Monitoring and Management of Visitor Flows in Recreational and Protected Areas
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Models to Predict Visitor Attendance Levels and the Presence of Specific User Groups

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Abstract: This paper proposes approaches to modeling visitor flows in the context of weather and outdoor recreation. The nature conservation area and area under investigation the Lobau, which is a part of the Danube Floodplains National Park, lies in close proximity to the large conurbation of Vienna, the capital city of Austria. This circumstance presents the managers and researchers of the Lobau with a variety of challenging problems, due to the high number of visitors and the multifaceted visitor structure. An ecologically and economically sustainable management of the recreation and conservation area Lobau requires a profound knowledge of the uses visitors make of this area and a reliable prediction of the potential numbers of visitors. The investigation of the prognostic model is based on the results of a visitor monitoring project. Within this project, video-cameras were installed at several entrance points to the Lobau to monitor recreational activities throughout one year. The prognostic models were based on the dependence of the daily number of visitors on external factors such as weather and day of the week. Using a linear regression, these relationships were investigated and used to predict visitor loads. For the model, a distinction was made between workdays and weekends and/or holidays. The weather was considered in a very differentiated way: Meteorological elements, i.e. air temperature, cloud cover, precipitation, appear directly as parameters in the models as well as indirectly in thermal comfort indices, e.g. the Physiological Equivalent Temperature (PET). Reliable models can be obtained for the daily totals of visitors as well as for specific user groups with high visitor loads, i.e. hikers and bikers. The day of the week has the greatest influence on the daily totals of visitors as well as on individual user groups. The numbers of bikers and hikers depend heavily on the Physiological Equivalent Temperature. The effects of precipitation and cloud cover during the preceding seven days are small. The usage patterns of joggers and dog walkers are more difficult to model as they are less influenced by the day of the week and weather related factors.

INTRODUCTION

Leisure-time activities in protected areas are a subject of interest for management and research. A lot of studies point at the necessity of a comprehensive understanding of recreational use for the sustainable and effective management of protected areas (Heywood, 1993). Only when detailed information on the leisure and recreational usage of these areas is available, is it possible to blend these with findings from the fields of natural science and sociology to arrive at an ecologically and economically sustainable management of recreation and conservation areas (Coch et al., 1998; Eagles et al., 1999). The results of these research activities have to fulfil scientific criteria, have to be suitable for planning and practice oriented. The results can only be included as a planning factor when both the planner and practitioner are capable of completely understanding and implementing the information provided by this data. Only when all these basic conditions are fulfilled, will visitor management measures receive increased acceptance (Harfst, 1980; Höppe et al., 1987).

The dependence of human well-being and, therefore, of recreationists on the weather is a well-known phenomenon and there has been widespread research into the relationship between recreational activities and the weather (De Freitas, 1999; Gibs, 1973; Hunziker, 1997; McCalla et al., 1987; McColl et al, 1990). Biometeorological research in these fields and in the field of thermic comfort has resulted in a considerable increase in knowledge for applied research and the implementation in planning and management demands.

The individual perceives weather as a combination of air temperature, humidity, cloudiness, wind, sunshine, solar radiation and complex values for human hygro-thermic sensitivity (Hoffmann, 1980; Blüthgen, 1980; de Freitas, 1999; Hammer et al., 1990; Jendritzky et al., 1979;

Höppe, 1997, 1999). In this context, mention must be made of the "Physiological Equivalent Temperature" which is defined as where the heat balance of a person, in an interior room (unaffected by wind or sun) is equivalent. This enables the layperson to compare the complex thermic conditions felt in the open air with his experience gained indoors - something he can easily relate to. (Jendritzky et al., 1979; Höppe, 1997, 1999).

Although thermal comfort can be achieved on most days of the year by adjusting one's clothing and activities accordingly, the weather still has a major influence on leisure and recreational behavior. In the case of the research area it seems to be quite clear: One might expect a higher number of visitors over the weekend and whenever the weather is fine, than on rainy workdays; the degree of influence of the respective factors, i.e. of the weather and day of the week, and their interaction is unknown. But, only knowledge of existing relationships between the numbers of visitors and weather, as well as the weekday, permits a detailed description of recreational attendance levels in a certain area. However, if it is intended to understand and forecast the recreational events in a specific area in detail - in terms of a prognosis model with a high temporal resolution of the attendance levels and user categories - it will be necessary to be in possession of quantitative data of high temporal resolution concerning both recreational use and the respective, current weather.

MATERIALS AND METHODS

The Danube Floodplains National Park is situated to the east of Vienna, the capital city of Austria, with a population of 1.6 million. A portion of about 2.400 ha (9.3 square miles) of this zone – the research area the so-called Lobau - actually lies within the Vienna city boundaries and is a traditional local recreation area. In 1996 the Danube Floodplains were declared a National Park and in 1997 received international recognition - IUCN category II. The protection of the floodplains is gaining in importance compared to the management of the recreational activities. The park management now has the task of fulfilling both the demands posed by intensive daily recreational use and by the need to protect the floodplains' forest ecosystem.

The Institute for Landscape Architecture and Landscape Management was commissioned by the Viennese City Forest Department to collect data on the attendance levels and structure of the visitors to the area as well as their spatial and temporal distribution.

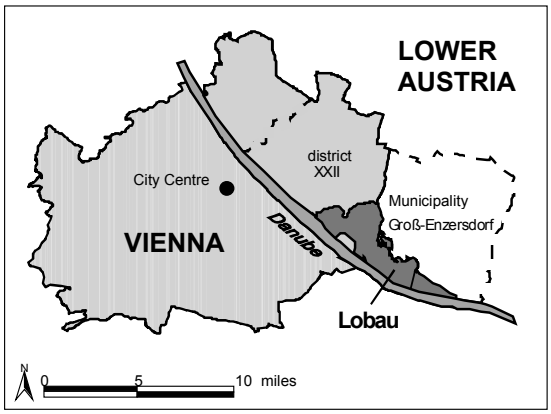

Figure 1: Study area: Lobau, the Viennese part of the Danube Floodplains National Park (Hinterberger, 2000, modified)

Permanent time-lapse video recording systems were installed at five entrance-points and recreational activities were monitored the whole year round, from dawn to dusk (Leatherberry & Lime, 1981; Vander Stoep, 1986). For the analysis of the video tapes only 15 minutes per hour of observations were taken into account. The data based on 15-minute evaluations were statistically verified by data of a complete survey. The examination using linear regression resulted in the R^2 value of 0.9 (Brandenburg, 2001). When analyzing the video tapes the following data were registered: date, day of the week, time, video station, number of persons in a group, direction of movement, user type (bikers, hikers, joggers, ...) and the number of dogs. The type of video system installed made it impossible to identify individual persons, thus guaranteeing anonymity. For modeling the daily number of visitors to the Lobau respectively the logarithm of these data was used. Days, when there was a loss of data of more than three hours at one of the video stations, were not included in the model. Therefore, 206 complete data sets of daily totals obtained when all cameras operated without failure, were available. The remaining data sets were used to verify the model.

In addition, on four days and at 12 entrance points to the park, visitors were counted and interviewed about their motives, activities and needs, etc. The survey took place on a Thursday and the immediately following Sunday, once in spring and once in summer. To collect as much data as possible, the survey was conducted on days with fine weather. The total sample size was 780 interviews. Temporal-selective counting, combined with video data, was needed for an extrapolation of the total number of visitors per year.

Meteorological data such as air temperature, precipitation, wind velocity, vapor pressure, relative humidity, cloud coverage and global radiation was provided by a nearby meteorological registration station of the Central Institute of Meteorology and Geodynamics in Vienna (ZAMG). The meteorological parameters 2 p.m. data, the day mean or categorized factors (i.e. cloud cover,

precipitation, ...) were used for individual stages of the modeling. In addition, using meteorological parameters thermal comfort indices such as the Physiological Equivalent Temperature (PET) were calculated using 2 p.m. data of the meteorological elements. The calculation of the Physiological Equivalent Temperature was done by the RayMan Program (Matzarakis et al., 2000).

As a tool for studying the interaction between recreational use and external influences the univariate analysis of variance was used. The contribution of each variable factor in explaining the total variation of the dependent variables can be investigated independently. It is also possible to investigate their specific interaction. Using categorized factors with a variance analysis it is possible to depict non-linear connections.

The modeling of the connections and correlation between the number of visitors and user types and the external factors weather and day of the week were carried out successively. Firstly, the following demands on a prognostic model were formulated:

- Practical efficiency
- Existence of secure input-data
- Simple input-data accessibility
- Sufficient quantity of input-data
- Simple interpretation by the layperson
- Realization of the results by management
- Comparison of the results.

Basic questions concerning the modeling included: Do the weekday and season have an influence on the number of visitors and their recreational activities? What is the extent of the influence of each individual factor? Which meteorological elements – the day under observation and the weather progression – are particularly relevant for specific user-groups? How large is their influence on the kind and extent of recreational activity in the research area?

RESULTS

The recreational use of the research area

The long-term video monitoring in combination with the survey led to the following results, which were used as the basis for the modelling process:

- Temporal-spatial distribution of the visitors: for example, number of visitors for the whole year, by month or season; daily visits, peak days, minimum and average number of visitors per day, number of visitors using various entrance points, choice of direction at the intersection of paths.
- Linking of temporal and spatial data: for example, number of visitors at a certain entrance point at a certain time.
- Quantification of specific user groups and their distribution over space and time.
- Connecting the temporal and spatial data of visitors and visitor behaviour with meteorological data, such as temperature or precipitation etc..
- A basis for the development of prognostic models to predict visitor loads.

In order to better understand the visitor structure and, therefore, to interpret the results accordingly, some results of the surveys follow. More than 90 percent of the visitors interviewed came from Vienna and more than 60 percent of the interviewees visited the Lobau at least once a week. The Lobau can therefore be called the "Green Living Room" of a large number of Vienna's inhabitants (Arnberger et al. 2001a). The Lobau is visited by about 600,000 people per year. The main visiting period is between March and October, highest frequencies could be observed in May and on Sunday afternoons, when all visitor types can be found in the Lobau. The main year-round users of the Lobau are bikers with 58 % and hikers with 37 %. The main visiting period for bikers is the summer, for hikers it is spring. Joggers can be mainly observed between March and September (Arnberger et al, 2001b).

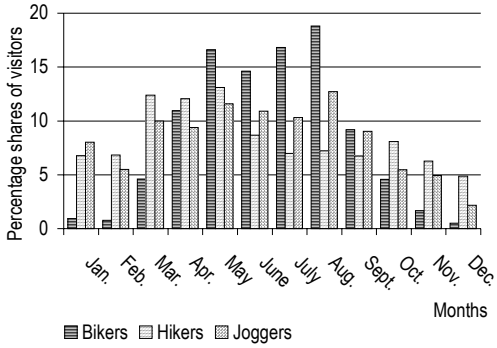

Figure 2: Relative Distribution of User Types over the Year 1998 - 1999, Data source: Video monitoring .09.1998-.08.1999

The workdays - Monday to Friday - are frequented by all user groups at a similar level. A significant increase in the number of visitors can be observed on Saturday and Sunday.

The observations of the individual types of visitors revealed a strongly differing pattern in respect to their dependence on the temperature. The number of bikers in the area is particularly susceptible to the temperature - an increased number can be observed only when the temperature rises above 10°C. Cloud cover played a more important role for bikers than for other users.

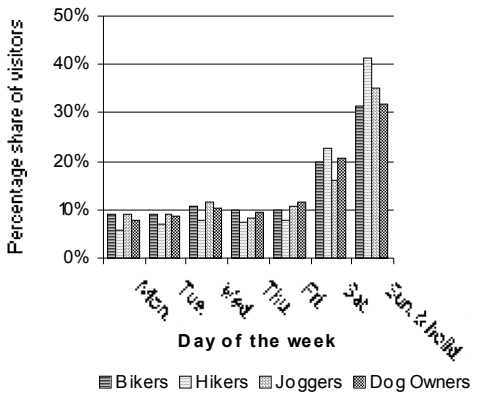

Figure 3: Visits per day of the week, Data source: Video monitoring .09.1998-.08.1999

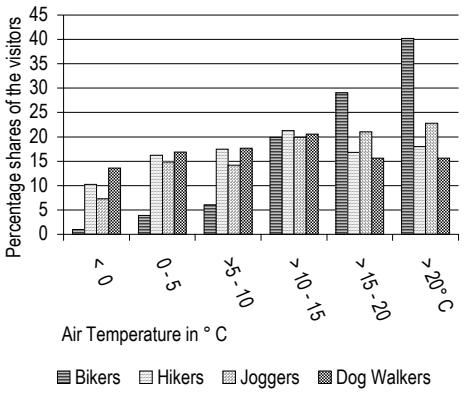

Figure 4: The Influence of Air Temperature on Visits to the Lobau, Data source: Video monitoring and ZAMG .09.1998-.08.1999

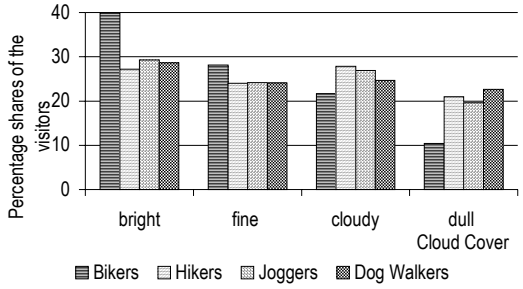

Figure 5: The Influence of Cloud Cover on Visits to the Lobau, Data source: Video monitoring and ZAMG .09.1998-.08.1999

Even a very superficial observation of the reasons for the various kinds and intensity of recreational use displays the influence of the weekday and weather. A fleeting look at the data appears to show clear-cut circumstances: One can count on more visitors on a fine weekend than on a rainy weekday. But, the dimension of the influence of the individual factors and their interaction is still unknown and it is precisely these parameters which are necessary for the prediction of the number of visitors and user types and, therefore, for effective visitor management.

The modeling process

In the first experiments, using daily total number of visitors, day of the week and only meteorological parameters such as cloud cover, cloud cover over the last seven days, precipitation during the day, wind velocity during the day, the day's mean air temperature and air temperature over the last seven days, no satisfactory results were obtained, particularly in interactive areas.

In the final model for the logarithm of daily visitor totals - without any distinction between the various user groups such as bikers, hikers etc. - the differentiation between workday (Monday to Friday), weekend or holiday (Saturday, Sunday, Holiday), the PET value according to the Ashrae scale (very cold (< 4 °C), cold (4 – 8 °C), cool (> 8 – 13 °C), coolish (> 13 – 18 °C), comfortable (>18 – 23 °C), mild (>23 – 29 °C), warm (>29 – 35 °C), hot (>35 – 41 °C), very hot (> 41°C) (Jendritzky et al., 1999)), occurrence (> 1 mm) or non-occurrence (0-1 mm) of precipitation at the principle activity times as well as the type of cloud cover (bright (< 2/10), fine weather (> 2/10 - 5/10), cloudy (> 5/10 - 8/10), dull weather (> 8/10) (Auer, 1990)), were all included. Even though cloudiness is used in the calculation of PET, it is also necessary for explaining visitor numbers as a separate covariant. This can be substantiated by the theory, that, among other things, the brightness of the sky is decisive for a person's psychological feeling.

Tests of Between-Subjects Effects
Dependent Variable:LN Daily total Number of the Visitors

Source	Type III Sum of Squares	df	Sig.	Eta Squared
Corrected Model	152,863	20	0,000	0,850
Intercept	1172,414	1	0,000	0,985
Day of the week	42,852	1	0,000	0,613
Cloud Cover	6,822	3	0,000	0,202
Type of PET	58,181	8	0,000	0,683
Percipitation	7,191	1	0,000	0,210
Day of the week * Type of PET	3,05	7	0,005	0,101
Error	27,026	185		
Total	8039,229	206		
Corrected Total	179,879	205		
a	R Squared = ,850 (Adjusted R Squared = ,834)			

Table 1: Evaluation of the Model of the Logarithm of Daily Totals of the Visitors

Using these results, it is possible to derive a formula for predicting visitor frequency:

Because of the greatly differing demands of these specific groups, it is necessary to develop an individual model, using partially different parameters, for each user group, for fine-tuning. Reliable models can be obtained for the total number of visitors per day as well as for specific, large user groups (i.e. hikers and bikers.)

$$Daily\ Totals\ of\ the\ Visitors = e^{(7,5 + (-0,735088\ AF(1)) + (0\ AF\ (2)) + (-0,320381\ NSTYP(0)) + (0\ NSTYP(1) + (-1,913796\ PETTYP\ (1)) + (-1,604032\ PETTYP\ (2)) + (-1,126833\ PETTYP\ (3)) + (-1,653791\ PETTYP\ (4)) + (-1,245516\ PETTYP\ (5)) + (-1,488712\ PETTYP\ (6)) + (-0,589738\ PETTYP\ (7)) + (0,0302933\ PETTYP\ (8)) + (0\ PETTYP\ (9)) + (0,461441\ BEWÖLKTYP\ (0)) + (0,4303512\ BEWÖLKTYP\ (1)) + (0,314313\ BEWÖLKTYP\ (2)) + (0\ BEWÖLKTYP\ (3)) + (-0,6152587\ [A\_F=1,00] * [PETTYP=1,00]) + (-0,616591\ [A\_F=1,00] * [PETTYP=2,00]) + (-0,772573\ [A\_F=1,00] * [PETTYP=3,00]) + (-0,660745\ [A\_F=1,00] * [PETTYP=4,00]) + (-0,239951\ [A\_F=1,00] * [PETTYP=5,00])]) + (0,1220991\ [A\_F=1,00] * [PETTYP=6,00]) + (-0,042184\ [A\_F=1,00] * [PETTYP=7,00])]) + (0\ [A\_F=1,00] * [PETTYP=8,00])).}$$

Figure 6: Formula for Predicting visitors attendance levels

Summarising, the day of the week has the greatest influence on the number of visitors. The Physiological Equivalent Temperature (PET) also has a major impact on the number of visitors per day, in particular on bikers and walkers. Precipitation and cloud cover have a moderate influence on the number of visitors. The current modeling experiments show that the weather over the previous 7 days does not play an important role on the number of visitors.

To evaluate the model, data records, not included in the model creation, were used to test these models. A control - using a linear regression - results in a determinacy of almost 90% for the model of the daily totals of all visitors.

DISCUSSION

The availability of the discussed data on visitor monitoring permits a statistical evaluation of the correlation between the total daily number of visitors, as well for specific user categories, and the day of the week, meteorological parameters and comfort indices. The fact that it is so difficult to calculate the daily number of visitors of a specific category, such as joggers, is partially due to the fact that different decision-making patterns are decisive in the considerations of whether to jog or not.

Another problem arises from the size of the sampling. One specific group - swimmers - was not dealt with in this article because the sample size was too small for use in an analysis using the univariate analysis of variance. In order to model low-frequency user groups it is necessary to incorporate sophisticated statistical methods such as regression trees (Ploner et al., 2002). Another possibility would be to increase the sample size by carrying out the survey over an extended period of time.

The demonstrative power of the model for days with peak loading is not yet satisfactory. Particular emphasis must, however, be placed on these days because they are of particular importance for the supervision of the park and its ecological system management.

A major foundation for the establishment of the model is the potential visitors' decision-making process, which results in their respective use of the research area. It can be assumed that the decision on whether, or not, to take advantage of the leisure time possibilities of the Lobau, which is used predominantly by residents, is made more-or-less spontaneously and not planned well in advance. Weather forecasts which, for example, play a role in the planning of short holidays (Ammer et al., 1991; Lozza,1996) are not relevant to decision making in this case. Rather, the individual activities which a person carries out in his leisure time depend on the current temperature. The weather values of the day in question and possibly of the previous days play an important role in the recreational use of the area under investigation (Harlfinger, 1978).

Extent of interference	LN Total number of visitors	LN Bikers	LN Hikers	LN Joggers	LN Dog Walkers
Workday, weekend and holiday	high	high	high	small	moderate
Precipitation	moderate	moderate	small	existent	existent
PET	high	high	moderate		existent
Cloud Cover	moderate	moderate	small		small
Interaction between weekday and PET	moderate		small		existent
Cloud coverage of the last 7 days			very small	existent	existent
Air Temperature of the last 7 days		moderate	very small		
Value of model	adj. R^2=.834	adj. R^2=.844	adj. R^2=.744	adj. R^2=.291	adj. R^2=.440

Table 2: Explanatory value of the total number of visitors per day and the user categories

Relevant, practice oriented and reproducible data is required to enable leisure and recreational planning. This data must: be easily interpretable, permit simple further digital processing; be principally quantitative and result from continuous and simple data collection. Meteorology provides unbiased data which, however, does not include any planning information (Höppe et al., 1987). The interpretation of this data or its linkage with additional data is necessary for reaching appropriate further decisions. If these data are available, the number and distribution of the expected visitors can be determined. The management of recreational and protected areas only needs to input the weather parameters and the appropriate date and the estimated number of visitors will be calculated automatically. The precision of this will depend on the complexity of the data available for the individual recreational area.

Last but not least the park management needs the prediction of attendance levels for: the preparation of employment plans for the personnel of the conservation area: e.g. personnel at information points, rangers, first aid helpers, ..., to know the type of information required and best way to convey it depending on the visitor types at various access points, to refined distribution zones: marking of rest or recreational areas in connection with a certain guidance of visitors in time and space and to know the kind of facilities needed in recreational areas at a certain time.

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