Monitoring and Management of Visitor Flows in Recreational and Protected Areas
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GIS-Supported Network Analysis of Visitor Flows in Recreational Areas

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Abstract: The application of GIS tools for visitor monitoring facilitates a profound analysis of visitor flow patterns. Giving a visual impression of the distribution of visitors within an area via maps, interpretation of visitor use data is much easier and better. Furthermore, a GIS also allows to determine and analyse quantitative parameters of visitor use such as trail and visitor density. These parameters can also be used to characterise and compare different areas within a park. With a standardised approach, also comparisons between parks can be realised. Therefore, GIS is increasingly used in the area of visitor monitoring to assist recreation planners and park managers in their everyday work. This paper demonstrates how a GIS-based trail network analysis was used in the framework of a visitor monitoring project in the Danube Flood Plains National Park, Austria.

INTRODUCTION

Recreational areas located close to big cities are often used by high numbers of visitors and show a highly diverse visitor structure. As visitor numbers increase, there is a simultaneous increase in environmental impacts, crowding, and conflicts between different recreational types and users. Additionally, modern leisure activities and behaviour of visitors do often not fit traditional concepts of recreation. Therefore, an intensive monitoring of visitors in these areas in needed, in order to be used as prerequisite for successful and effective management.

Network analyses based on Geographic Information Systems (GIS) offer a possibility to analyse spatially referenced data describing traffic flows. While they have been used in road traffic planning for a long time, they have only rarely been applied to recreation planning and analysis. Here it is a very useful tool to trace out areas of potential conflicts between recreational use by visitors and the needs of fauna and flora (Volk, 1995, Roth et al., 2000), as well as conflicts between different groups of visitors having complementary interests or simply crowding too much. Once these conflicts and their potentials are recognized, the recreational infrastructure and the management scheme can be adequately adopted.

STUDY AREA

The Danube Floodplains National Park is situated east of Vienna, the capital city of Austria, with a population of about 1.6 million. One part of the national park, the Lobau, actually lies within the city boundaries of Vienna. The national park extends about 50 kilometres along the Danube river from Vienna to the border of Slovakia. In 1997, the Danube Floodplains were declared a National Park, and received international recognition in the IUCN category II. The Park is used predominantly by the Viennese and Lower Austrian population for everyday recreation purposes.

In order to deal effectively with the high number of visitors, the park management needs in-depth information on the leisure and recreational usage of the area. Therefore, the Institute for Landscape Architecture and Landscape Management at Bodenkultur University Vienna, commissioned by the Vienna City Council, forest department, and the National Park Administration, collected data on the number and structure of the visitors to the area as well as their spatial and temporal distribution.

METHODS

Investigations on the recreational use of the Viennese (western) part of the national park were conducted in 1998 and 1999. Between June 2000 and May 2001, visitors were also monitored in the Lower Austrian (eastern) part of the national park. Various different methods were applied for the monitoring of the visitor activities: permanent long-term video monitoring over one year, short-term visitor observations, interviews as well as route registrations.

Permanent time lapse video recording, installed at highly frequented access points, gathered information about the number of visitors entering and leaving Lobau from dawn to dusk.

At the main access points into the park visitors were interviewed about their motives, activities, expectations etc. The interviews took place on either four or eight days, at each case a Thursday and the following Sunday, once in each season. In order to obtain high data volumes, the survey was conducted on days of fine weather. In addition, at the same time also the total number of visitors at the main entrance points was determined. This temporally selective counting was combined with video monitoring data for extrapolating to the total number of visitors per year.

As part of the survey, visitors were asked to mark in a simple map the route through the national park, which they took or planned to take (see also Wang et al. 2000). All the trails contained in the Austrian topographic map 1:50.000 were considered. The trail network was digitised and the route information from the interviews was spatially referenced and stored into a database. In a first step, all records have been checked for topologic consistency (e.g. contiguous route segments). By linking the route data and interview results with the help of the Access database, an analysis by topic was possible and the respective number of visitors per segment of trail could be made visible on maps of the study area (Hinterberger, 2000).

RESULTS

Distribution of visitors

Figure 1 gives an overview of the spatial distribution of visitors within the Lobau. The map shows the parts of the park with high or low use levels. Heavily frequented paths could easily be identified and potential conflicts between user groups as well as between nature conservation and recreational goals were allocated. By linking the route information with other interview data, an analysis of routes by access point was possible.

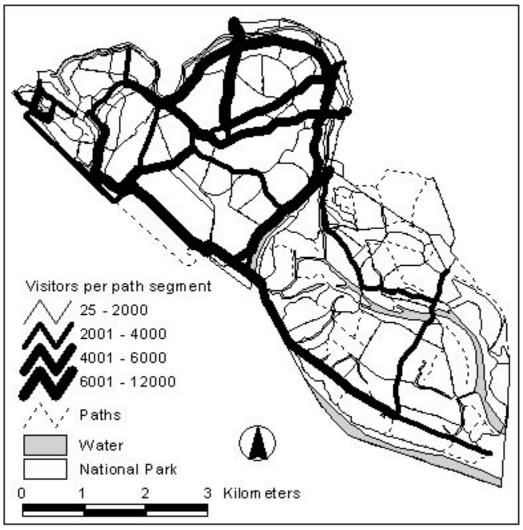

Figure 1: Spatial distribution of visitors in the Viennese part of the Danube Floodplains National Park, on 8 counting days

Figure 2 shows the routes of the visitors entering the Lobau at three selected entry points. At the entry point ‘Essling’ a settlement is very close to the national park. The visitors entering there are mainly staying in the area very close to this access point. The analysis of the questionnaire also showed, that these people are predominantly hikers and regular visitors. At the access points ‘Uferhaus’ and ‘Lausgrund’, in contrast, more bikers were observed. This is also reflected in the spatial patterns of routes reported by visitors passing these two observation points. The routes are fairly long and show high frequencies along the official bike trails within the national park. The video observation showed furthermore, that the numbers of visitors observed at these two stations are highly correlated, which is also represented in the routes.

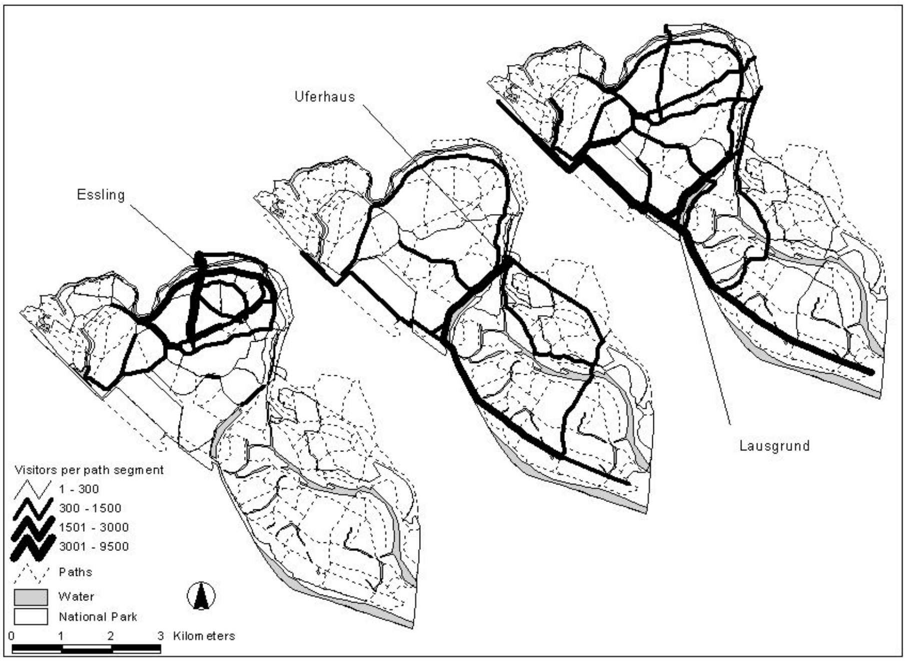

Figure 2: Visitor flow patterns by entrance point

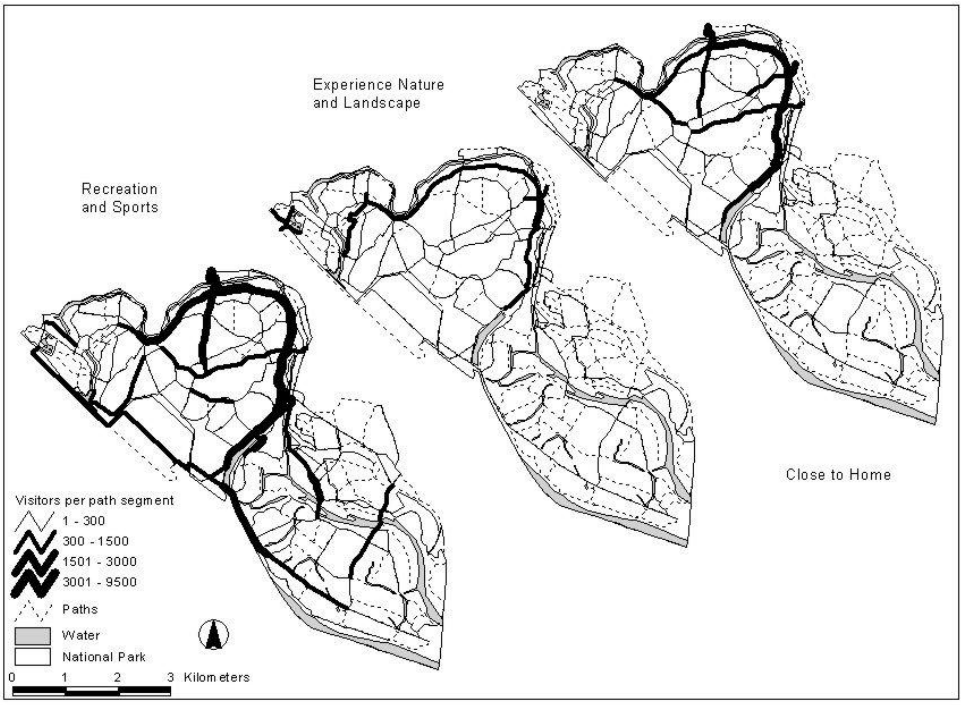

Figure 3: Visitor flow patterns by motivation

By linking the route data to other results of the questionnaire, the spatial distribution of recreationists by visiting motive can be analysed. Figure 3 shows use concentrations of nature related visits along the old branches, whereas visitors coming from the settlements adjacent to the Lobau tend to stay in the parts close their own residential area. Visitors who stated to use the Lobau for recreational and sportive activities, show a wider distribution over the study area.

Calculation of total visitor load

Route data obtained from interviews were also linked with visitor countings from permanent video recording, thus facilitating an estimation of the total visitor load during the one-year period of video observation.

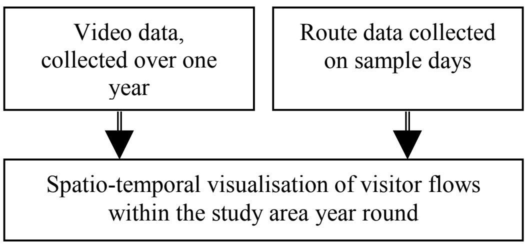

Figure 4: Combination of video data and route data

At the access point ‘Lausgrund’, for example, bikers were monitored by video recording as well as interviewed. Therefore, one knows both the patterns of routes taken by the bikers and the temporal distribution of bikers passing the station year round (see fig 5). This information can be combined in order to do some first and simple calculations of distribution of cyclists within the study area during the year.

The number of cyclists in the study area is particularly susceptible to the temperature, an increasing number was observed between April and September when the temperatures rise above 10°C (Brandenburg, Arnberger, in print). Consequently, also different spatial patterns of cyclists could be observed between April and September.

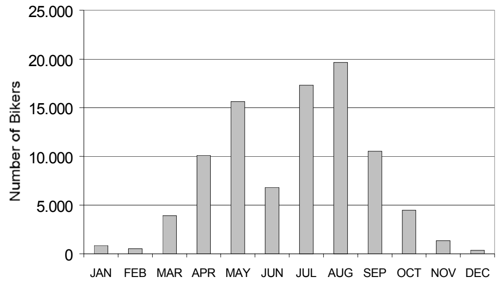

Figure 5: Bikers at access point ‘Lausgrund’ per month

Indices of Public Use

It is quite difficult to compare the amount of visitor use regarding pressure on resources in different parks due to different spatial characteristics such as size, shape and relief (Dawson 2000). Attempts have been undertaken to make the usage and the recreational impacts on various wilderness areas somehow comparable by defining indices of recreational infrastructure and use.

Table 1 shows two such simple indices for the two parts of the Danube Floodplains National Park. By combining these indices with actual visitor data from both the route analysis and the visitor counting, more refined parameters can be derived.

Indices	*Viennese Part of National Park - Lobau*	*Lower Austrian Part of National Park*
Entry points per km²	*0,9*	*0,8*
Kilometres of trail per km²	*5,9*	*3,8*

Table 1:Comparing study areas by representative numbers

Length of Routes

Analysing visitor routes with the help of GIS tools offers the possibility to explore also the length of routes. The shortest route reported in the Lobau was only 163 meters long, leading from the entrance point to a water pond and return. The longest route (27.8 km) was reported by a biker, spending his time in the Lobau on a Sunday in spring.

Seasonal variations of the route length could also be observed. First of all, the skewness of the histograms shows characteristic differences. In summer, many visitors only come to the Lobau to swim in the old branches of the Danube. These visitors tend to hike or bike only for a short distance in order to get to their favourite spot (Fig.6), where they often spend the whole day.

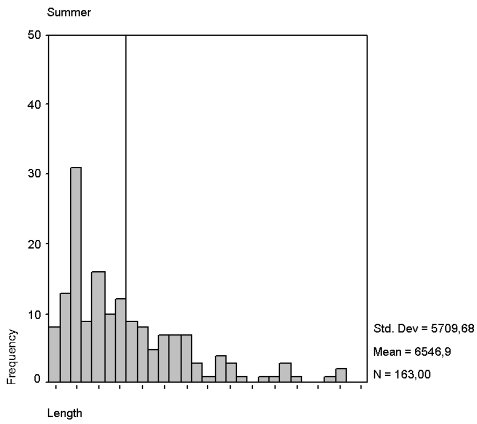

Figure 6: Distribution of route lengths in summer

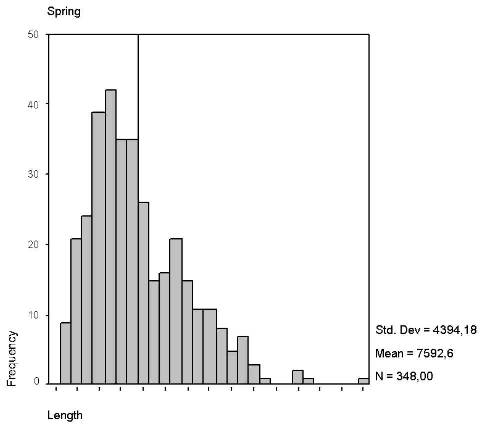

Figure 7: Distribution of route lengths in spring

In contrast, the distribution of route lengths in spring (Fig.7) is more symmetric and many of the distances are grouped around the mean route length. This shows, in measurable numbers that in spring people are moving around much more, spending time biking or walking instead of resting in one place for a long time. Also the means of the distributions of routes are slightly different. In spring the mean distance, taken by the visitors is bigger than in summer. As the number of visitors counted in spring is about twice the number of the summer visitors, the overall impact in spring is significantly higher.

Visitor load

The combination of video recording data with the mean route length allows a calculation of the visitor load, calculated as visitor kilometers per year within the area. This parameter gives an idea of the use intensity of recreational infrastructure, in particular the trail system. The results are also indices in order to compare different recreation areas.

In the Viennese part of the National Park the average route length is 7.26 kilometers. With 600,000 visits counted per year, this section of the National Park is charged by 4,356,000 visitor kilometers per year. Opposed to that, the Lower Austrian part had 390,000 visits with 4,356,000 visitor kilometers per year. Referring to the size, the trail network of the Viennese part is stressed by visitor kilometers more than three times as much as the Lower Austrian part. As the Viennese trail network is more dense, the visitor load per respective trail segment is about twice as high compared to the Lower Austrian part.

Study area	*Mean length of routes / total visitors per year*	*Visitor kilometer s per year within area*	*Visitor kilometer s per km² per year*	*Visitor kilomete rs per trail km per km² per year*
Lower Austrian part of National Park	*9.04 km (n = 340) / 390,000*	*3,525,600 km*	*51,100 km/km²*	*13,500 km/km/ km²*
Viennese part of National Park - Lobau	*7.26 km (n = 511) / 600,000*	*4,356,000 km*	*181,500 km/km²*	*30,800 km/km/ km²*

Table 2:Visitor kilometers per year within area

Trail Use Concentration

Ordering the path segments by intensity of use and plotting the total cumulative percent of visitor meters against the cumulative percent of trail meters, results in a graph representing the density of visitor use within an recreational area (see also Lucas, 1990).

In Lobau, for example, fifty percent of the visitor kilometers refer to about fifteen percent of the total trail kilometers.

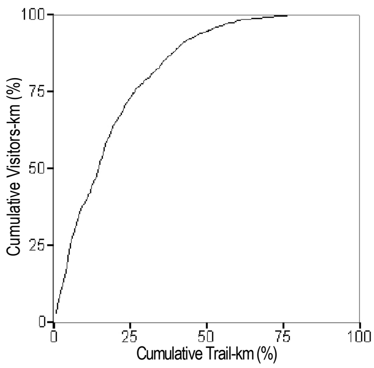

Figure 8: Graph of total travel in cumulative percent of visitor kilometers against cumulative percent of trail kilometers Viennese part, Lobau

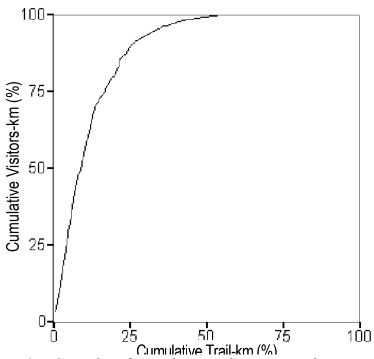

Figure 9: Graph of total travel in cumulative percent of visitor kilometers against cumulative percent of trail kilometers, Lower Austrian part

In the Lower Austrian part, however, fifty percent of the visitor kilometers refer to only nine percent of the total trail kilometers, which indicates an extremely high concentration of visitors on few path segments.

DISCUSSION AND OUTLOOK

The combination of data on visitor numbers, routes and visitor characteristics with the spatial functions of a GIS has proven to be a very useful method to investigate and analyse visitor flows in recreational areas.

One important next step will be to link our data with road traffic data from areas close to the National Park.

So far, our analyses were mostly explorative. Single models have been developed to predict total visitor loads (Brandenburg, Arnberger) depending on weather factors; however, the next step will be to apply these models in a spatial context.

To achieve reasonable models, the data gained from permanent video observation will play an important role and the connection of these data to the routes needs to be done very carefully. These models could also be improved by including information about the directions of the visitors´routes.

Concerning the conservation function of an area, the use of GIS in combination with quantitative data of the recreational use can help exploring the effects on fauna and flora caused by people spending their leisure time in recreational areas. Building more complex models of agents moving trough the recreational area (Itami et al., 2001), interacting with their surrounding according to a bundle of attributes they are applied with, should enable predictions about changes in visitor flow, if certain paths or entrances need to be closed.

Exploration of the visitors opinions in terms of comfort and attractiveness of paths will also be contributing to predictive models.

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