

# PERI-URBAN RECREATION AND BIODIVERSITY SERVICES BALANCING IN BRNO: STAKEHOLDER PRIORITIES AND MANAGEMENT FOR MASARYK FOREST KŘTINY

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## Abstract

Brno City and neighboring forests face conflicting pressures balancing recreation and other ecological services, such as water provision, biodiversity, climate regulation, and timber production. Our study explores stakeholders' priorities and preferences to assess how to balance recreation and lasting ecological resilience. The study surveyed (n = 234), evaluating perceived forest ecosystem services ranking and management in Brno and adjacent neighborhoods, mainly Masaryk Forest Křtiny. The participants were mostly young people aged 18 to 24 years (approximately 39%), with a balance by gender/sex. Most participants (about 91%) recognized recreation services such as walking and cycling as their major forest visiting activities on a weekly or monthly basis. Biodiversity and climate regulation services were the top choices for participants, i.e., approximately 83% and 78%, respectively, and recreation values at about 39%. Tourism and recreation were robustly weighted at about 39% valued forest recreation support as being very important, 41% (important). Moreover, for future forest management priorities, recreation services ranked roughly 43%. Forest Ecosystems Trade-offs predominantly focused on timber versus biodiversity; however, participants selected and acknowledged the necessity to sustain recreational quality and standards together with regulatory/support services. More so, for forest management considerations, concerns were raised about the possible effects of climate change on recreational prospects. *Ceteris paribus*, forest management that conserves recreational services accessibility and values whereas improving biodiversity and resilience to climate impacts were prioritized by stakeholders. The study results support a directed approach to integrating recreation obligations with preservation and adaptive management in peri-urban forestry.

**Key words:** Climate regulation, Ecosystem services, Forest management, Public preferences, Recreation services, Trade-offs

## Introduction

Society's welfare and ecological resilience in and around cities hugely depend on peri urban forests for essential supportive ecosystem services and production (Bolund and Hunhammar 1999, Kabisch et al. 2016, Bamwesigye et al. 2021, Doli et al. 2021, Yu et al. 2024). These forest services include climate regulation, supporting (biodiversity), water and soil protection, nutrient cycling, provisioning (timber), and cultural services such as recreational and outside facilities (Bolund and Hunhammar 1999, Kabisch et al. 2016, Deng et al. 2016, Doli et al. 2021, Bamwesigye et al. 2023, Yu et al. 2024). Peri urban forests are currently facing increasing societal pressure and burden due to rising numbers of urban inhabitants and an increasing obligation/demand for outdoor leisure and relaxation. There is pressure and competing interests between environmental and habitat conservation, production purposes, public access, and infrastructure requirements (Chan et al. 2012, Gómez Baggethun and Barton 2013).

Brno faces opposing obligations and huge demands in its urban and peri urban forests, such as high and consistent forest recreational usage that impends and degrades track/trail quality, wildlife habitat, and soil and water protection services. Moreover, insufficient climate adaptation strategies and the demand for conforming timber harvesting could worsen the negative impacts and associated externalities, including floods and droughts (Haase et al. 2014, O'Brien et al. 2022). The possibility of user conflicts is said to risk the situation further and yet can be solved as necessary by stakeholders and management (Kabisch et al. 2016, Haase et al. 2014).

Furthermore, the mutual ecosystem services, service quantity and quality, and recreational services face systematic risks from climate change effects on precipitation and temperature patterns, extreme events (e.g., flooding), and pests and diseases (Haase et al. 2014, O'Brien et al. 2022). Therefore, city management and stakeholders ought to balance forest ecosystem services, public priorities, and

perceived trade-offs to meet current recreational needs while supporting sustainability goals for biodiversity protection, regulatory functions, and climate resilience.

This study examined and documented stakeholders' priorities for ecosystem services in peri urban forests neighboring Brno City, highlighting forest recreation services to inform related forest planning and management.

We particularly evaluated and ranked stakeholders' patterns and priorities of forest use and visitation, valuation of ecosystem services, and stated trade offs such as between timber production, biodiversity, and recreation. Moreover, current management and concerns about climate impacts were analyzed. The research strives to offer evidence based on stakeholders' preferences and opinions to facilitate management actions that balance excellent recreational services access together with biodiversity protection, adaptability, and nature-thoughtful forestry management practices.

## **Material and methods**

The study conducted a cross-sectional survey to elicit public preferences/opinions and priorities regarding forest ecosystem services in the Brno City neighborhood. An online questionnaire was conducted both in Czech and English. It consisted of multiple-choice, single-answer, multiple-answer, importance ratings, preference and ranking, and socioeconomic characteristics questions.

### *Sampling and data collection*

The study collected data through an online link and QR code between the period 18 March 2025 and 06 March 2026. The overall survey visits were 1,348, while the accomplished responses were 236 and after cleaning 234 usable responses were used for investigation. The target population consisted of forest visitors and stakeholders around the Masaryk Forest Křtiny and nearby training forests.

The study results envisioned for research and policy recommendations were obtained and presented in an incognito manner. The study informed respondents about the purpose and privacy on the survey from the beginning. Moreover, we did not obtain personally identifiable details from the study.

### *Analytical approach*

The study carried out descriptive statistical analysis to obtain frequencies and fractions for categorical variables. Moreover, significant tendencies in ranked factors, such as importance scores, were analyzed to identify preferences, ordered choices, and scaling to create comparative classifications.

We conducted an exploratory analysis to examine connections between main variables, such as forest primary use and recreation importance ratings, to classify patterns across participant subcategories. The study investigated the occurrence and preference, such as timber vs. biodiversity selected (70.5%).

Analyzed results are presented and reported with tallies, sums, and percentages for all categorical results and ranked measurements.

## **Results and Discussion**

Young people were the majority of the respondents, with 38.5% aged 18–24, 25-34 (9.4%), 35-44 (19.7%), and above 45, accounting for 34.4%. The study results demonstrated a gender-balanced general population, with 120 males (51.3%), 107 females (45.7%), and 7 others (3%).

The respondents' educational levels were as follows: high school graduation, 75 (32.1%); Master's degree, 70 (29.9%); Bachelor's degree, 54 (23.1%); and other levels, accounting for about 15%. Educational levels were also categorized as technical (31.6%), biological (41.5%), social sciences (19.2%), and others (7.7%).

The employment results were: 40.6% students employed, 50.9% unemployed, and 7.7% retired.

Regarding primary forest use, respondents were strongly associated with recreation services, with 213 (91.0%) acknowledging activities such as walking, cycling, and sunbathing. Dog walking accounted for 28.6%, spirituality 62 (26.5%), sport 25.2%, and mushroom picking and education also scored highly at 24.8% and 20.5%, respectively (Fig 1).

Respondents stated their forest visiting frequency and usage, the concurrence showed a high connection with forest recreation services, e.g., daily (13.2%), weekly (30.8%), monthly (27.4%), and yearly (28.6%). This demonstrates that approximately 71% of study respondents associate with nature or forest monthly and 44% daily or weekly, indicating continuous recreational demand and consistent forest use in the Brno City neighborhood (Fig 2).

Regarding the four most important forest ecosystem services, 91 (about 39%) participants ranked recreation and tourism fourth. Even though biodiversity (195, 83.3%), climate regulation (183, 78.2%), and soil protection (98, 41.9%) were selected as the most frequently followed by recreation and cultural services. This demonstrates that stakeholders value forest recreation services among the top forest ecosystem services (Fig 3).

Answer Choices
● Recreace (procházky, jízda na kole, opalování atd.) / Recreation (walks, biking, sunbathing etc)
● Duchovní / Spiritual
● Sběr hub / Mushroom picker
● Sport / Sport
● Výzkum / Researcher
● Výuka / Education
● Samovýroba dřeva / Wood picker
● Odborná práce v lese (hajný, dělník atd.) / Forestry worker
● Venčení psa / Dog owner/walking

Fig. 11: Primary forest use associated with recreation services

Answer Choices	Responses
● Denně / Daily	31
● Týdně / Weekly	72
● Měsíčně / Monthly	64

Fig. 12: Forest visiting frequency

Answer Choices	Responses
● Regulace klimatu / Climate regulation	11
● Recreace a cestovní ruch / Recreation and tourism	9
● Biologická rozmanitost / Biodiversity	11
● Ukládání uhlíku / Carbon storage	6
● Produkce dřeva / Wood production	8
● Kvalita vody / Water quality	5
● Zmírnění následků povodní / Flood mitigation	3
● Zmírnění následků sucha / Drought mitigation	9
● Ochrana půdy / Soil protection	8

Fig. 13: four most important forest ecosystem services

Concerning the categorical ranking of the forest service's importance/preference-order, recreation services had an average importance score of 4.2 on the 0–10 ordering assignment. Forest recreation ranked lowest to climate regulation (7.2), drought mitigation (6.8), soil protection (6.8), biodiversity (6.6), water quality (5.6), and flood mitigation 4.2. Thus, our study revealed that forest recreation services are valued as distinguished services among the top-priority forest services for stakeholders. The examination of direct importance ratings for forest recreation using a single choice importance rating about the forest's role in supporting recreation and tourism results showed that participants 79 (34.3%) ranked very important, 94 (40.9%) important, 48 (20.9%), and 9 (3.9%) not important. Our study findings further illustrated that collectively, 75.2% of participants rated the forest recreation as important or very important, demonstrating a robust community/stakeholder valuation of forest recreational services around Brno City.

#### *Forest Recreation and Future Management Priorities*

Regarding future sustainable forest management, the study asked which services should be prioritized. Consequently, recreation services were selected by 101 participants (43.2%). Nevertheless, for future forest management, supporting biodiversity scored highest, 193 (82.5%), and other services, such as flood and drought mitigation, 141 (60.3%), and soil protection and nutrient retention (133; 56.8%) were more frequently selected, respectively. Forest recreation services demonstrated a strong management priority for stakeholders among other important forest ecosystem services and functions for Brno city and neighborhood forest management (Fig 4).

Answer Choices	R
● Produkce dříví / Timber production	
● Zásobování pitnou vodou / Provision of clean water	
● Zmírňování dopadů povodní a sucha / Mitigating floods and droughts	
● Podpora biologické rozmanitosti / Supporting biodiversity	
● ochrana půdy a vázání živin / Soil protection and nutrient retention	
● Ukládání uhlíku / Carbon sequestration	

Fig. 14: Management priority for stakeholders among important forest ecosystem services

Forest conservation-focused methods regarding forest management preferences indicated that 112 (47.9%) participants preferred the preservation of old-growth forests, while 104 (44.4%) chose continuous cover forestry as the two forest management enhancements in forests around Brno city. Moreover, the stated preferences are harmonious with the support and sustainability of forest recreation quality services, such as trail experience, shade, and structural complexity. More so, the results showed stakeholders' preference and support for actions and management that sustain naturalness and continuous forest cover rather than large clear-cuts.

Regarding implications for forest recreation services based on participants' satisfaction with the current forest management in Brno and surrounding areas, such as Training Forest Enterprise Masaryk Forest Křtiny, 28 (12.0%) were very satisfied, 92 (39.3%) Satisfied, 97 (41.5%), somewhat satisfied, and 17 (7.3%) not satisfied. Mutually, approximately 93% of the participants expressed some level of satisfaction with current forest management. The results demonstrate that the current management is acceptable to most forest recreational consumers and stakeholders, nevertheless approximately half of the respondents were only somewhat satisfied. The results demonstrate demand for targeted improvements, including access, trail maintenance, and amenities.

#### *Trade-offs and conflicts affecting recreation*

Timber production over Recreation & Tourism was chosen by 91 participants (approximately 39%) as a significant trade-off. Timber production against biodiversity (165; 70.5%), timber production against climate regulation (139; 59.4%), and timber production against drought mitigation (132; 56.4%) were the most commonly identified trade-offs that indirectly affect the quality of forest recreational services.

Timber production ranks low in importance (3.3 out of 10) compared to Recreation and tourism. While numerous participants recognized the conflict between timber and forest recreation, stakeholders ranked this conflict lower than soil protection services, water, and other regulatory forest services. Essentially, forest ecosystem resilience and biodiversity were more concerned with trade-offs than with the direct timber-versus-recreation conflict.

#### *Climate change concerns specific to recreation*

The impacts of climate change on forest ecosystem services were analyzed, and the results of the rating indicated that changes in temperature and precipitation patterns (169; 72.2%), increased pests and diseases (152; 65.0%), and extreme events (141; 60.3%) were the most significant.

Regarding how climate change might impact ecosystem services, the effect on recreational services scored an average importance of 5.9 out of 10. Recreation ranked in the mean range behind temperature and precipitation changes (9.8) and shifting species distributions (8.4), but on top of many other measurements.

Ranking among the top four climate change impacts on forest ecosystems, 29 participants (12.4%) chose impacts on recreational activities. The mean classification showed that stakeholders are reasonably worried that climate stressors could destroy forest recreation amenities, such as trail degradation by storms and increased pest and disease threats.

Forests in Brno City neighborhoods are viewed by stakeholders as spaces for recreation activities. Moreover, participants stated frequent visits and valued recreational services highly, besides robust value attached to biodiversity and forest regulatory services. Study results suggest a management approach that focuses on the quality of recreational services while also deepening protection of biodiversity, soil, and water, and enhancing climate resilience services. The long term sustainable use of peri urban forests is expected to reflect user and stakeholder management priorities and to best reflect climate effects.

#### *Practical implications for recreation-focused management*

Prioritize low-impact recreation design combined with biodiversity conservation: given users' dual interest in recreation and biodiversity, management that promotes continuous cover, retains structural complexity, and locates trails to minimize ecological disturbance will likely be socially acceptable.

Maintain access and quality while reducing conflict with production: mitigate timber–recreation conflicts through spatial/temporal zoning (e.g., schedule harvesting outside peak recreational seasons, buffer trails), clear signage, and community consultation.

Invest in climate-resilient recreation infrastructure: strengthen trails, drainage, and hazard monitoring to reduce impacts from extreme weather and shifting precipitation, addressing the moderate concern users have about climate effects on recreation.

Target engagement by user groups: tailor communication and participatory planning to the dominant visitor profiles (young adults, students) and secondary user types (dog walkers, cyclists), and align amenities and rules with users' preferences.

## **Conclusion**

The study aimed at examining public/stakeholder priorities for ecosystem services in peri urban forests of Brno. This study focused on forest recreation services, acknowledged trade-offs such as timber production, and drew on concerns about climate change effects to inform management and policy direction. An online survey was conducted, and  $n = 234$  responses were collected from stakeholders and visitors connected with Masaryk Forest Křtiny. The survey tool used multiple-choice, significance ratings, and classification-priority ecosystem service questions. We used descriptive analysis to obtain frequencies and proportions, as well as ranking scores for ordered preferences. Forest recreation services were ranked as the primary use, with 91% of respondents. Moreover, 44% of respondents visit the forest weekly or daily, and 71% at least monthly, indicating a regular trend in preference for forest recreational services. Biodiversity services ranked highest at 83.3% and, followed by climate regulation services at 78.2%. However, forest recreation was hugely valued at 75.2% as important and ranked 43.2% among future management priorities amongst public valuation of multiple forest services. Stakeholders' opinions on timber vs. biodiversity trade off were the most frequently identified conflict (70.5%), while timber vs. recreation was acknowledged by nearly 39%, although rated lower than trade offs distressing adaptable services. The survey results regarding management outlooks indicated that the public prefers conservation-oriented practices and approaches: 82.5% prioritized biodiversity, 47.9% old growth conservation, 44.4% continuous cover forestry, and were mostly satisfied or somewhat satisfied with current management approaches, indicating openness to nature friendly variations that protect recreation quality. The participants prioritized changes in temperature/precipitation, pest outbreaks, and extreme events as top climate threats; impacts on

forest recreational services were a mid ranked concern, suggesting a need for adaptation measures to maintain recreation amenities.

#### *Policy Outlook*

The study recommends implementing multifunctional, participatory planning that unequivocally distinguishes and appreciates forest recreation services as an essential service while also benefiting biodiversity and regulatory resilience of Masaryk Forest Křtiny. Forest management that balances sustained access to better-quality recreational services with conservation and climate resilience actions ought to support public preferences and ensure sustainability, extensive endowment of multiple forest ecosystem services in the Brno peri urban setting.

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#### **Souhrn**

Cílem studie bylo prozkoumat priority veřejnosti a zainteresovaných stran v oblasti ekosystémových služeb v okrajových lesích Brna. Studie se zaměřila na rekreační služby lesů, zohlednila kompromisy, jako je produkce dřeva, a vycházela z obav ohledně dopadů změny klimatu, aby poskytla podklady pro směřování lesního hospodaření a politiky. Byl proveden online průzkum a bylo shromážděno n = 234 odpovědí od zainteresovaných stran a návštěvníků spojených s Masarykovým lesem Křtiny. Průzkumný nástroj využíval otázky s výběrem z více možností, hodnocení významu a otázky týkající se klasifikace a priority ekosystémových služeb. K získání četností a podílů, jakož i skóre pro pořadí preferencí jsme použili deskriptivní analýzu. Lesní rekreační služby byly 91 % respondentů hodnoceny jako primární využití. Navíc 44 % respondentů navštěvuje les týdně nebo denně a 71 % alespoň jednou měsíčně, což naznačuje pravidelný trend v preferenci lesních rekreačních služeb. Služby v oblasti biologické rozmanitosti se umístily na prvním místě s 83,3 %, následované službami v oblasti regulace klimatu s 78,2 %. Lesní rekreace však byla ve veřejném hodnocení různých lesních služeb vysoce ceněna jako důležitá (75,2 %) a v žebříčku budoucích priorit hospodaření se umístila na 43,2 %. Názory zainteresovaných stran na kompromis mezi dřevem a biologickou rozmanitostí byly nejčastěji identifikovaným konfliktem (70,5 %), zatímco kompromis mezi dřevem a rekreací uznávalo téměř 39 %, i když byl hodnocen níže než kompromisy ohrožující adaptabilní služby. Výsledky průzkumu týkající se výhledů na hospodaření naznačily, že veřejnost upřednostňuje postupy a

přístupy orientované na ochranu přírody: 82,5 % upřednostňovalo biologickou rozmanitost, 47,9 % ochranu pralesů, 44,4 % lesnictví s nepřetržitým porostem a bylo většinou spokojeno nebo spíše spokojeno se současnými přístupy k hospodaření, což naznačuje otevřenost vůči přírodě přátelským variantám, které chrání kvalitu rekreace. Účastníci upřednostňovali změny teploty/srážek, výskyt škůdců a extrémní jevy jako hlavní klimatické hrozby; dopady na rekreační služby lesů byly středně závažným problémem, což naznačuje potřebu adaptačních opatření k zachování rekreačních zařízení. Studie doporučuje zavést multifunkční participativní plánování, které jednoznačně rozlišuje a oceňuje rekreační služby lesů jako nezbytnou službu a zároveň přispívá k biologické rozmanitosti a regulační odolnosti Masarykova lesa Křtiny. Lesní hospodaření, které vyvažuje trvalý přístup k kvalitnějším rekreačním službám s opatřeními na ochranu a klimatickou odolnost, by mělo podporovat preference veřejnosti a zajistit udržitelnost a rozsáhlé poskytování různých lesních ekosystémových služeb v brněnském příměstském prostředí.

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