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Short Note

First analysis of European bison damage to trees in Poloniny National Park, Slovakia

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Abstract

The European bison (*Bison bonasus* L.) is a keystone megaherbivore whose growing population in Central Europe raises new conservation and management challenges, particularly in forested and agricultural landscapes. In Slovakia's Poloniny National Park, the only region in the country with a free-ranging European bison population, concerns over forest damage prompted an investigation into the species' trophic preferences. We assessed browsing pressure across five forest sites, analysing damage to seven common tree species using a generalized linear mixed model. Our results reveal strong species-specific preferences, with Norway spruce and silver fir showing the highest probabilities of bison-induced damage, while European beech and hornbeam were least affected. These findings suggest that European bison browsing is non-random and may influence forest composition over time. The study highlights the need for targeted management strategies to mitigate negative impacts on forestry while supporting the continued conservation of this emblematic species.

The European bison, or wisent (*Bison bonasus* L.), is the largest extant terrestrial mammal in Europe. It was driven to extinction in the wild during the 20th century, surviving only in captivity before successful reintroduction efforts. Two subspecies are generally recognized: the mountain or Caucasian bison (*Bison bonasus caucasicus* Turkin and Satunin 1904) and the lowland or Białowieża bison (*Bison bonasus bonasus* L.) (Krasiński and Krasińska, 2007). Unlike the mountain bison, which became completely extinct in the early 20th century, the lowland bison has persisted to the present day. Historically, the lowland subspecies inhabited forested regions across western, central, and southeastern Europe (Heptner et al., 1966).

Thanks to successful captive breeding programs and reintroduction efforts in suitable habitats, the global lowland bison population now numbers approximately 8,000 individuals, with nearly half residing in Poland and Belarus (Bluhm et al., 2025). In Slovakia, free-ranging lowland bison are found only in Poloniny National Park (NP), located in the northeastern part of the country (Pčola, 2012). This population has expanded significantly since the introduction of five founder individuals in 2004 and, as of 2024, comprises 58 animals (Raczyński and Bołbot, 2023; Vajanský, 2024). The European bison in Poloniny range within a predominantly forested (sub)montane landscape, where European beech (*Fagus sylvatica* L.) is the dominant tree species (Pčola, 2006).

As a megaherbivore, the European bison functions as a keystone species, enhancing biodiversity through selective feeding (Gottlieb et al., 2024), which in turn creates open habitats for other organisms (Perzanowski and Paszkiewicz, 2000; Jaroszewicz and Pirożnikow, 2008), as well as facilitating plant seed dispersal (Jaroszewicz et al., 2008). However, increasing wisent numbers in Slovakia and elsewhere pose emerging challenges for conservation and management, particularly due to their potential for causing damage to crops and forest stands. Severe damage to forests is caused mainly by bark stripping, which facilitates fungal infection (Paszkiewicz and Januszczak, 2010). This can elevate the risk of human–wildlife conflict (Hofman-Kamińska and Kowalczyk, 2010, 2012), potentially threatening the long-term viability of the species. Despite this, the extent of damage caused by European bison to crops and woody vegetation remains insufficiently studied, and data on their dietary preferences—especially in Poloniny NP—are still lacking. In this study, we investigated the dietary preferences of wisent using field observations of damage to forest stands within five research plots in Poloniny NP, West Carpathians, Slovakia.

We evaluated wisent browsing preferences among tree species using field data collected from five forest sites, each subdivided into three distinct plots. All individual trees within each research plot were recorded, rather than a subsample, ensuring complete coverage of species availability. For each plot, the number of individual trees per species was recorded and categorized by browsing status: undamaged, damaged (chewed), or destroyed by wisent. The total number of trees per observation was calculated by summing these categories. Tree species with fewer than 50 total individuals observed across all plots were excluded from analysis to reduce bias caused by low-frequency categories, resulting in a final dataset including European beech (*Fagus sylvatica* L.), silver birch (*Betula pendula* Roth), European hornbeam (*Carpinus betulus* L.), silver fir (*Abies alba* Mill.), sycamore maple (*Acer pseudoplatanus* L.), European ash (*Fraxinus excelsior* L.), and Norway spruce (*Picea abies* (L.) Karst.). To provide context for browsing intensity, we report the availability of tree species across all plots (Tab 1). This allows direct comparison between species abundance and browsing probability.

To assess whether wisent exhibited preferences for particular tree species, we fitted a generalized linear mixed model (GLMM, Bolker et al. 2009) with a binomial error distribution and a logit link using the glmmTMB package (Brooks et al., 2017). The response variable was constructed as a two-column matrix of damaged (i.e., chewed plus destroyed) versus undamaged trees. Tree species was included as a fixed effect, and plot identity nested within site was included as a random in-

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Table 1 – Availability of tree species in each study stand and plot. Numbers represent total individuals per plot; percentages show relative abundance within the plot. Only the seven tree species included in the analysis are listed separately; all other species are grouped under "Other spp.".

Stand/Plot	Beech	Fir	Spruce	Sycamore	Hornbeam	Birch	Ash	Other spp.
7930b/P1	13 (31.0%)	19 (45.2%)	1 (2.4%)	1 (2.4%)	2 (4.8%)	2 (4.8%)	–	4 (9.5%)
7930b/P2	–	63 (100%)	–	–	–	–	–	–
7930b/P3	–	77 (100%)	–	–	–	–	–	–
7931b/P1	–	–	43 (91.5%)	–	4 (8.5%)	–	–	–
7931b/P2	–	–	–	–	–	–	66 (100%)	–
7931b/P3	10 (23.8%)	–	–	–	4 (9.5%)	18 (42.9%)	–	10 (23.8%)
7933b_2ps/P1	–	–	–	108 (100%)	–	–	–	–
7933b_2ps/P2	–	–	105 (100%)	–	–	–	–	–
7933b_2ps/P3	–	–	28 (30.1%)	–	58 (62.4%)	2 (2.2%)	–	5 (5.4%)
7946_2ps/P1	8 (11.6%)	15 (21.7%)	–	–	29 (42.0%)	–	–	17 (24.6%)
7946_2ps/P2	82 (91.1%)	–	–	–	–	5 (5.6%)	–	3 (3.3%)
7946_2ps/P3	63 (87.5%)	–	–	–	–	2 (2.8%)	–	7 (9.7%)
7953_2ps/P1	3 (4.2%)	16 (22.2%)	–	50 (69.4%)	–	–	–	3 (4.2%)
7953_2ps/P2	8 (18.6%)	–	–	35 (81.4%)	–	–	–	–
7953_2ps/P3	7 (14.9%)	37 (78.7%)	–	3 (6.4%)	–	–	–	–

tercept to account for spatial clustering and the hierarchical sampling design.

Model diagnostics were conducted using the DHARMa package (Hartig, 2024) to ensure the validity of model assumptions. Simulated residuals showed no significant deviation from uniformity (Kolmogorov–Smirnov test: $p = 0.146$), no evidence of overdispersion (dispersion $= 0.691$, $p = 0.064$), and no outlier inflation (expected outlier frequency $= 0.0054$, observed $= 0$, $p = 1$). Zero-inflation was not detected (observed/simulated zero ratio $= 1.10$, $p = 0.992$). Visual inspection of residuals across tree species confirmed the absence of species-specific model misfit. Estimated marginal means of damage probability for each species were computed using the emmeans package (Lenth, 2024), and pairwise comparisons were adjusted using Tukey's method to control for multiple testing.

Generalized linear mixed modelling identified a strong effect of tree species on the likelihood of bison-induced tree damage. After filtering out species with low sample sizes, the model included seven common species and accounted for nested spatial structure via random intercepts for plots within sites. Site-level variance was negligible, while plot-level effects were retained to account for localized variability in browsing intensity.

Estimated damage probabilities varied widely among species (see Fig. 1). Norway spruce (*prob* $= 0.88$, 95 % CI: 0.73–0.95) and silver fir (*prob* $= 0.81$, 95 % CI: 0.63–0.92) exhibited the highest likelihood of damage by wisent. Moderate levels of damage were observed for sycamore maple (*prob* $= 0.56$, 95 % CI: 0.34–0.75) and European ash (*prob* $= 0.52$, 95 % CI: 0.14–0.87), although the latter had wider confidence intervals, indicating higher uncertainty. In contrast, European beech and European hornbeam showed the lowest estimated probabilities of damage at 0.12 (95 % CI: 0.06–0.24) and 0.13 (95 % CI: 0.06–0.27), respectively.

These results confirm that European bison browsing is not random but instead exhibits clear species-specific preferences. Tree species such as Norway spruce and silver fir appear highly susceptible to wisent impact, whereas European beech and European hornbeam exhibited the lowest browsing probabilities. This pattern is unlikely to reflect intrinsic resistance traits of these species, but rather the feeding preferences of European bison. These results and interpretation are corroborated by a recent study of wisent debarking intensity in Bieszczady Mountains, Poland, which demonstrated that coniferous species were more likely to be damaged, and that frequency of damage to forest stands was the highest in Norway spruce-dominated stands (Nieszała et al., 2022). Further support for this pattern comes from observations on habitat use of a semi-free wisent herd in the hunting enclosure of Židlov in the Czech Republic and an introduced herd in a fenced enclosure on the island of Bornholm, Denmark which confirmed the wisent's preferences for coniferous forests (Brandtberg and Dabelsteen, 2013; Červený et al., 2014). These patterns have important implications for forest composition and management in wisent-inhabited areas. The European bison's presence in Poloniny NP contributes to biodiversity and conservation goals but also presents challenges for forest management and landowners. As the population size increases, larger herds are more likely to cause human-wisent conflict (Tusznio et al., 2024). This study demonstrates clear dietary preference of the European bison for certain tree species, underscoring the need for targeted mitigation strategies to minimize negative impacts while ensuring the species' long-term viability. Continued monitoring and adaptive management are essential for balancing conservation and forestry interests.

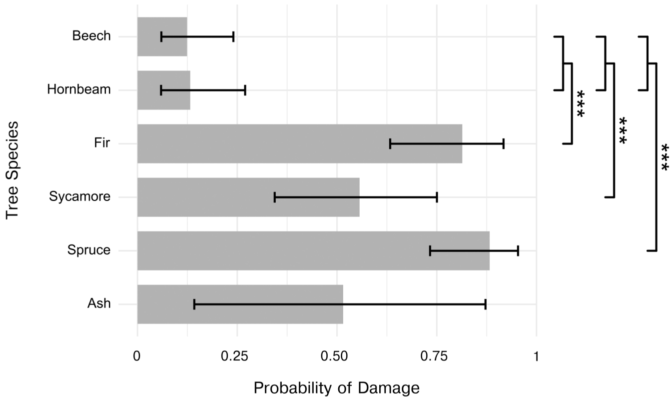

Figure 1 – Estimated probability of European bison damage by tree species. The horizontal bars represent model-predicted probabilities that a tree is damaged (i.e., chewed or destroyed) by wisent, based on a generalized linear mixed model (GLMM) with binomial distribution. Error bars indicate 95 % confidence intervals around the estimated marginal means. Species names are provided in English for clarity: beech (*Fagus sylvatica*), hornbeam (*Carpinus betulus*), fir (*Abies alba*), sycamore (*Acer pseudoplatanus*), ash (*Fraxinus excelsior*), and spruce (*Picea abies*). Asterisks denote statistically significant pairwise differences between species (Tukey-adjusted comparisons; $p < 0.05*$, $p < 0.01**$, $p < 0.001***$). The model includes plot nested within site as a random effect to account for spatial structure.

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