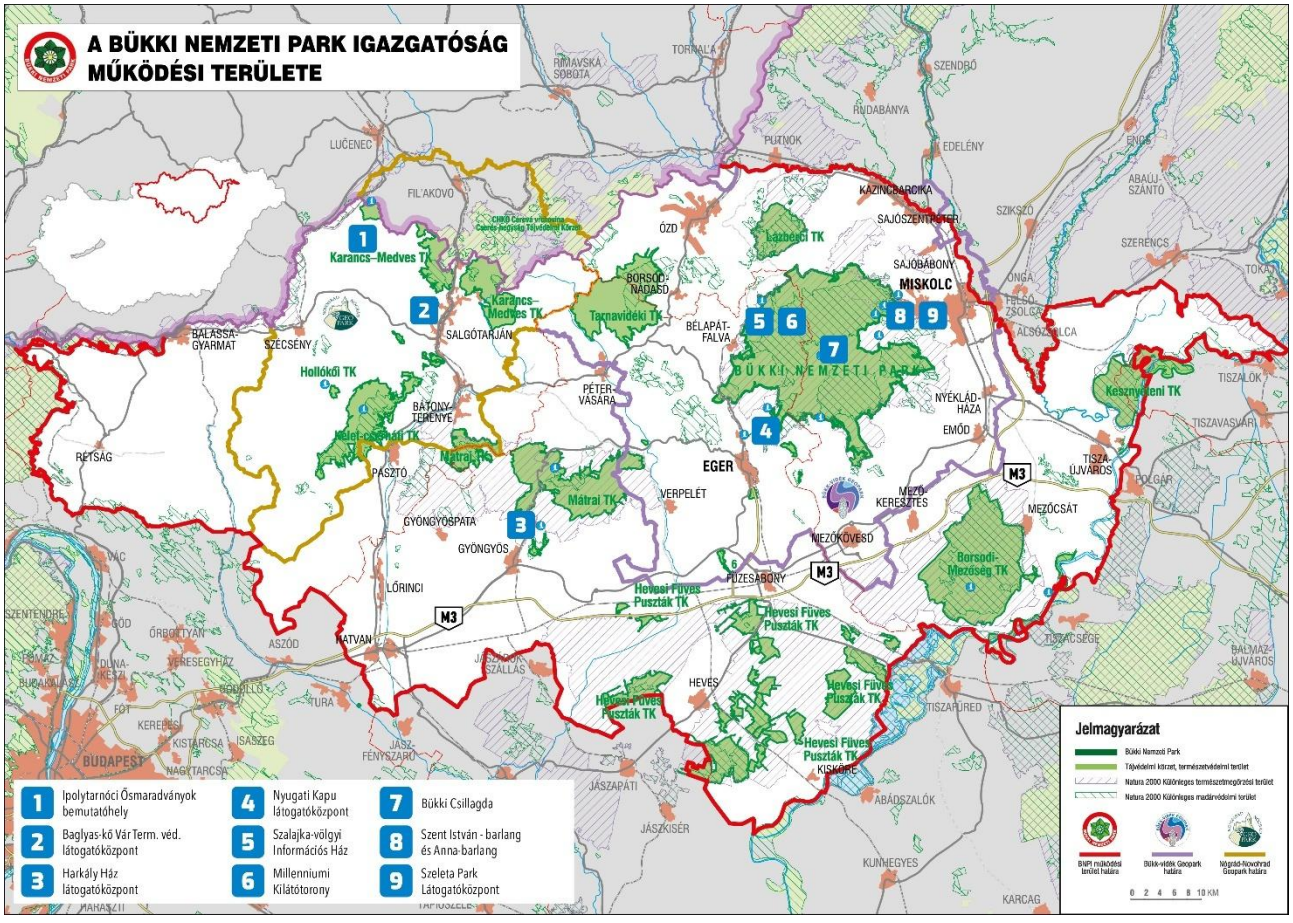

Figure1: Operational area of the Bükk National Park Directorate

1.2. Bükk National Park: Karst Systems and Biodiversity

The Bükk Mountains, dominated by sedimentary rocks of geological antiquity, form a characteristic karst landscape. The surface is mainly composed of highly karstified limestone interspersed with shale and volcanic formations. The central geomorphological element is the Bükk Plateau, with an average elevation of around 800 metres, bordered by pronounced rocky outcrops locally known as "stones" (e.g. Tar-kő).

The area features a complex system of surface and subsurface karst phenomena, including sinkholes, gullies and an extensive network of caves. These caves are of outstanding cultural and historical significance, as

they have provided shelter for prehistoric humans over hundreds of thousands of years and yielded archaeological evidence from the Palaeolithic to the Bronze Age.

Ecologically, the park represents a regional biodiversity hotspot. Approximately 94% of the territory is covered by forests, ranging from oak-dominated stands at lower elevations to montane beech forests above about 400 metres. The karst topography creates a diverse pattern of microclimates, which support a mosaic of Carpathian, Mediterranean and Alpine flora, including several endemic species. Plateau meadows and steep dolomitic limestone cliffs form particularly sensitive habitats, harbouring species such as the lady's-slipper orchid (Cypripedium calceolus) and the northern dragonhead (Dracocephalum ruyschiana).

The fauna is similarly diverse, with notable populations of protected invertebrates such as the alpine longhorn beetle (Rosalia alpina), and a range of vertebrate species including cave-dwelling bats and large carnivores. The presence of Eurasian lynx (Lynx lynx), grey wolf (Canis lupus) and occasionally brown bear (Ursus arctos) underlines the park's role as a regional refuge for apex predators.

1.3. Mátra Landscape Protection Area: Volcanic Heritage

In contrast to the sedimentary Bükk Mountains, the Mátra Mountains form part of the Inner Western Carpathians' volcanic chain. The central massif is a Middle Miocene stratovolcanic complex composed mainly of pyroxene andesite and associated tuffs. The landscape is characterised by deeply incised valleys and steep northern slopes with andesitic lava formations and scree fields.

The Mátra Landscape Protection Area plays a key role in conserving high-mountain habitats of national importance. The distinct "High Mátra" block provides refugia for glacial relict species and Carpathian high-mountain flora, including the alpine rose (Rosa pendulina) and alpine clematis (Clematis alpina). The hydrological network, consisting of small ponds and bogs, supports important populations of protected amphibians such as the alpine newt (Ichthyosaura alpestris) and the yellow-bellied toad (Bombina variegata). As in the Bükk, the Mátra sustains a rich avifauna, including strictly protected raptors such as the eastern imperial eagle (Aquila heliaca) and the short-toed snake eagle (Circaetus gallicus).

1.4. Conservation Challenges and Management Requirements

The conservation status of these protected areas is increasingly affected by the intensification and spatial redistribution of tourism. While they provide important ecosystem services and recreational opportunities, unmanaged or poorly managed visitor flows have led to a range of negative environmental impacts. Key challenges include physical degradation of habitats, disturbance of wildlife, transmission of pathogens, and conflicts between recreational use and other land-use demands such as forestry.

Addressing these challenges requires a transition from ad-hoc, observation-based monitoring towards a structured, data-driven management approach. This, in turn, calls for integrated monitoring systems capable of tracking visitor flows and relating them to spatiotemporal patterns of environmental change. Developing and maintaining such systems is essential for balancing the mandate for public education and recreation with the fundamental objective of ensuring the favourable conservation status of these unique ecosystems.

2. Current state-of-the-art of tourism impacts

This chapter outlines the baseline status of environmental impacts resulting from tourism activities within the operational area of the Bükk National Park Directorate (BNPD), specifically focusing on the Bükk National Park and the Mátra Landscape Protection Area. The assessment reflects the initial state of these protected areas, drawing upon preliminary observations, ad-hoc monitoring, and historical data available prior to the systematic interventions of the HUMANITA project. It serves as a reference framework for understanding the critical pressure points and establishing priorities for medium- to long-term management planning.

2.1. Status by Impact Category

Prior to the implementation of structured monitoring systems, the assessment of tourism impacts was largely derived from ranger service reports, sporadic scientific studies, and general habitat mapping. The following categories define the primary areas of concern:

A. Physical Degradation of Habitats (Soil and Geology)

The most visible impact of tourism in the Bükk and Mátra regions is the physical degradation of geological features and soil structures.

- **Trampling and Erosion:** High-traffic areas, particularly the rocky grassland peaks (e.g. Tar-kő) and popular ridges in the Mátra, exhibit significant soil compaction and erosion. In these locations, visitors frequently deviate from designated trails to reach viewpoints, creating a network of informal "social trails" that fragment sensitive habitats.

Figure 2: Cenological survey on the Tar-kő peak pilotsite

- **Cave Vandalism**: The karst systems in the Forrás Valley (e.g., Kecske-lyuk, Büdös-pest caves) have suffered from direct physical damage. This includes illegal graffiti on cave walls, the construction of unauthorized fire pits at cave entrances and interiors, and the accumulation of waste. Such activities not only degrade the geological value but also alter the microclimate essential for cave-dwelling fauna.

B. Vegetation Damage and Invasive Species

Vegetation monitoring has historically indicated two primary threats linked to tourism:

- **Habitat Degradation:** In the rocky grasslands of the Bükk Plateau, trampling has led to the degradation of endemic plant associations (e.g. *Sesleria* grasslands). At the Tar-kő pilot site, small, denuded patches were recorded near viewpoints even before detailed monitoring began, signalling concentrated pressure. Furthermore, illegal collection of protected plants (foraging) remains a persistent issue.
- **Spread of Invasive Species:** Tourism corridors act as vectors for the introduction of non-native species. The disturbance of soil along hiking and biking trails facilitates the establishment of invasive weeds, which outcompete native flora. This is particularly problematic in the lower elevations and transition zones of the Hór Valley.

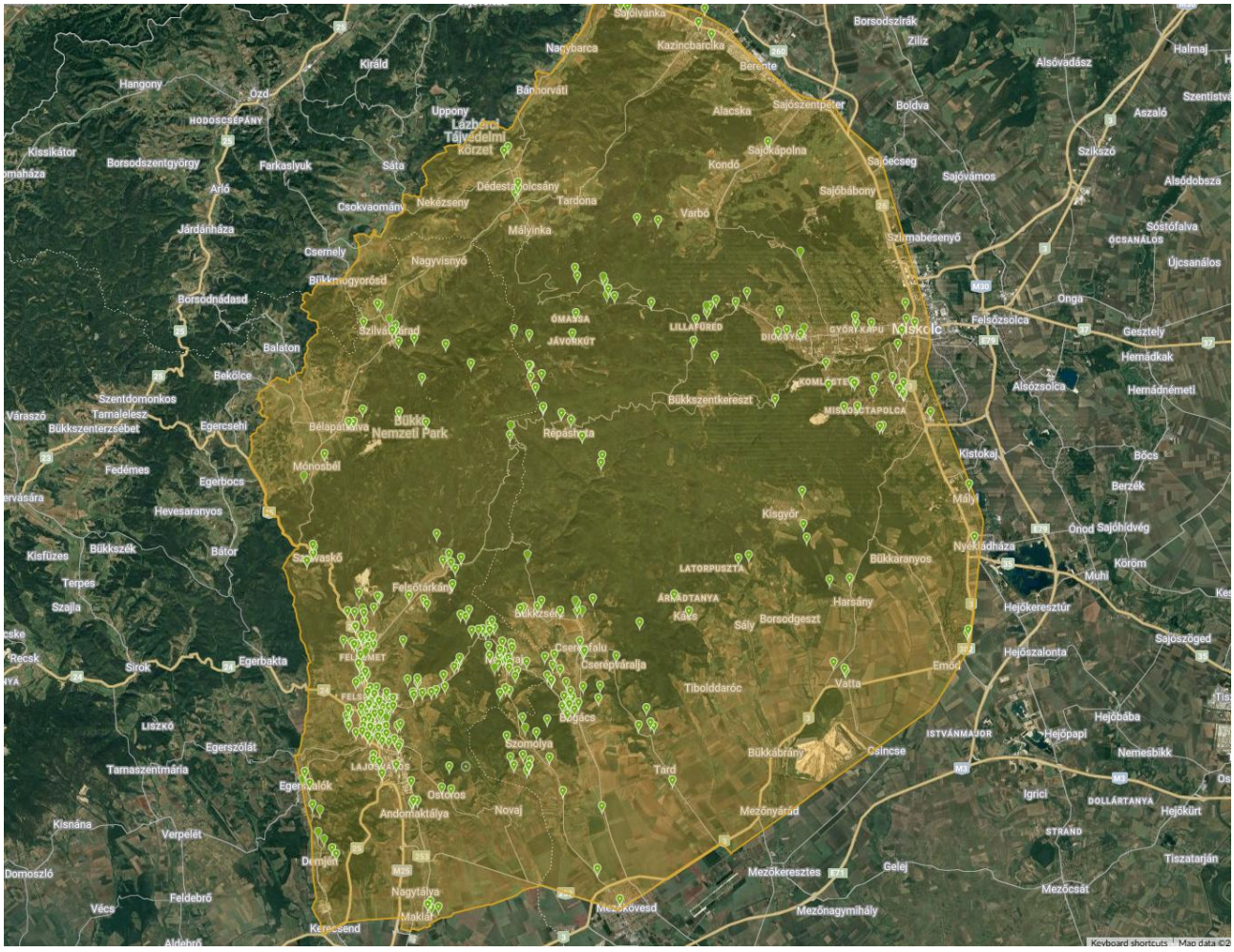

Figure 3: Inaturalist project for the mapping of invasive species in the Bükk Region

C. Wildlife Disturbance

Human-wildlife conflict is a critical area of concern, often exacerbated by a lack of visitor awareness regarding the sensitivity of local fauna.

- **Chiroptera (Bats):** The caves in the Bükk Mountains serve as essential hibernacula and breeding sites for strictly protected bat species (e.g., Miniopterus schreibersii, Rhinolophus spp.). Unregulated entry, noise pollution, and the use of light sources by tourists have historically caused significant stress to these colonies, threatening their reproductive success and survival rates.
- **Amphibians and Pathogen Transmission:** In the Mátra Mountains, a direct link has been hypothesized between human activity and the spread of pathogens. Before the project, mass mortality events of the yellow-bellied toad (Bombina variegata) were observed (e.g., in 2019), attributed to chytridiomycosis. The movement of tourists and vehicles through wet habitats is considered a primary vector for spreading the Batrachochytrium dendrobatidis (Bd) fungus.

Figure 4: Swab testing a common frog in the Mátra Pilot site

- **Large Carnivores and Raptors:** Unauthorized recreational activities, such as off-trail hiking, geocaching, and illegal motorized sports (quads, dirt bikes), disrupt the territories of large carnivores (lynx, wolf, bear) and nesting raptors (e.g., eastern imperial eagle), causing stress and potential displacement.

D. Pollution and Waste Management

Waste accumulation is a pervasive issue, categorized into incidental littering and illegal dumping.

- **Littering:** Popular hiking trails and resting spots frequently accumulate food packaging and plastic waste. A specific issue noted in the Hór Valley is the presence of human waste and tissue paper in secluded areas near major attractions, posing hygiene and contamination risks.
- **Illegal Dumping:** While less associated with hikers, the accessible edges of the protected areas are subject to fly-tipping of communal and construction waste, which degrades the landscape aesthetic and pollutes soil and water resources.

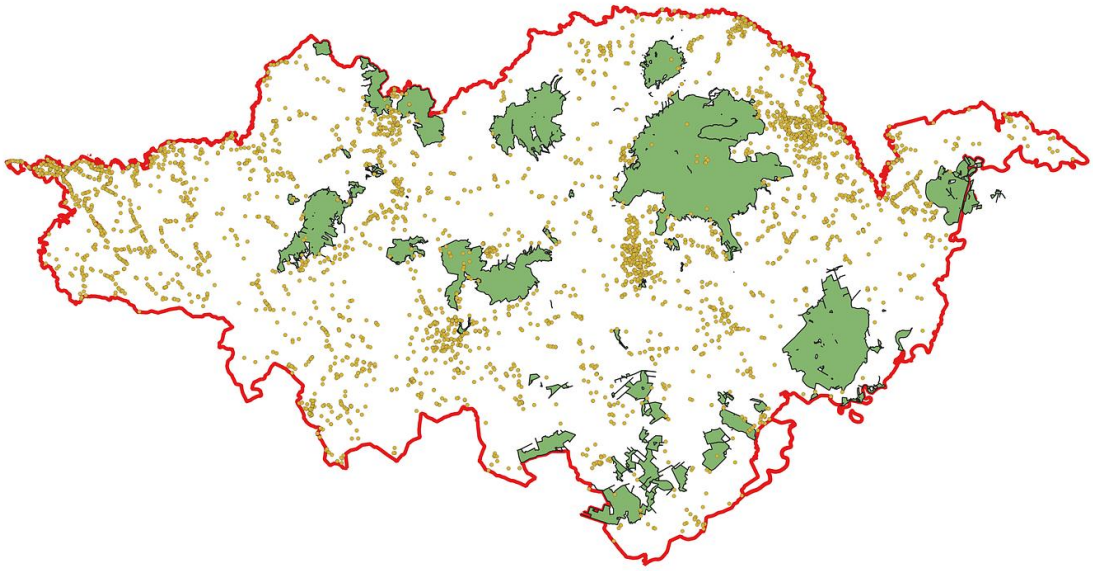

Figure 5: Recorded illegal trash locations during the HUMANITA project within the BNPD operational area

2.2. Priorities for Intervention

Based on the initial assessment of impacts, the following priorities have been identified to guide medium- to long-term management planning:

1. **Regulation of Visitor Flow at Hotspots:** Immediate priority must be given to managing visitor density at highly sensitive locations such as the Tar-kő peak and the cave systems of Forrás Valley. This requires the implementation of strict zoning, physical barriers (railings), and the rehabilitation of designated trails to discourage off-trail dispersal.
2. **Disease Mitigation in Amphibian Habitats:** Given the lethal nature of the chytrid fungus, high priority is assigned to monitoring and limiting human interaction with critical amphibian breeding sites in the Mátra. This includes re-routing trails away from sensitive water bodies and educating visitors on biosecurity (e.g. disinfecting footwear).
3. **Control of Illegal Motorized Access**: A medium-term enforcement strategy is required to eliminate illegal motorized tourism (quads, cross-motorcycles) from strictly protected areas, particularly in the Hór Valley and forest interiors, to reduce noise pollution and wildlife disturbance.
4. **Waste management infrastructure and Sanitation Improvement:** Long-term planning must address the lack of adequate sanitation facilities at major trailheads to prevent organic pollution.

Simultaneously, waste management infrastructure needs reinforcement to handle peak season loads.

5. **Transition to Systematic Monitoring:** A fundamental priority is shifting from reactive, ad-hoc observations to a standardized, data-driven monitoring system. This will enable the Directorate to quantify trends, assess the efficacy of interventions, and make evidence-based management decisions regarding visitor capacity and conservation measures.

3. Current mitigation measures

The management of tourism impacts within the Bükk National Park Directorate (BNPD) has historically relied on a combination of regulatory enforcement, infrastructural channelling, and educational measures. The following sections detail the baseline measures established to address environmental pressures in the Bükk and Mátra regions.

3.1. Regulatory and Administrative Control

The primary line of defence for natural assets involves the legal and administrative restriction of human activities.

- **Zoning and Spatial Restriction:** The Directorate utilizes a strict zoning system to segregate high-intensity tourism from sensitive core areas. Strictly protected areas are legally inaccessible to tourists except on designated hiking trails. This spatial containment is crucial for preserving undisturbed habitats for large carnivores and nesting raptors.
- **Event Permitting System:** To mitigate the impact of mass tourism, a permitting system regulates sporting and community events (e.g. trail running competitions, performance tours). Authorization is generally granted only for events occurring outside the active vegetation period or breeding seasons, and routes are restricted to less sensitive, designated trails.
- **Ranger Service Enforcement:** The BNPD Ranger Service performs regular patrols to enforce nature conservation laws. Their activities include sanctioning illegal entry into strictly protected zones, reporting unauthorized motorized vehicle use (quads, dirt bikes), and dismantling illegal infrastructure such as unauthorized fire pits or campsites.

3.2. Infrastructural Management and Channeling

Physical infrastructure is strategically employed to concentrate visitor flows in key locations, thereby reducing pressure on the wider, more sensitive landscape.

- **Concentration at Visitor Hubs:** Major investments have been directed towards developing high-capacity visitor centres (e.g. the Bükk Observatory, Harkály House, and cave visitor centres in Lillafüred). These facilities are designed to absorb the bulk of mass tourism, providing controlled recreational experiences that reduce the incentive for visitors to disperse into sensitive hinterlands.
- **Designated Trail Network:** A dense network of marked hiking trails (maintained in cooperation with the Hungarian Nature Hiker Association and forestry companies) serves to channel foot traffic. By maintaining these paths, the Directorate aims to prevent the widening of trails and the creation of unofficial trails that fragment habitats.

- **Physical Barriers and Cave Protection:** To protect the geological and biological integrity of karst systems, non-show caves are physically closed with grating systems. This measure is aimed at protecting wintering bat colonies from disturbance while allowing for the free movement of fauna.

3.3. Educational and Interpretive Initiatives

Educational management techniques aim to modify visitor behaviour through awareness-raising, fostering a culture of voluntary compliance.

- **Educational Trails:** The Directorate operates a network of over 50 educational trails (e.g. the older Ördögtorony trail in Hór Valley). These trails utilize static information boards to interpret natural values, explaining the geological history and biological diversity of the area, thereby justifying conservation rules to the public.
- **Forest Schools and Environmental Education:** The BNPD maintains "Forest Schools" (e.g. Bábakalács Nature School) that offer immersive educational programmes for youth. These initiatives focus on long-term behavioural change by instilling environmental ethics in the younger generation.
- **Digital and Print Communication:** Prior to the project, communication efforts included the distribution of brochures, field guides, and online content regarding codes of conduct (e.g. "Leave No Trace" principles). This includes specific warnings about the risks of spreading invasive species or pathogens, though these campaigns were often broad rather than site-specific.

3.4. Participatory and Cooperative Mechanisms

Recognizing that tourism management requires cross-sectoral cooperation, the Directorate engages with various stakeholders.

- **National Park Product Trademark:** To foster a sustainable local economy, the BNPD manages a trademark system that certifies local products and services that align with nature conservation goals. This initiative encourages local stakeholders to operate in an environmentally friendly manner.
- **Citizen Reporting (Waste Management):** While structured citizen science was limited, the Directorate has promoted the use of the national "Hulladékradar" (Waste Radar) application. This tool allows visitors to report illegal dumpsites, facilitating targeted cleanup operations by park staff and municipal partners.
- **Cooperation with Forestry:** Coordination with state forestry companies (Egererdő Zrt., Északerdő Zrt.) is established to harmonize forest management with nature conservation objectives and accessibility for the public, such as maintaining the walkability of trails.

4. Monitoring activities' results

The implementation of the HUMANITA project marked a transition from ad-hoc observations to a systematic, multi-dimensional monitoring framework within the Bükk National Park and Mátra Landscape Protection Area. By integrating quantitative data from technological sensors and digital databases with qualitative insights from citizen science and visitor surveys, the Directorate has established a comprehensive baseline of tourism-related pressures.

The following sections summarize the key findings achieved through these diverse monitoring activities, correlating visitor dynamics with specific ecological responses.

4.1. Visitor Dynamics and Perceptions

Visitor Flow and Demographics (Telekom Data & Automatic Counters)

The analysis of cellular network data (2023–2024) and automatic counters revealed distinct visitation patterns across the pilot sites, highlighting a dichotomy between "traditional" domestic destinations and emerging international hotspots.

- **Growth Trends:** The **Suba-lyuk** site in Hór Valley emerged as the fastest-growing destination (+15.3%), successfully attracting a mixed demographic of domestic and international visitors. This surge correlates with the data from automatic counters, which show high concentrations of visitors during the May–October window.
- **Stable vs. Declining Hubs:** The **Kékes North** site remains a stable, highly domestic-focused destination (78.5% domestic), functioning as a traditional summer and winter getaway. Conversely, sites like **Totovics** and **Parádi meadows** experienced declines in visitation, suggesting a shift in tourist preferences or the seasonal nature of their appeal.
- **International Vectors:** While domestic tourism dominates, the presence of international visitors (e.g., from Germany, North America) at hubs like Kékes poses a specific biosecurity risk regarding the transboundary spread of pathogens, a factor previously underestimated.

Visitor Attitudes (Surveys & Interviews)

Surveys conducted by BNPD and CEEweb (n=195 in Bükk) indicate a high level of environmental awareness among visitors, though often abstract rather than practical.

- **Perception of Impact:** While 88% of visitors are aware they are in a protected area, over half initially claimed their activity had "no impact." Among those who acknowledged an impact, **vegetation damage** (77%) and **wildlife disturbance** (45%) were the most cited concerns.
- **Perceived Threats:** Visitors identified **overtourism** and **waste management** as the most critical threats to the area, aligning with the Directorate's management concerns. However, there is a gap in awareness regarding "invisible" threats, such as the introduction of invasive species or pathogens, which were rarely mentioned by tourists.

4.2. Ecological Impacts

Amphibian Health and Pathogen Transmission

Research into the spread of amphibian diseases (chytridiomycosis and ranavirus) yielded perhaps the most critical conservation finding of the project.

- **Correlation with Tourism:** Testing confirmed significantly **higher infection rates** of the chytrid fungus (*Batrachochytrium dendrobatidis*) in yellow-bellied toad populations at turistically frequented sites in the Mátra (e.g., Kékes-North, Haluskási road) compared to remote control sites.
- **Vector Identification:** The results strongly suggest that hikers and vehicles are acting as vectors, transporting the pathogen into sensitive aquatic habitats. The detection of visitors from North America (a hub for new viral strains) via Telekom data further underscores the high risk of introducing new, more virulent pathogen lineages.

Vegetation and Trampling

Botanical monitoring at the Tar-kő and Hór-valley pilot sites provided a nuanced view of physical degradation.

- **Localized Damage:** While trampling damage (bare soil, presence of disturbance-tolerant weed species) is detectable along designated trails and viewpoints, it is currently confined to the immediate vicinity of the path (0.5–1 m).
- **Climate vs. Tourism:** Interestingly, the monitoring period revealed that broader environmental factors, specifically severe drought, currently exert a more significant pressure on vegetation composition than tourism alone. However, the physical disturbance caused by hikers exacerbates the stress on these drought-affected habitats.

Wildlife Disturbance (Bats)

Acoustic monitoring in the cave systems (e.g. Kecske-lyuk) has begun to quantify the overlap between human activity and bat presence. Preliminary data indicates that unregulated entry and noise pollution in non-show caves continue to pose a disturbance risk, particularly given the late arrival and vulnerability of bat colonies in these accessible karst features.

Pollution and Invasive Species (Participatory Monitoring)

Citizen science initiatives provided valuable spatial data on environmental hygiene.

- **Waste Patterns (Hulladékradar):** Monitoring revealed that illegal waste disposal is not randomly distributed but clustered near roads and access points (48% within 20 m of a road). The volume and type of waste suggest that **fly-tipping** (organized dumping) is a more significant volume driver than incidental tourist littering, although the latter remains a widespread aesthetic pollution issue.
- **Invasive Flora (iNaturalist):** Volunteer observations confirmed a spatial bias of invasive plant species towards populated hubs (e.g., Eger) and tourism corridors, validating the theory that tourist trails serve as conduits for the spread of non-native flora.

5. Gaps/weaknesses to address

Despite the implementation of the HUMANITA monitoring framework and existing management efforts, several critical vulnerabilities remain in the protection strategy of the Bükk National Park and Mátra Landscape Protection Area. The transition from diagnostic monitoring to active management has highlighted specific deficiencies in biosecurity, infrastructure, and enforcement that require immediate strengthening.

The following areas represent the primary gaps where current measures are insufficient to mitigate the identified pressures:

5.1. Biosecurity Deficits in Amphibian Habitats

The most urgent gap identified by the project is the lack of infrastructure and protocols to contain the spread of the *Chytrid* fungus (*Batrachochytrium dendrobatidis*).

- **Critical Issue:** While monitoring has confirmed that tourists and vehicles are vectors for this lethal pathogen, there is currently **zero biosecurity infrastructure** (e.g. boot cleaning stations, vehicle disinfection points) at key entry points in the Mátra region.
- **Weakness:** Reliance on voluntary avoidance of wet habitats is insufficient. Without physical decontamination facilities and mandatory protocols, the continued introduction of new pathogen strains remains a high-probability risk.

5.2. Limitations in Waste Management and Enforcement

Participatory monitoring (*Hulladékradar*) revealed a dichotomy in waste pollution that current management cannot fully address.

- **Critical Issue:** While ranger services effectively manage trail litter, they lack the capacity and infrastructure to prevent **illegal fly-tipping** (communal and construction waste) at the perimeters of protected areas.
- **Weakness:** The accessibility of forest roads to unauthorized vehicles facilitates this dumping. The current lack of physical barriers (gates, barriers) and surveillance (camera traps specifically for waste) at these vehicular entry points is a significant infrastructural weakness.

5.3. Fragmentation of Visitor Flow Data

While the project successfully tested various counting methods (automatic counters, Telekom data, Strava), the integration of these data streams remains fragmented.

- **Critical Issue:** There is no centralized, real-time dashboard that correlates visitor density with ecological stress markers. Currently, visitor data and biological monitoring data are analyzed separately.
- **Weakness:** This separation prevents dynamic management (e.g., closing a trail *before* trampling damage becomes irreversible). The transition from "collecting data" to "data-driven rapid response" is a procedural gap that must be bridged.

5.4. The "Invisible Impact" Awareness Gap

Survey results indicate a dissonance between visitor intent and visitor impact.

- **Critical Issue:** Educational initiatives focus heavily on visible impacts (litter, noise, physical damage). There is a significant **communication gap** regarding invisible impacts, such as the transport of invasive seeds on clothing or pathogens on footwear.
- **Weakness:** Current static information boards and educational trails do not adequately convey these complex biological risks. Visitors do not perceive themselves as biological vectors, rendering voluntary compliance with biosecurity measures ineffective.

5.5. Inadequate Control of Illegal Motorized Traffic

Despite legal prohibitions, the presence of quads and off-road motorcycles remains a persistent stressor, particularly in the Hór Valley and forest interiors.

- **Critical Issue:** High-speed motorized intrusion causes disproportionate soil erosion and wildlife disturbance compared to hiking.
- **Weakness:** The current enforcement relies on sporadic patrols. There is a lack of systemic physical exclusion (barriers that allow hikers/bikers but stop motors) and a lack of cooperation with local municipalities to penalize offenders effectively outside the park boundaries.

5.6. Vulnerability of Cave Ecosystems

While show caves are managed, the non-show caves (e.g. Kecske-lyuk) remain vulnerable.

- **Critical Issue:** Acoustic monitoring proved that human presence persists in protected caves during sensitive bat hibernation and breeding periods.
- **Weakness:** Existing physical barriers (grates) are sometimes vandalized or circumvented. Furthermore, there is a lack of "soft" control measures, such as smart sensors that could trigger alerts or warnings when unauthorized entry occurs during critical biological windows.

6. Integration into the current tourism impact management strategy

The tourism impact management actions proposed within the HUMANITA project for the Bükk National Park Directorate (BNPD) constitute a comprehensive reinforcement of existing conservation strategies rather than a departure from them. The measures developed through project monitoring and pilot testing directly correspond to and operationalise the conservation objectives and management protocols already established in the approved or submitted management plans of the two protected areas under BNPD stewardship: the **Bükki Nemzeti Park** (Bükk National Park) and the **Mátrai Tájvédelmi Körzet** (Mátra Landscape Protection Area). This integration operates within the existing regulatory framework established by Hungarian nature conservation legislation and EU environmental directives.

6.1. Bükk National Park – submitted Management Plan

The submitted Bükk National Park Management Plan establishes comprehensive conservation objectives that directly accommodate the action plan's tourism impact mitigation measures. The management plan was finalized in 2017, but it has not yet signed by the Ministry of Agriculture. The alignment operates across multiple dimensions:

6.1.1. Habitat and Species Protection Framework

The management plan's primary objectives to preserve the natural state of biotic communities and ecosystems and improve habitat conditions for protected and endangered species provide the foundational justification for all visitor flow management actions and biosecurity protocols proposed in the action plan. The project's monitoring infrastructure and data-driven management systems operationalise these objectives by providing empirical evidence for adaptive management decisions. The management plan's commitment to reducing invasive alien species directly correlates with the HUMANITA project's actions addressing pathogen transmission and invasive species spread along tourism corridors. Ecological monitoring conducted during the project – particularly the documentation of *Batrachochytrium dendrobatidis* fungal pathogen vectors linked to human traffic – provides the scientific foundation for implementing enhanced biosecurity protocols at amphibian breeding sites.

6.1.2. Forest and Woodland Management

The management plan's goal to improve the natural state of forests and forest communities while maintaining biological and genetic diversity integrates seamlessly with the action plan's proposed trail infrastructure improvements and visitor concentration measures. By directing visitor flows to designated, well-maintained pathways and honeypot locations, the tourism impact management actions reduce off-trail trampling and vegetation damage that would compromise forest regeneration objectives.

6.1.3. Karst and Cave Ecosystem Protection

The management plan emphasises preservation, maintenance and restoration of karst formations and caves, their geological formations and fauna, as well as groundwater resources. Acoustic monitoring of human disturbance impacts on bat populations in caves such as Kecske-lyuk operationalises this objective by quantifying human-wildlife conflict and providing evidence for targeted protective measures including temporal access restrictions during critical biological windows.

6.1.4. Cultural and Landscape Values

The management plan mandates preservation and maintenance of landscape and natural values, as well as cultural-historical monuments. The action plan's proposed educational trail infrastructure, visitor information systems, and interpretation measures directly support this objective by facilitating public understanding of both natural heritage and conservation rationale for visitor restrictions.

6.2. Mátra Landscape Protection Area Management Plan

The Mátrai Landscape Protection Area, regulated under the 15/2008. (VI. 3.) KvVM ministerial decree, establishes management objectives complementary to and reinforced by the HUMANITA action plan for each following conservation areas and actions.

6.2.1. Protected Species and Habitat Conservation

The management plan's strategic commitment to preserve and strengthen populations of protected and strictly protected species through active nature conservation management and traditional land use practices directly supports the project's amphibian disease monitoring and habitat protection measures. The specific protection of the alpine newt (*Ichthyosaura alpestris*) and yellow-bellied toad (*Bombina variegata*) – identified as highly vulnerable to pathogenic infection via tourism corridors – aligns perfectly with the biosecurity infrastructure and visitor management protocols proposed.

6.2.2. Ecosystem-Based Management Strategies

The management plan's strategic orientation toward preserving natural plant associations through active management, combined with the transformation of non-native forest stands to native species, creates a framework within which the project's vegetation monitoring data becomes operationally significant. Documented spread of invasive plant species along tourism corridors provides empirical justification for enhanced trail management and visitor education measures.

6.2.3. Forest Management and Continuity

The management plan's emphasis on continuous forest cover combined with continuous cover forestry management creates regulatory space for implementing tourism-focused trail maintenance and infrastructure improvements. These improvements complement forestry operations by distributing visitor pressure predictably along designated corridors, reducing uncontrolled off-trail impacts.

6.2.4. Visitor Access and Recreation Management

The management plan explicitly regulates visitor access through provisions stating that pedestrian visitation is permitted freely except in strictly protected natural areas, where deviation from designated marked trails is prohibited. The action plan's proposed measures – including trail designation, signposting, information infrastructure, and temporal restrictions – directly implement these regulatory provisions by providing operational infrastructure and management protocols necessary for effective enforcement.

7. Linkages to national-regional plans

The HUMANITA action plan for tourism impact management in the Bükk National Park Directorate (BNPD) is embedded within a multi-layered regulatory and strategic framework at both national and regional levels. Rather than introducing new regulatory structures, the action plan operationalises existing conservation principles and legal frameworks established through Hungarian nature conservation legislation, European Union directives, and internationally negotiated environmental protection standards.

7.1. National Strategies

7.1.1. 1996. évi LIII. törvény (Nature Protection Act)

The Nature Protection Act constitutes the foundational legal framework for all nature conservation activities in Hungary, including protected area management. The HUMANITA action plan directly implements several core principles articulated in this legislation.

The Act establishes that nature conservation must ensure the protection and sustainable use of natural values and territories, support biological diversity, and maintain ecosystem functionality and integrity. The HUMANITA action plan's monitoring and educational initiatives directly serve these statutory objectives. The establishment of systematic visitor flow monitoring—through automatic counters, cellular data analysis, and digital platforms—translates the Act's requirement for informed management into concrete operational practice. The project's ecological monitoring of tourism impacts on amphibian populations, vegetation communities, and wildlife disturbance provides the empirical foundation necessary for evidence-based decision-making mandated by legislation.

The Act furthermore requires nature conservation management to address threats to protected species and habitats. The biosecurity infrastructure and pathogen transmission protocols developed through the HUMANITA project—specifically targeting the chytrid fungus threat to amphibian populations—directly implement the statutory obligation to protect species from human-induced threats whilst preserving habitat integrity.

7.1.2. 2009. évi XXXVII. törvény (Forest Protection and Management Act)

The Forest Protection and Management Act governs forestry operations within protected areas and establishes principles for sustainable forest management directly relevant to the HUMANITA project's tourism impact mitigation measures.

The Act mandates sustainable forest management practices, maintaining forest biodiversity, naturalness, productivity, and regenerative capacity whilst simultaneously fulfilling social welfare and economic functions. Section 2 specifies that sustainable forestry management must ensure forests remain suitable for fulfilling their environmental protection, public welfare, and economic roles – a formulation that explicitly integrates tourism and recreational functions into forest management objectives.

The tourism trail infrastructure improvements proposed in the HUMANITA action plan – including enhanced trail maintenance, strategic path designation, and visitor concentration measures – serve to implement these statutory sustainability principles. By channelling visitor flows along designated, well-maintained corridors, the proposed measures reduce uncontrolled off-trail impacts that would undermine the forest's productive capacity and regenerative potential whilst enabling the forest's public welfare function to be exercised sustainably.

7.1.3. 275/2004. (X. 8.) Government Decree (Natura 2000 Protected Areas Framework)

The Government Decree on European Community Protected Areas establishes the legal and administrative framework for designating and managing Natura 2000 sites in Hungary. The BNPD operates within the context of several overlapping Natura 2000 designations, and the HUMANITA action plan directly operationalises this decree's requirements.

The decree stipulates that Natura 2000 areas shall be established and maintained to preserve, maintain, and restore the favourable conservation status of community-significant species and habitat types for which sites are designated. The action plan's monitoring and management measures directly serve these statutory conservation objectives by addressing documented threats to designated species and habitats.

The decree further specifies that management measures shall be coordinated with socio-economic development objectives and cultural preferences, a requirement that the HUMANITA action plan fulfils through its integration of tourism management with community engagement, educational initiatives, and economic considerations related to sustainable tourism development.

7.2. Regional Strategies

7.2.1. Natura 2000 Management Plans

The protected areas under BNPD stewardship encompass multiple overlapping Natura 2000 designations, each governed by comprehensive maintenance and management plans. These regional-level strategic documents operationalise the national legislative framework whilst addressing the specific ecological characteristics, species compositions, and management challenges of individual designated sites.

7.2.1.1. Special Protection Area (SPA) Designations:

The Bükk National Park and Mátrai Landscape Protection Area together form part of the Bükk-hegység és peremterületei special protection area (HUBN10003) designated under the EU Birds Directive, establishing conservation objectives for 35 species of community-significant birds, including raptors (Aquila heliaca, Circaetus gallicus) and woodland specialists (Dendrocopos leucotos, Dendrocopos medius).

The HUMANITA project's visitor flow management and disturbance reduction measures directly support the achievement of these avian conservation objectives. The proposed trail designation, signposting, and temporal restrictions on visitor access during critical nesting seasons operationalise SPA management objectives regarding raptor nesting site protection and reduction of human disturbance during breeding periods.

7.2.1.2. Special Areas of Conservation (SAC) Designations:

Multiple Special Areas of Conservation designated under the EU Habitats Directive overlay the BNPD's operational territory. Key designations include the Hór-völgy és Déli-Bükk (HUBN20002), designated for woodland habitat types (9110, 9130, 9150, 9180, 91E0, 91G0, 91H0, 91M0), and the Mátrai Landscape Protection Area site complex (HUBN20044–HUBN20051), focused on montane forest types, grassland habitats, and specialist alpine species including the yellow-bellied toad and alpine longhorn beetle (Rosalia alpina).

The HUMANITA project's conservation objectives align directly with SAC management goals. The biosecurity infrastructure and amphibian disease monitoring operationalise SAC objectives for maintaining favourable conservation status of amphibian populations. The forest vegetation monitoring and visitor impact assessment provide data for evaluating whether tourism-related habitat degradation threatens achievement of SAC conservation targets for designated forest habitat types.

7.2.1.3. Management Plan Specification:

The HUMANITA action plan relates to established Natura 2000 maintenance and management plans in three critical respects: (1) Monitoring and Data Foundation – the project's systematic monitoring provides empirical data regarding visitor dynamics, vegetation responses, and wildlife disturbance patterns, enabling more precise calibration of management interventions; (2) Threat Mitigation – the action plan provides concrete, operationally specific measures for addressing tourism impacts identified in regional plans as significant threats; and (3) Institutional Coordination – the action plan's participatory monitoring approaches and educational initiatives facilitate stakeholder engagement processes required by Natura 2000 management frameworks.

8. Pilot site Action plan

> **ACTION 1** > **TITLE OF THE ACTION**	**Incorporation of HUMANITA Visitor Impact Monitoring Results into Operational Forest Management Planning**
> **DESCRIPTION**	> Integration of HUMANITA visitor monitoring data, ecological impact assessments and management recommendations into all relevant forest management plans (Erdőterv) so that visitor impact thresholds and mitigation measures become part of routine forest planning and operations.
> **SPECIFIC OBJECTIVES**	> Translate HUMANITA indicators (trampling, soil compaction, disturbance) into quantified management benchmarks for forest compartments. > Define visitor management zones (restricted, managed, intensive use) within forest plans. > Embed protocols for trail maintenance, seasonal closures and habitat protection into plan annexes. > Align forest monitoring with HUMANITA methods for long-term impact tracking
> **PROJECT MANAGEMENT TOOLS**	> Multi-stakeholder working group (BNPD, forest managers, authorities) > Draft amendment templates for forest plans
> **RESPONSIBLE DEPARTMENT(S)**	> BNPD Nature Conservation Department and Ranger Service
> **INVOLVED STAKEHOLDERS**	> BNPD conservation staff; regional forest management districts and companies; county forest authorities; relevant ministries; academic experts from forestry and ecology
> **IMPLEMENTATION STEPS**	> 1. Analyse HUMANITA datasets; extract forest-relevant indicators > 2. Draft proposed text and maps for inclusion in upcoming forest plan revisions

	> 3. Conduct formal consultations and adjust drafts > 4. Submit and adopt amendments within regular forest planning cycles
> **IMPLEMENTATION PERIOD TIMELINE**	> Preparation and first round of integrations: 2026–2028; thereafter aligned with each 10-year forest planning cycle (continuous).
> **POSSIBLE FUNDING SOURCE AND COSTS ESTIMATION**	> BNPD core budget; targeted applications to KEHOP/KEHOP Plus or national nature-conservation funds for workshops and expert studies
> **EXPECTED RESULTS / MONITORING**	> 100% of Natura 2000 forest area under BNPD has defined visitor impact thresholds and zoning. > Regular reporting on how monitoring results triggered management adjustments (e.g., changed trail routing, new seasonal closures). > Reduced incidence of forest habitat degradation attributable to tourism, documented by repeated HUMANITA-type surveys.

> **ACTION 2** > **TITLE OF THE ACTION**	**Grassland Habitat Reconstruction in the Mátra Foothills and Mountain Meadows Using HUMANITA-Informed Visitor Impact Mitigation**
> **DESCRIPTION**	> Implementation of large-scale restoration on approx. 70.5 ha of degraded grasslands and mountain meadows in the Mátra region (KEHOP Plus project), while using HUMANITA visitor-flow data and impact assessments to design access, timing and infrastructure so that restored habitats remain resilient to tourism pressures.
> **SPECIFIC OBJECTIVES**	> - Remove shrubs, invasive trees and dense litter to restore semi-natural grassland structure. > Re-establish traditional management (mowing, targeted grazing) where appropriate. > Use HUMANITA data to locate trails, viewpoints and barriers to minimise trampling in sensitive patches. - Monitor vegetation and target species in parallel with visitor pressure indicators. > Maintain landscape connectivity between restored patches.
> **PROJECT MANAGEMENT TOOLS**	> Detailed habitat restoration plan with GIS layers combining ecology and visitor data. > KEHOP Plus project management structure (milestones, indicators, procurement). > Standardised monitoring protocols

> **RESPONSIBLE DEPARTMENT(S)**	> BNPD Mátra Ranger Service and BNPD Project Management Department
> **INVOLVED STAKEHOLDERS**	Local municipalities (Mátraszentimre, Parád, Gyöngyössolymos, Gyöngyös/Pálosvörösmart/Abasár); local farmers and landowners; contracted restoration companies; academic botanists and zoologists; tourism operators using the restored areas.
> **IMPLEMENTATION STEPS**	1. Finalise site-level restoration designs integrating HUMANITA visitor-flow maps. 2. Secure permits and agreements with landowners/municipalities. 3. Procure contractors and equipment. 4. Carry out shrub removal, invasive control, mowing and biomass removal. 5. Install or adjust trails, waymarking, barriers and information panels based on sensitivity. 6. Start long-term vegetation and target-species monitoring alongside visitor-use monitoring. 7. Adjust management based on monitoring results
> **IMPLEMENTATION PERIOD TIMELINE**	> Restoration implementation: 2025–2028; follow-up management and monitoring: from 2028 onward (at least 10 years).
> **POSSIBLE FUNDING SOURCE AND COSTS ESTIMATION**	> KEHOP Plus 3.2.1 (main capital and operational costs – total project about 120 million HUF). > Additional national Natura 2000 and agri-environment payments for ongoing management. > BNPD own budget for monitoring
> **EXPECTED RESULTS / MONITORING**	> 70.5 ha of grassland in favourable or improving conservation status (structure, species composition). > Increased populations of key species (e.g. leánykökörcsin, piros kígyószisz, Janka-tarsóka, specialist butterflies). > Visitor use largely confined to designated routes; off-trail damage <5–10% of restored area

> **ACTION 3** > **TITLE OF THE ACTION**	**Bél-kő Upper Quarry Educational Trail with HUMANITA-Based Visitor Management and Interpretation**
> **DESCRIPTION**	> Construction and operation of a 2–3 km educational trail in the Bél-kő upper quarry area, combining physical infrastructure (paths, viewpoints, barriers) with interactive

	interpretive tools modelled on HUMANITA's Suba-lyuk trail. The trail guides visitor flows away from the most sensitive botanical and faunal sites while providing high-quality education about geology, biodiversity, and visitor impacts.
> **SPECIFIC OBJECTIVES**	> Clearly delineate a safe, attractive trail circuit through the former quarry. > Protect priority habitats by restricting access to defined viewing points. > Deploy interactive interpretation (QR codes, digital content, possibly AR) illustrating geology, habitats, and tourism impacts. > Embed a visitor monitoring scheme (counters, trail-condition checks, simple surveys).
> **PROJECT MANAGEMENT TOOLS**	> KEHOP Plus project management framework and Gantt chart. > Trail routing and sensitivity maps > Design dossiers for infrastructure and signage. > Monitoring protocols for trail condition, visitor counts and off-trail use.
> **RESPONSIBLE DEPARTMENT(S)**	> BNPD West Bükk Ranger Service, BNPD Project Management Department
> **INVOLVED STAKEHOLDERS**	> BNPI (Nyugat- and Kelet-Bükki Tájegység, ecotourism and conservation staff); Bélapátfalva municipality; contractors (trail building, signage); interpretation designers; schools and tour operators using the trail; forestry and nature-conservation authorities.
> **IMPLEMENTATION STEPS**	> 1. Finalise route and design based on sensitivity analysis. > 2. Obtain permits and stakeholder approvals. > 3. Tender and contract trail and infrastructure works. > 4. Build or refurbish paths, railings, small structures, and viewpoints. > 5. Install informative and warning signs plus interactive elements tied to HUMANITA messages. > 6. Set up visitor counters and trail inspection schedule. > 7. Launch trail and run pilot guided tours; fine-tune based on feedback and monitoring.
> **IMPLEMENTATION PERIOD TIMELINE**	> Planning & permitting: 2025; construction and installation: 2026–2027; full operation and routine monitoring from 2027 onward.
> **POSSIBLE FUNDING SOURCE AND COSTS ESTIMATION**	> KEHOP Plus 3.2.1 (Bél-kő project – about 100 million HUF total, Bél-kő share including trail ≈ 40–60 million HUF).

> EXPECTED RESULTS / MONITORING	> Completed loop trail with clear zoning and interpretation. - >90% of visitors remain on marked paths (measured by observations and counters at shortcuts). > Decrease or stabilization of habitat degradation indicators in formerly trampled zones. > Annual visitor-use statistics, condition surveys and short questionnaires informing future adjustments

> ACTION 4 > TITLE OF THE ACTION	**Long-Term Deployment of the Hulladékradar App for Litter Monitoring in BNPI Areas**
> DESCRIPTION	> Continued and expanded use of the Hulladékradar mobile application as a citizen-science tool to record and map litter occurrences in and around protected areas. Data from visitors and volunteers will support prioritisation of clean-ups, enforcement, and targeted awareness campaigns, and will become a permanent indicator of tourism-related pressure
> SPECIFIC OBJECTIVES	> Maintain active use of the app across key sites (Bükk, Mátra, major valleys). > Identify and regularly update maps of litter “hotspots”. > Integrate litter data into BNPI monitoring and management decisions.
> PROJECT MANAGEMENT TOOLS	> Volunteer network management tools (mailing list, social media groups). > Dashboard for visualisation of litter reports and trends.
> RESPONSIBLE DEPARTMENT(S)	> BNPD Ecotourism Department
> INVOLVED STAKEHOLDERS	> Hulladékradar developers; local municipalities and waste-management companies; nature-conservation NGOs; schools and volunteer groups; visiting tourists.
> IMPLEMENTATION STEPS	> 1. Promote the app via panels at entrances, website, and social media. > 2. Train rangers, guides, and key volunteers to use and explain the app. > 3. Periodically extract and analyse data, create hotspot maps. > 4. Organise clean-ups and enforcement actions based on hotspot data.

> IMPLEMENTATION PERIOD TIMELINE	> 2026 onwards (continuous).
> POSSIBLE FUNDING SOURCE AND COSTS ESTIMATION	> BNPD core budget
> EXPECTED RESULTS / MONITORING	> Year-on-year comparison of hotspot locations and contamination levels to assess whether education and enforcement are reducing littering. > Quantified correlations between visitor volume and litter occurrence (e.g. peak season vs. off-season; weekends vs. weekdays).

> ACTION 5 > TITLE OF THE ACTION	**Long-Term Expansion of iNaturalist Biodiversity Citizen Science Platform for BNPI Protected Area Monitoring**
> DESCRIPTION	> Sustained and expanded deployment of iNaturalist as a primary distributed biodiversity monitoring network, engaging visitors, schools, local naturalists, and researchers to document species occurrences across all habitat types in BNPI territory. Observations will feed into conservation status assessments, early detection of invasive species, climate-change impacts, and will simultaneously serve as a powerful educational and engagement too
> SPECIFIC OBJECTIVES	> Document species distributions and temporal trends, particularly for protected/threatened species and invasives. > Build an active community of iNaturalist contributors focused on BNPI areas
> PROJECT MANAGEMENT TOOLS	> iNaturalist project administration interface and dataset management. > Species-identification field guides and keys (printed and digital). > Training modules for community groups and teachers.
> RESPONSIBLE DEPARTMENT(S)	> BNPD Nature Conservation Department
> INVOLVED STAKEHOLDERS	> BNPI (conservation research, education, community engagement staff); iNaturalist global platform team; individual naturalists and amateur scientists; schools (teachers and students); naturalist societies and bird-watching clubs; tourism guides and hospitality operators; academic research partners (universities); international biodiversity research networks.

> **IMPLEMENTATION STEPS**	> 1. Develop and print species identification guides for common groups (birds, butterflies, wildflowers, amphibians, etc. > 2. Create interpretive signage at key visitor locations explaining iNaturalist, QR codes linking to platform. > 3. Reach out to schools (environmental studies, biology classes) to integrate iNaturalist into curriculum.
> **IMPLEMENTATION PERIOD TIMELINE**	> Establishment and initial recruitment: 2026; full operation and data integration: 2026 onwards (continuous, expanding year-on-year).
> **POSSIBLE FUNDING SOURCE AND COSTS ESTIMATION**	> iNaturalist platform access: no direct cost – rest BNPD core budget and international funding scouces
> **EXPECTED RESULTS / MONITORING**	> iNaturalist project for BNPI established with clear metadata and observation guidance. > Geographic coverage: all major vegetation zones and habitat types (grasslands, forests, wetlands, caves, rocky outcrops). > Detection of invasive species establishment or range expansion (e.g. Impatiens parviflora, alien snails, neozoan insects) enabling early management response > Community awareness: demonstrated increase in naturalist club membership and informal nature-study groups in BNPI region.

9. Zone Plan

The Bükk National Park Directorate (BNPD) operates within a zoning framework established through the BNPD Management Plan and applicable nature conservation legislation (1996/LIII Nature Protection Act). The proposed zone plan modifications outlined in this section represent refinements to this existing zoning system based on findings from three years of HUMANITA project monitoring and pilot testing. Rather than creating new zones, this plan recommends strategic adjustments to visitor management practices, tourism infrastructure development, and access controls within the existing A, B, and C zone classifications to better align recreational use with conservation objectives identified through evidence-based monitoring.

9.1. Existing BNPD Zoning Framework

The BNPD Management Plan designates protected areas according to the following classification structure:

A-Zone (Strictly Protected Areas – Fokozottan Védett Terület):

- Covers the most ecologically sensitive core habitats and species populations requiring maximum protection from disturbance.
- Legally restricted to designated hiking trails only; off-trail access is prohibited.

- Tourism infrastructure is minimal and limited to trail maintenance and trail marking.
- Examples: Bükk Plateau (Bükk-fennsík), cave ecosystems (non-show caves), rare specialist habitat patches

B-Zone (Protected Areas - Védett Terület):

- Encompasses areas of significant conservation value but with greater resilience to some visitor activity
- Permits hiking and walking access on designated trails plus limited additional activities (e.g., nature photography, scientific research, educational programming)
- Some basic tourism infrastructure permitted (information signage, modest facilities)
- Subject to event permitting system for organized activities.

C-Zone (Managed Recreation Areas - Kezelés Alatt Álló Terület):

- Represents landscape protection areas and managed recreation zones where conservation objectives can be compatible with sustainable tourism use.
- Permits diverse recreational activities within management guidelines (hiking, cycling, horseback riding, picnicking in designated areas)
- Supports infrastructure development (visitor centres, parking, amenities, trails)
- Represents interface between protected area and broader landscape management.

9.2. HUMANITA-Informed Modifications to Zone Management

9.2.1. Modifications to A-Zone (Strictly Protected Areas) Management

The HUMANITA project monitoring, particularly at Tar-kő Peak and Forrs Valley cave sites, identified two critical management needs within A-zones that the existing regulatory framework does not adequately address:

9.2.1.1. Designated Trail Visitor Monitoring System:

Building on HUMANITA pilot testing of visitor flow monitoring, the BNPD will implement systematic visitor monitoring on all designated trails within A-zones. This initiative will:

- Deploy automatic counters (infrared sensors) at strategic points on major A-zone trails to document visitor numbers, temporal patterns, and peak-use periods.
- Correlate visitor flow data with ecological condition monitoring (vegetation damage, wildlife disturbance, cave microclimate changes) using protocols tested during HUMANITA.
- Establish quantified visitor impact thresholds for each trail segment, calibrated to preserve habitat integrity and species populations.
- Implement adaptive management protocols: if monitoring indicates exceedance of thresholds (e.g., >30% increase in vegetation disturbance area within one season, acoustic disturbance to bat colonies beyond tolerance limits), temporary trail closures or visitor diversion measures will be activated.
- Maintain integration between visitor monitoring and biological monitoring to document whether visitor management adjustments are achieving conservation goals.

9.2.1.2. Temporal Access Restrictions Based on Biological Sensitivity:

The HUMANITA project documented critical biological windows when visitor disturbance poses maximum risk to sensitive species (bat hibernation/breeding seasons in caves, raptor nesting in spring, amphibian breeding in specific wetland periods). The updated zone management will:

- Establish seasonal closure protocols for specific A-zone areas during critical conservation periods (e.g., October-April for cave sites with hibernating bats; March-June for raptor nesting sites; March-May for amphibian breeding sites).
- Deploy interpretive signage explaining conservation rationale for closures, transforming restrictions into educational opportunities.
- Maintain exceptions for scientific research, monitoring, and conservation management activities requiring special permits.
- Publish annual closure calendars on BNPD website and key information platforms.

9.2.2. Modifications to B-Zone (Protected Areas) Event Permitting System

HUMANITA project findings revealed that organized events (trail running competitions, mountain biking races, group tours) can generate acute visitor concentrations that exceed habitat carrying capacity and violate species protection objectives. The updated event management framework will:

9.2.2.1. Evidence-Based Event Assessment Protocols:

- Utilize HUMANITA-derived visitor impact assessment methodologies to evaluate event applications.
- Assess: (1) expected visitor numbers and temporal concentration; (2) event footprint in relation to sensitive habitat boundaries; (3) timing in relation to critical biological windows; (4) comparison with documented visitor impact thresholds for the area
- Require event organizers to submit: visitor management plan (route briefings, signage, group size limits), ecological baseline data (vegetation condition, species status photos taken in advance), and post-event monitoring protocols
- Permit events only when management measures can demonstrably prevent exceedance of conservation impact thresholds.
- Examples of permissible events under updated protocols:
    - Small-group guided nature tours (max 15-20 persons) in B-zones during non-critical seasons.
    - Organized clean-up activities (Hulladékradar-based litter removal events) – permitted year-round as they generate conservation benefits.
    - Educational activities directly contributing to nature literacy and conservation support.
- Examples of activities likely to be restricted:
    - High-speed athletic competitions (trail running races, mountain bike races) in sensitive habitat areas during nesting/breeding seasons.
    - Large events generating peak-hour visitor densities >2-3 persons/hectare in sensitive grassland or cave ecosystems.
    - Events in A-zones with sensitive cave ecosystems or endangered species colonies move to modification to Zone A

9.2.3. Modifications to C-Zone (Managed Recreation Areas) Tourism Infrastructure Development

HUMANITA monitoring identified that tourism infrastructure development (trails, facilities) in C-zones, if poorly designed, can inadvertently redirect visitor pressures toward adjacent protected areas or create ecosystem damage through concentrated use. The updated framework for C-zone infrastructure development incorporates HUMANITA-derived best practices:

9.2.3.1. Tourism Infrastructure Design Guidelines for C-Zones:

- **No New Trail Designation in A-zones**: Consistent with HUMANITA findings that visitor concentration on poorly maintained or inappropriately routed trails creates habitat fragmentation and species disturbance, no new hiking trails will be designated in A-zones. Existing trails will be optimized through maintenance and signage; new access demands will be accommodated through C-zone trail network expansion. Refer also in zone A
- **Strategic Visitor Concentration in C-Zones**: New tourism infrastructure in C-zones will be explicitly designed to concentrate visitor activity away from adjacent A-zone boundaries, creating spatial buffers through attractive facilities, interpretation, and amenities in C-zones (visitor centres, picnic areas, parking, scenic viewpoints)
- **Trails as Visitor Management Tools:** Trail design in C-zones will incorporate HUMANITA-tested principles:
    - Clear trail demarcation (painted markers, signs) to prevent off-trail wandering toward sensitive areas.
    - Strategic trail routing away from A-zone boundaries using landscape features and positive incentives (scenic overlooks, information points) rather than negative restrictions.
    - Trail maintenance at level sufficient to keep trails attractive and prevent visitor migration to social trails toward sensitive areas.
    - Integration of environmental education content into trail design (interpretive signs explaining ecological values of adjacent A-zones, visitor impact mitigation rationale)
- **Amenity Provision in C-Zones:** New visitor amenities (toilets, waste bins, water points, parking) will be concentrated in C-zones, reducing visitor impacts in more sensitive areas and providing infrastructure support for visitor experience quality.
- **Seasonal Access Management:** In C-zones adjacent to sensitive A-zones, seasonal trail access restrictions may be implemented during critical biological windows (e.g., raptor nesting season restrictions on trails with views of nesting cliffs) using soft education and signage rather than legal closure.

10. Remarks and Conclusions

The HUMANITA project represents a paradigm shift in the Bükk National Park Directorate's approach to tourism impact management, transitioning from ad-hoc, observation-based management to systematically evidence-based, adaptive management informed by three years of intensive monitoring using cutting-edge technologies and methodologies.

10.1. Principal Findings and Their Management Implications

10.1.1. Quantification of Tourism-Ecological Linkages

The project established empirical evidence of specific visitor-impact mechanisms: trampling damage is highly localized (>90% occurs within 0.5-1.0 meters of trail edges) with rapid habitat recovery when access is prevented; visitor pressure is highly seasonal (peak impacts May-October); chytrid fungal infection rates in amphibian populations at high-visitation sites are significantly elevated, providing rare empirical evidence of pathogen transmission via tourism; and wildlife responses show species-specific tolerance thresholds. This quantitative foundation enables targeted, evidence-based management (restricting specific activities in specific locations during specific periods) rather than broad precautionary restrictions.

10.1.2. Development of Replicable Monitoring Infrastructure and Protocols

Standardized, transferable monitoring systems are now available for long-term operational use: automatic counters, cellular data analysis, Strava activity analysis; coenological vegetation surveys, photo-point monitoring, acoustic surveillance; GIS frameworks linking visitor density to ecological condition; and citizen science platforms (Hulladékradar, iNaturalist). These systems enable detection of whether management interventions are achieving intended conservation outcomes and support long-term data continuity.

10.1.3. Innovation in Visitor Education and Engagement

Interactive educational trails and transparent communication of monitoring data make abstract conservation principles concrete and understandable. Visitor empowerment through citizen science engagement and interpretive infrastructure reflecting contemporary conservation science creates engagement across diverse demographics and enhances social license for conservation restrictions.

10.1.4. Institutional Capacity Building and Knowledge Development

Staff training in monitoring methodology, data analysis, and GIS analysis; integration of ecology, visitor management, education, and recreation planning; and international knowledge exchange through INTERREG Central Europe have created technical expertise and interdisciplinary collaboration that will enhance management effectiveness for decades.

10.1.5. Alignment with Broader Policy Frameworks

The action plan operationalizes EU Biodiversity Strategy 2030 commitments to improve protected area management effectiveness and achieve favorable conservation status; Natura 2000 management objectives through concrete actions with measurable outcomes; Hungarian Nature Conservation Act principles regarding evidence-based management and public participation; and sustainable tourism development supporting regional economic development while protecting ecological values.

10.2. Conclusion

The Bükk National Park Directorate has been provided with scientific foundation, institutional capacity, and proof-of-concept demonstrations necessary for systematic, evidence-based visitor impact management. Success depends on institutional commitment to implementation, sustained resource dedication, genuine stakeholder engagement, and adaptive learning culture. The BNPD possesses the technical expertise and conservation mandate necessary for success. The challenge ahead is to walk the pathway illuminated by the HUMANITA project consistently, learning and adapting as new information emerges, ensuring that the Bükk Mountains remain a thriving, dynamic ecosystem for centuries to come.