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Urban sprawl and protected areas: How effective are buffer zones in reducing recreation impacts on an urban national park?

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Abstract

New housing developments for tens of thousands of new local residents in the 22nd Viennese district will increase the recreation use pressure on the nearby Donau-Auen National Park and the UNESCO Biosphere Reserve Untere Lobau. These areas are intensively used settings and the high use pressure caused by urban sprawl will further negatively impact the natural resources and the quality of the visitor experience. This study investigated planning and management options regarding their capability to reduce the visitor pressure on these areas. The main challenge was how can the existing large-scale agrarian-dominated areas surrounding the park be transformed into attractive recreational landscapes. Stakeholders from several administration bodies and scientists from various disciplines developed these scenarios, which included a bundle of landscape design, land use, traffic and recreational infrastructure measures. In addition, measures to restore the ecological integrity of the area were included. An agent-based model tested the effectiveness of these buffer zone scenarios. The definition of agents (=virtual visitors) and their decision making algorithms included several approaches such as an image-based conjoint choice survey among area visitors and visitor counts. The agent-based simulations indicated that these buffer zones can only absorb up to 30% of the recreation use pressure.

Keywords

Agent-based modelling; Protected area planning; Recreation; Stated choice; Urban sprawl; Vienna

Introduction

National parks within the borders of larger cities provide many ecosystem services for urban population. They are biodiversity hot spots, produce for example drinking water, regulate hot summer temperatures, and provide wildlife viewing, recreational, spiritual and eco-tourism opportunities and wellbeing for their visitors (DANIEL et al. 2012). They are also refuges from hectic city life and the work environment and are settings for social gatherings (ARNBERGER et al. 2010; HAMMITT 2002). At the same time, they are confronted with high recreation use pressures throughout the day, week and year because of their attractiveness. Crowding, recreational conflicts, and degraded environments may occur within urban protected areas and reduce the recreational quality they offer. Serious conflicts between recreation use and nature conservation management can arise because users may displace due to overcrowding to areas of high ecological value and, thereby, potentially reduce undisturbed zones and times for wildlife (ARNBERGER & BRANDENBURG 2007).

The Viennese part of the IUCN-category II Donau-Auen National Park, which also includes the UNESCO Biosphere Reserve Untere Lobau, is such an example of a heavily used urban protected area (Figure 1). This area is a traditional, intensively used, recreational setting of high ecological value as documented by more than 600,000 visits annually (ARNBERGER 2006). New housing developments for tens of thousands of new local residents will further increase the recreation use pressure on the nearby national park. This development will result in drastic transformations of the local environments surrounding the park. About 50,000 new local inhabitants are expected within the next 15 years (ARNBERGER et al. 2012). The increasing high recreation use pressure will further degrade the park's natural resources and the quality of the recreational experience because of crowding and user conflicts (ARNBERGER et al. 2010; EDER & ARNBERGER 2012).

This study, which was co-financed by the Austrian Man & the Biosphere Programme (ÖAW-MAB), investigated planning and management options regarding their capability to reduce the visitor pressure on these areas (ARNBERGER et al. 2012). Urban sprawl is obviously one of the relevant research priorities affecting this and many

other protected areas in the world. The question of arises whether protected areas under pressure can fully achieve their objectives in terms of protection of processes, ecological functions and biodiversity, and recreational quality.

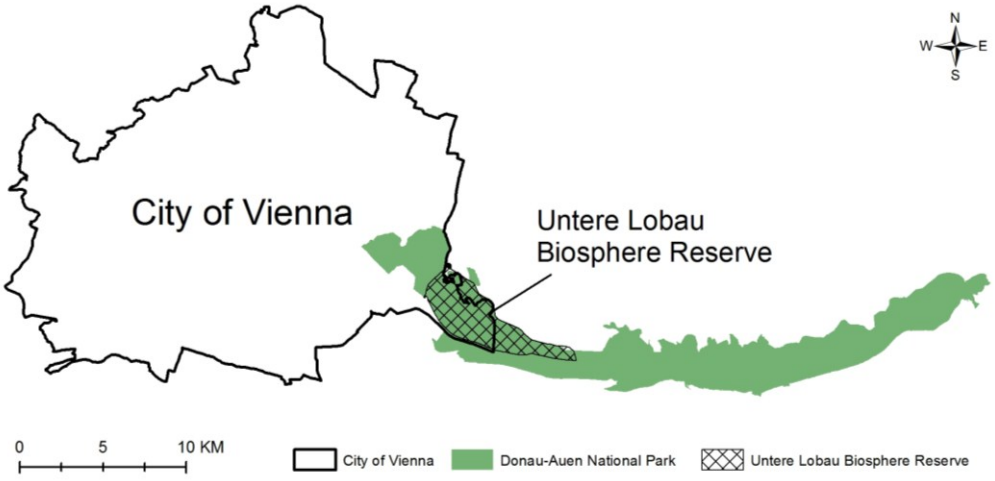

Figure 1: Study area: UNESCO Biosphere Reserve Untere Lobau and Donau-Auen National Park.

The goal of this research was to identify the optimal measures to reduce the visitor pressure on this area. One strategy is to transform the existing large-scale agrarian-dominated areas surrounding the national park into attractive recreational landscapes using a bundle of landscape design, land use, traffic and recreational infrastructure measures. The following research questions guided this study:

- How can the existing large-scale agrarian-dominated areas surrounding the national park be transformed into attractive recreational landscapes?
- What is the best combination of landscape design, land use, traffic and recreational infrastructure measures?
- Which visitor groups should be specifically addressed by these measures?
- What influences have such measures on spatial behaviour of visitor groups?
- How many visitors will visit the new recreational landscapes instead of the national park?
- What parts of the protected area will face decreasing visitor use levels because of these measures?

Methods

Study area

This study area is an alluvial landscape, called the Lobau, and is located in the eastern part of Vienna, the capital city of Austria, with a population of about 1.7 Mio. The 2,400 ha-area is part of the 22nd district of Vienna and managed by the Forest Department of the City of Vienna. It protects one of the largest natural riparian wetlands in Central Europe that are still ecologically intact to a relatively high degree. It was declared a National Park in 1996 and accredited by the IUCN as a Category II protected area in 1997. About 60 % of the Danube Floodplains National Park consists of floodplains; the remaining areas are watercourses, fields and meadows. The protected area is surrounded by large-scale agrarian-dominated areas, Viennese suburbs, the Community of Groß-Enzersdorf in Lower Austria, and the Danube River. Close to 15,000 inhabitants live within 15–20 min walking distance. A dense network of about 120 km of forest roads, trails and several narrow paths run through the area, especially in close proximity to the main residential areas. Area access is free and unlimited. Several trails are open for bicycling and one international cycle route passes through the national park. Several parking lots are provided. The area provides several visitor facilities such as a visitor centre and interpretive trails. A one-year visitor monitoring carried out in the Viennese part between 1998 and 1999 showed that bicycling (47 % of all users) and walking activities (40 %) dominate, followed by dog walking (10 %) and jogging (3 %) (ARNBERGER 2006).

Methodological approaches

This project relied on several methodological approaches. Stakeholders from several administration bodies and scientists from various disciplines participated in the project. Area visitors' preferences and stated behaviours were included in the modelling approach to analyse the effects of different landscape design and land use, traffic and recreational infrastructure measures on their spatial behaviour. In a first step, planning scenarios for the existing large-scale agrarian-dominated areas as new buffer zone were defined. In a second step, these scenarios were simulated regarding their effectiveness in reducing recreation impacts on the protected area.

Definition of recreational scenarios

The main question was how can the existing large-scale agrarian-dominated areas surrounding the protected area be transformed into attractive recreational landscapes. Four base scenarios were developed in stakeholder workshops (Table 1). Each of these scenarios included a bundle of landscape design, land use, traffic and

recreational infrastructure measures. Recreational infrastructure measures, for example, included new bicycling and hiking trails. The relocation of parking lots and closing streets for motorized traffic were examples for traffic measures. In addition, measures to restore the ecological integrity of the area were included in the scenario definition. These measures would lead to higher water dynamics in parts of the protected area. It was decided within the workshops to focus on bicyclists as largest user group and dog walkers because of their problematic behaviour not keeping their dog on a leash.

Table 1: Landscape design, land use, traffic and recreational infrastructure measures per scenario

Measures	**Scenario A1**	**Scenario A2**	**Scenario B1**	**Scenario B2**
Extension of recreational trail network in the new buffer zone	X (smaller trail network)	X (smaller trail network)	X (larger trail network)	X (larger trail network)
River restoration measures		X		X
Traffic measures	X	X	X	X
Landscaping measures			X	X

Assessing trail preferences with an image-based stated choice approach

Modelling visitors' recreation behaviour in the study sites (within the national park as well as in the planned buffer zone) requires a sound knowledge about their landscape, recreational infrastructure and social use preferences. An image-based conjoint-choice survey asked the influence of various landscape types (ranging from natural to built environments), recreational infrastructure facilities and trail use conditions (trail user numbers, visitor activities) on protected area visitors' trail use intentions for specific leisure activities such as bicycling (N = 520; Figure 2).

Such stated choice approaches are rooted in the traditional microeconomic theory of consumer behaviour and preference theory and have been applied to study preferences and choice behaviour for a range of recreation and tourism related issues (ARNBERGER et al. 2010; KEMPERMAN & TIMMERMANS 2006; LAING et al. 2005; LOUVIERE et al. 2000; REICHHART & ARNBERGER, 2010). The stated preference approach asks respondents to evaluate alternative configurations of hypothetical, multi-attribute, goods or services (LOUVIERE et al. 2000). Such alternatives – in this case buffer zone scenarios – are defined as combinations of factors, for example physical/resource, social and infrastructural characteristics of the Danube floodplains landscapes. Random utility theory postulates that choices can be modelled as a function of the factors of the alternatives. Selection of one alternative over the other implies that the utility of that alternative is greater than the utility of any other alternative (HENSHER et al. 2005). In addition, latent-class choice modelling was applied to account for possible heterogeneity of respondents in their trail choice. Latent class methods can identify visitor segments based on their choices and provide within-segment share predictions (KEMPERMAN & TIMMERMANS 2006). Such analyses assist in explaining the heterogeneity of individuals and allow a more complete explanation of choices. Latent class models have been recently used in different research fields including outdoor recreation (ARNBERGER et al. 2010; KEMPERMAN & TIMMERMANS 2006; REICHHART & ARNBERGER 2010; SCARPA & THIENE 2005).

Figure 2: Example of computer-generated visual trail scenarios to assess visitors' trail use intentions.

Agent-based modelling

An agent-based model tested the buffer zone scenarios regarding their capability to reduce visitor use pressure. The definition of agents and their decision making algorithms included several approaches. Besides trail preference data based on the stated choice approach, behavioural and individual data, derived from visitor counts or on-site visitor surveys completed the definition of the agent types. Agents were defined as activity types such as bicyclists or dog walkers. GIS-data of the protected area itself as well as of the surrounding existing and planned buffer areas served as spatial input data and included vegetation structures, land uses, water bodies, access points and recreational infrastructures such as trail types. Agent-based simulations relied on the MASOOR simulation platform (JOCHEM et al. 2008). Setting the input parameters was partly based on a previous agent-based model carried out in the study area (TACZANOWSKA et al. 2008).

Modelling results

The image-based stated choice survey found that visitors' trail use intentions were influenced by all physical and social trail factors. More relevant factors were the trail environment, water bodies and visitor numbers on the trail. However, the role of these trail factors on visitor intentions depended on specific leisure activities: dog walking, for example, required different site factors than bicycling. Agent-based simulations indicated that the planned buffer zones can only absorb about 30% of the recreation use pressure. Within the measures, parking lot relocation and new bicycling trails seems to be rather efficient.

Discussion

This study found that the use pressure on the protected area can be lowered. Nevertheless, recreation use will drastically increase despite of these investments in recreational infrastructure and landscape design. Thus, recreation use intensity will further negatively impacting the natural resources and the quality of the visitor experience. Area management will be further challenged by the increasing use pressure and will face more investments in visitor management efforts and maintenance of recreation infrastructure within the area. The buffer area seems not to be able sufficiently absorbing all recreation use. Therefore, additional green spaces in the urban-sprawl region seem to be required to substantially reduce recreational use pressure on the protected area.

Conclusion

This study tested a rather new method mix to simulate the effectiveness of several recreational scenarios regarding their capability in reducing recreation impacts on the protected area. This study relied on interdisciplinary and transdisciplinary approaches, which required substantial resources. Nevertheless, the simulation of the scenarios assessed their effectiveness and thus can avoid suboptimal and costly planning and management measures. While first evaluations of the simulations indicate that results are reliable, further analyses which specifically compare stated with revealed behaviour of respondents are necessary. The integration of other (recreational) areas surrounding the national park and the new settlements into the simulation programme may provide a more holistic understanding of recreation use patterns in the region. A comprehensive long-term monitoring programme addressing the effects of urban sprawl on the national park and its ecosystem services would be useful. This would also include surveys among visitors and local residents on a regular basis investigating their perceptions of recreation quality and their responses to degrade environments and crowding.

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