RECREATION IN CZECH NATIONAL PARKS: TOURISM INTENSITY VS. VULNERABILITY OF PRIORITY AREAS

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Abstract
This study demonstrates how high-value protected areas are increasingly exposed to anthropogenic pressures, particularly landscape fragmentation and intensive tourism. Using Krkonoše National Park (KRNAP) as a case study, we integrated biological and environmental data describing natural values and invasive plant occurrence with spatial indicators of tourism intensity and recreational use. These datasets were synthesized to develop a typology capturing the relationships between ecological sensitivity and potentially harmful human activities. Our results indicate that the most valuable and vulnerable sites are concentrated in the core zones of the national park and, with the exception of built-up areas and their surroundings, significantly overlap with the most frequently visited locations. The approach presented here will be extended to all national parks in Czechia in the coming years. In the context of steadily increasing visitor numbers, understanding these interactions represents a critical prerequisite for the effective management of protected areas.

Key words: anthropogenic pressure, Krkonoše, landscape fragmentation, protected areas

Introduction

Protected areas (PAs) in the highly modified landscapes of Central Europe face increasing anthropogenic pressures that threaten their relatively natural and sensitive ecosystems. Since the first Czech National Parks (NPs) and Protected Landscape Areas (PLAs) were established in the 1950s, both anthropogenic structures and recreational use have increased considerably (Janík et al., 2024). In recent years, particularly after the COVID-19 pandemic, visitor numbers in the most attractive parts of PAs have grown even further. Consequently, effective PA management therefore requires an integrated assessment of internal pressures, conservation priorities, ecosystem vulnerability and the characteristics of municipalities within the PA.

The objective of this study is to synthesize these perspectives, reveal spatial patterns and identify localities where targeted management measures are needed. This paper focuses on KRNAP, while comparable assessments of the other Czech national parks are planned in the coming years.

Material and methods

The area will be captured in three different perspectives:

Pressures versus conservation priorities

Anthropogenic pressures were quantified by fragmentation analysis using the effective mesh size method (EMS; Jaeger, 2000; Moser et al., 2007). The analysis combined a regular 100 x 100 m grid with fragmentation geometry derived from built-up areas and the road network (ZABAGED – Land Survey Office 2024; KVES – NCA CR 2023). To better capture recreational pressure, the infrastructure layer was complemented by STRAVA data (https://www.strava.com/) linked to the OpenStreetMap path network. Comparison with data from Eco-Counter profiles showed a high

correlation, suggesting that the STRAVA-based model provides a useful proxy for visitor movement intensity. Modeled flow was then converted to a buffer around path sections (1 unit of modeled flow = 1 mm radius). The final fragmentation layer—incorporating both physical structures and recreational intensity—was intersected with a conservation priority layer generated in Zonation (Moilanen et al. 2005). These priorities were derived from habitat suitability models for 65 threatened and vulnerable species alongside other ecologically valuable habitats and landscape features.

Ecosystem vulnerability

Habitats within KRNAP were classified based on their susceptibility to plant invasions using the Detailed Habitat Layer 2022 (Global Change Research Institute CAS, 2025). Affinity was assessed across six groups of mechanisms affecting propagule pressure, establishment and spread: landscape context, connectivity, succession, disturbance, management and socio-cultural conditions. Each mechanism was scored on a 0-9 scale, where higher values indicate conditions facilitating plant invasion. This assessment effectively distinguished between degraded or ruderal habitats with high invasion risk and semi-natural or isolated habitats with lower susceptibility.

Characteristics of municipalities

To complement the environmental assessment, the study also analysed the socio-economic characteristics of municipalities in the KRNAP region. Tourism was treated as a spatial development process affecting demographic dynamics, housing markets, local economies and governance capacities (Butler, 1980; Hall and Williams, 2008; Müller, 2011). The analysis drew on demographic, economic and spatial indicators derived from Czech Statistical Office data, cadastral records, tourism statistics and anonymized GSM-based geolocation data capturing the actual presence of people in municipalities during working days, weekends and seasonal peaks. Combining conventional statistics with geolocation-based indicators helps reduce bias caused by the underrepresentation of small accommodation facilities and informal rentals in official statistics. Standardized indicators were used in a hierarchical cluster analysis based on Euclidean distance to identify groups of municipalities with similar development profiles.

Results

Areas with minimal landscape fragmentation occur mainly in the summit parts of KRNAP and in some southern peripheral sections. While conservation priorities are heavily concentrated at higher altitude, these areas are often intersected by intensively used tourist routes, for example around Labská louka and Liščí hora. Large high-value areas remain near the highest peaks (Sněžka, Luční hora and Studniční hora), without recreational use these core areas would form larger continuous patches (Fig. 1).

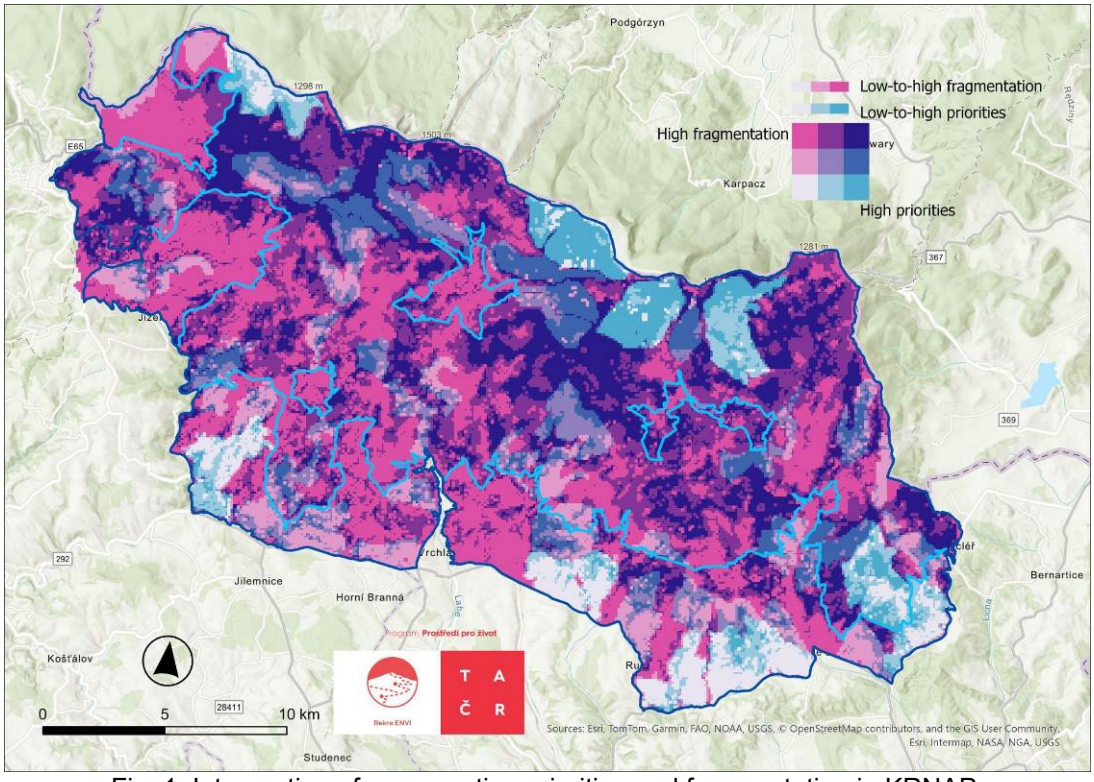

Fig. 1: Intersection of conservation priorities and fragmentation in KRNAP.

Susceptibility to plant invasions ranges from negligible in peat bogs and high-alpine habitats to high in ruderal stands and heavily disturbed urban sites. The spatial pattern closely follows altitude and distance from settlements, with the highest invasion affinity occurring in lower parts of the KRNAP, near built-up areas (Fig. 2).

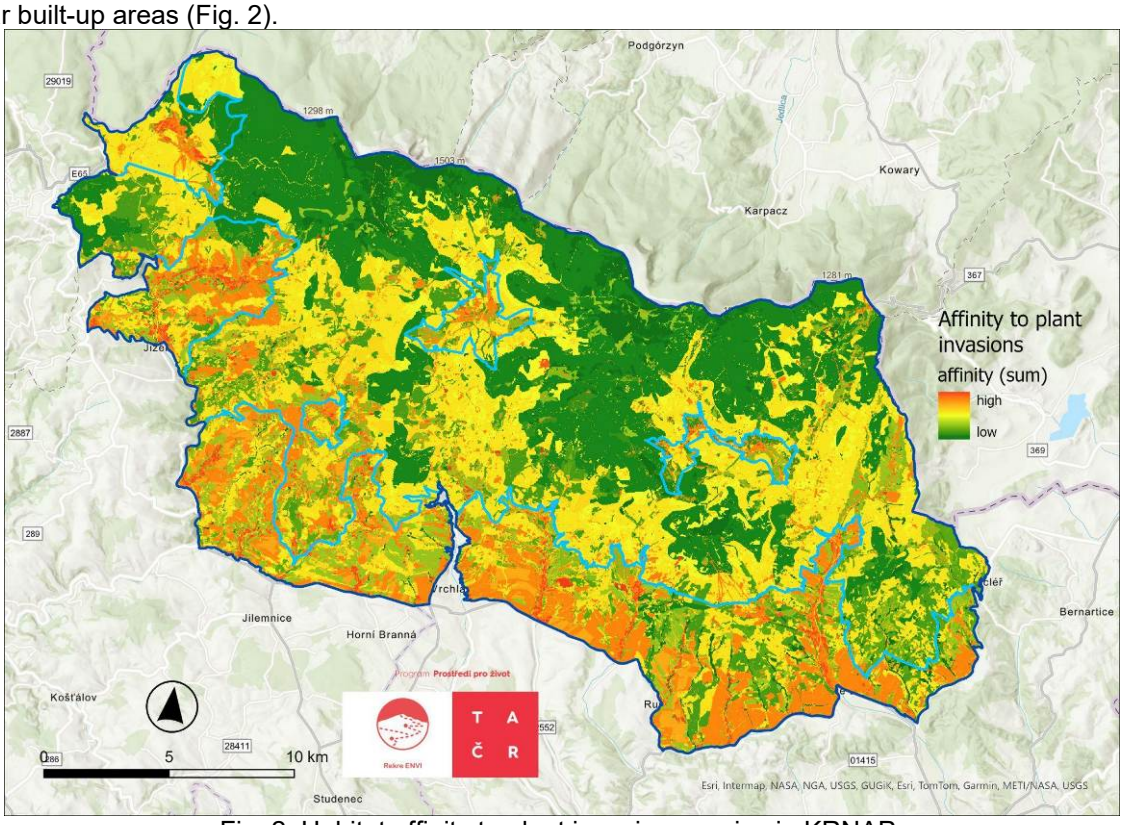

Fig. 2: Habitat affinity to plant invasion species in KRNAP.

Cluster analysis identified five municipality types reflecting different relationships between tourism intensity, housing structure and demographic development. The typology reveals a gradient from diversified foothill centers through traditional mountain resorts to specialized tourism centers. In the most tourism-oriented municipalities, tourism strongly influences housing markets through the growth of second homes and investment apartments (types 1–3). These municipalities also show a gap between registered population and actual presence, indicating seasonal pressure on infrastructure and services. In contrast, less tourism-intensive types maintain more diversified economic structures and greater capacity for future residential or recreational development (types 4–5; Fig. 3).

Discussion

The results reveal a distinct spatial pattern between conservation priorities and the distribution of anthropogenic pressures. While the most valuable parts of KRNAP are concentrated in high-altitude core areas, these same localities are intersected by some of the most intensively used tourist routes. This pattern suggests that recreation pressure is not confined to settlements and access corridors; it also penetrates the ecologically most sensitive parts of the park. In contrast, invasion risk is highest in lower elevations near municipalities and transport-linked habitats. Together, these patterns indicate that different management problems dominate in different parts of the park: visitor regulation is most urgent in high altitudes, while prevention and early control of invasive species are especially important in foothill zones and settlement-related habitats. The municipal typology adds an important planning dimension by showing where tourism-driven development already imposes seasonal stress on housing and infrastructure and where further development pressure may emerge in the future.

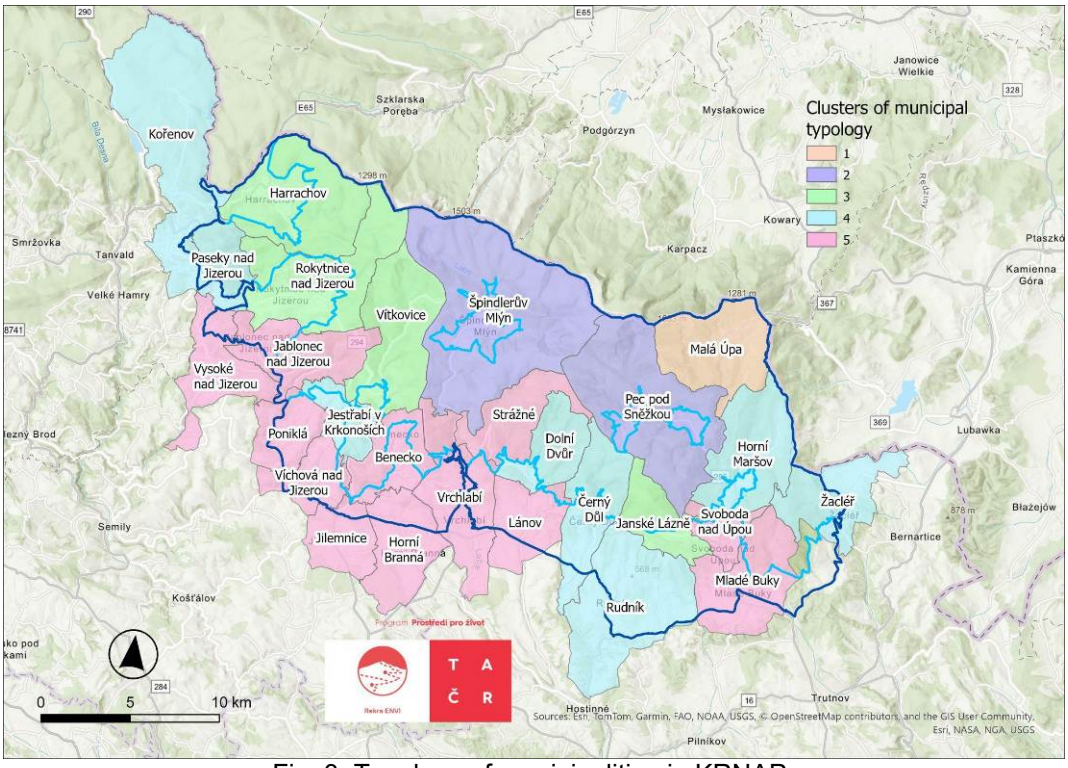

Fig. 3: Typology of municipalities in KRNAP.

Conclusion

This study provides a spatially explicit overview of key values and threats in KRNAP in relation to conservation priorities and increasing recreational pressure. It identifies localities where targeted management is most needed and demonstrates the benefit of linking fragmentation, visitor intensity, prioritization, habitat vulnerability and municipal development trajectories within one analytical framework. Given the continuing growth of visitor pressure, comparable analyses should be carried out for the other Czech national parks to support more proactive and spatially differentiated management.

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Souhrn
Příspěvek představuje integrované hodnocení vztahu mezi přírodními hodnotami a antropogenními tlaky v KRNAPu. Jde o propojení analýzy fragmentace krajiny, intenzity návštěvnosti, prioritizace územní ochrany, zranitelnosti biotopů vůči invazním druhům a socioekonomických charakteristik obcí. Výsledky ukazují, že nejcennější části KRNAP se soustřeďují především do výše položených území, která se však zároveň zčásti překrývají s nejintenzivněji využívanými turistickými trasami. Naopak vyšší náchylnost k šíření nepůvodních druhů se projevuje hlavně v nižších polohách a v blízkosti sídel. Typologie obcí ukazuje gradient od podhůří do jádra národního parku, kde cestovní ruch výrazně ovlivňuje bydlení, infrastrukturu a sezónní zatížení území. Studie tak přináší praktický podklad pro prostorově cílený management národního parku a současně vytváří metodický rámec pro obdobné hodnocení ostatních národních parků v Česku.

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