Monitoring and Management of Visitor Flows in Recreational and Protected Areas
Conference Proceedings ed by A. Arnberger, C. Brandenburg, A. Muhar 2002, pages 115-121

Stated Preference & Choice Models – A Versatile Alternative to Traditional Recreation Research

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Abstract: In outdoor recreation research and visitor management applications, stated preference and choice methods have not enjoyed the same amount of popularity when compared to other directions of applied research. This is somewhat surprising considering the fact that decisions that managers of protected areas and outdoor recreation in general face are typically multi-attribute in nature and require an understanding of the trade-offs that decision-makers of clients are willing to make. This paper provides an overview to stated choice research by explaining the essential considerations during the design and analysis of this approach. The various stages will be explained on hand of a simple example. Then the versatility of the approach will be demonstrated by discussing research design options in more detail.

INTRODUCTION

Stated preference and choice methods have received less attention in recreation research and visitor management of protected areas, compared to other research approaches. Yet, I will argue that under certain conditions, and for certain research questions, stated preference / choice approaches are more appropriate than visitor monitoring, or traditional social psychology methods.

Over the past few years, the analysis of observed behavior (visitor monitoring) has witnessed significant progress with the introduction of innovative monitoring equipment and GIS, both of which are accompanied by more sophisticated analytical techniques. Many contributions to this conference document these developments. However, by definition, such observational data are confined to past behavior, and if more details are desired about underlying explanations of the behavior, or evaluations about the effects of pending management decisions are desired, then observational data are of limited value.

Therefore, a wide range of behavioral research techniques, many of which are survey based, have been introduced and adapted to recreation research over the past 30 years. Behavioral research provides insights into the various behavioral antecedents, explaining why visitors behave in certain ways, and these insights might also be used for predicting future behavior. Studies focus on attitudes, motivation, satisfaction, perception, or simply preferences. Much of the traditional visitor management literature is built on these foundations of social psychology.

Research on the phenomenon of choice does not slot into the one or the other category conveniently. Choice research may be undertaken with observation type data, because any form actual human behavior actually manifests some choice. Such analysis is referred to as revealed preference or choice analysis. On the other hand, researchers may also inquire about future choices or behavioral intentions, which the literature refers to as stated preferences or choice research.

This paper will focus on the latter, stated preference and choice research. Specifically, I will present variations of the discrete choice experiment, a multivariate method that permits one to evaluate scenarios of recreation experiences, management alternatives or outcomes by describing these in scenarios composed of several attributes. Such evaluations may include currently non-existent alternatives, and provide insights into the trade-off behavior of respondents. [ultimately supporting decision making] In this paper I will provide a brief theoretical background to the method, explain the basic statistical concepts, present a simple study from recreational fishing, and document the versatility of the method by discussing variations of its application.

MODELLING PREFERENCE AND CHOICE BEHAVIOUR

Many management problems in visitor and protected areas management are of a multi-attribute nature and involve tradeoffs between several desirable policy or management goals. Among the various methods that have emerged in multi-attribute preference research, it is useful to distinguish between (a) revealed preference /choice approaches, in which the importance of salient variables influencing a decision is inferred by statistical analysis from actual behaviour, and (b) stated preference approaches, in which survey respondents evaluate hypothetical questions (Timmermans 1984). Discrete choice models, which rely on revealed preference data, have been applied successfully to transportation research (Ben-Akiva and Lerman 1985; Train, 1986), spatial analysis (Wrigley 1985; Kanaroglou and Ferguson 1996 and 1998) and also to recreation (Stynes and Peterson 1984).

Among the stated preference/choice approaches, it is important to distinguish between compositional and decompositional methods (Timmermans 1984). In compositional approaches, such as the theory of reasoned action (Ajzen and Fishbein 1980), respondents evaluate each aspect of a complex management issue separately, and thereafter the researcher calculates ('composes') an overall utility value for an alternative by combining the components of an alternative according to some predefined decision rule. Despite some interesting attempts towards wider application in various fields of environmental management (see, for example, Peterson et al. 1988), the operationalization of these compositional models has proven difficult.

In contrast, decompositional multi-attribute preference models have been applied to complex management issues with considerable success (for summaries see Timmermans 1984; Timmermans and Golledge 1990). These models have proven to be versatile, since they account for the multi-attribute nature of the management issues, permit the exploration of non-existing alternatives, and avoid the problem of multicolinearity. In these models, alternatives are defined as combinations of a set of attributes, and each set is evaluated as a whole. The alternative profiles are constructed by following statistical design principles, such as fractional factorial designs (for example, Raktoe et al. 1981). If respondents rate or rank each full profile separately, the technique is usually referred to as conjoint analysis (Green and Srinavasan, 1978). In a discrete choice experiment (DCE), two or more such hypothetical profiles are combined to choice sets, and respondents choose the most preferred alternative (profile) from each set they are asked to evaluate (Louviere and Woodworth 1983; Louviere et al. 2000). The advantage associated with a choice based response task is that the statistical analysis can be conducted with the same multinomial logit regression model (see below) that is typically applied in discrete choice models. In other words, DCEs combine the analytical elegance of the random utility model (McFadden 1974) with the experimental rigour of conjoint analysis (Green and Srinavasan, 1978). The advantages of stated choice over traditional conjoint analysis are that behaviorally, the analysis of choice - even though it is only hypothetical choice – is closer to actual behavior than a rating or ranking task, and that the statistical analysis has a rigorous error theory included (see below).

DCEs have been applied to spatial consumer choice behaviour (Timmermans et al. 1992), and to tourism and recreation issues (Louviere and Timmermans 1990; Haider and Ewing 1990). Lately, they have gained increasing popularity in resource economics (Swallow et al. 1994); more specifically, several recent studies have compared the performance of revealed and stated preference methods for resource valuation (Boxall et al. 1996; Adamowicz et al. 1997 and 1998). This interesting topic with significant relevance to outdoor recreation remains outside the scope of this paper.

THEORY - THE DCE

There are several stages to desinging a proper DCE. First, the attributes and attribute levels that are crucial to a recreation experience and/or a decision-making context need to be identified. Second, an experimental design needs to be selected. Third, statistical analysis needs to be undertaken. Finally, the results may be presented in a computerized decision support system. An example from a simple study in recreational fishing (ice fishers around Sudbury, Canada) will be used to demonstrate the various research stages of data.

Defining attributes and attribute levels

A realistic choice task requires the identification of crucial attributes and attribute levels that typically influence a respondent's decision when purchasing a good or service, or when selecting a recreational trip. Usually one considers attributes that contribute to the quality of the experience as well as the regulatory framework. Attributes and their specifications can be identified from the literature; management issues will be conveyed by managers; any variables pertaining to the experience may be elicited from potential respondents through informal interviews or in focus groups sessions. Attributes and their specifications for the ice fishing study are summarized in Table 1.

Selecting a fractional factorial design

Second, profiles need to be created, and thereafter two or more profiles need to be combined to choice sets. If one were to use all possible profiles (combinations of attribute levels) in a study, one would refer to it as a full factorial design, and ANOVA could be used as statistical analytical procedure. Given the large number of attributes and levels that make up a DCE, a full factorial approach is out of question. An alternative is to show respondents only a small set of all possible combinations. For that purpose, one can select appropriate fractional factorial design plans, which follow precise statistical design principles (for example, Raktoe et al. 1981). In most cases such fractional factorial designs ensure that attributes remain orthogonal (independent) of each other; The cost of employing a fractional factorial design is that many or all interactions may not be estimable (they are aliased with main effects). The obvious advantage is that respondents consider the attributes in the context of each other.

ATTRIBUTE	LEVELS
Travel	
Travel time to lake	• Half as much as today's • Same as today's • Twice as much as today's
Regulations	
Size limit	• None • 40-50cm slot
Creel limit	• 6 fish per day • 4 fish per day
Gear restrictions	• 2 lines • 1 line
Bait restrictions	• live bait allowed • artificial lures only
Length of season	• current (Jan 1 – April 30) • closes February 28
Expectations	
Number of fish	• many • few
Size of fish	• mostly small fish • mostly large fish

Table 1:List of Attributes and Levels for the ice fishing study.

If respondents rate or rank each profile separately, the technique is usually referred to as conjoint analysis (Green and Srinavasan, 1978). In a DCE, two or more such hypothetical profiles are combined to choice sets by following one further simple factorial design plan. Respondents choose the most preferred alternative (profile) from each set they are asked to evaluate (Louviere and Woodworth 1983; Louviere 2000). For a simple example of a choice set, see Table 2.

In the ice fishing study we used a total of eight attributes, seven of which were presented on two levels, and one as a three-level variable. We selected a 16^2 resolution III fractional factorial design plan (Raktoe et al. 1981), which permitted the estimation of all main effects. The three-level variable (travel time) was accommodated into the design by showing only two of the three levels in each of the two profiles of a choice set. Interviews were conducted at the fishing sites, and therefore the 16 choice sets that were required by the design were divided into four sets of four choice cards each, so that each respondent faced four choices. Respondents choose either of the two hypothetical lakes (Lake A or Lake B), or could also select to not fish. Presenting such a common base alternative is important, because it provides a shared platform for analysis.

	LAKE A	**LAKE B**
Travel time	Half of today's	Same as today
Size limit	40-50 cm slot	None
Creel limit	4 fish /day	6 fish / day
Gear	2 lines	1 line
Bait	Artifical lures only	Live bait only
Season	Current	Closes feb. 28
Number	Few	Many
Size	Mostly small	Mostly small
YOUR ' CHOICE	❒ **Lake A** ❒ **Would not fish**	❒ **Lake B**

Table 2: Example of a choice set.

Statistical analysis

The analysis of DCEs is based on the assumptions of the general discrete choice model (McFadden 1974 – also referred to as the random utility model), which in its original form is used for analysis of revealed preferences and is based on the following assumptions. Individual behaviour is considered as deterministic, but because of the inability of the research process to account for all influencing attributes and the need to aggregate individual choices across individuals, the modelling of behaviour is undertaken stochastically (Train 1986; Ben-Akiva and Lerman 1985). Therefore, it is assumed that the overall utility (U_i) contained in any one alternative is represented by a utility function that contains a deterministic component (V_i) and a stochastic component (e_i). Selection of one alternative over another implies that the utility (U_i) of that alternative is greater than the utility of any other alternative (U_j). The overall utility of alternative i is represented as (McFadden 1974; Train 1986):

$U_i = V_i + \varepsilon_i$
(Equation 1)

An individual will choose alternative i if $U_i > U_j$ for all $j \neq i$. However, since the utilities include a stochastic component, one can only describe the probability of choosing alternative i as:

Prob {i chosen} = prob $\{V_i + \varepsilon_i > V_j + \varepsilon_j \,;\, \forall j \in C\}$
(Equation 2)

where C is the set of all possible alternatives. If one assumes that, for the entire sample, the stochastic elements of the utilities follow a Gumbel distribution, the standard multinomial logit (MNL) model can be specified (McFadden 1974; Ben-Akiva and Lerman 1985):

Prob {i chosen} = $e^{Vi} / \quad e^{Vj}$
(Equation 3)

where the aggregate probability of choosing alternative i equals the exponent of all the measurable elements of alternative i over the sum of the exponent of all measurable elements of all j alternatives. This standard MNL model supports the estimation of parameters that allow one to express the choice probability of a given alternative as a function of the attributes comprising that alternative and those attributes of all other alternatives in the choice set.

The analysis produces regression estimates for each attribute level, which are referred to as partworth utilities, and typically are presented in a table jointly with standard error and t-value associated with each estimate (Table 3). All attributes were dummy coded (0,1). The estimate represents the part-worth utility for the attribute level compared to its 0-level, i.e. the level not shown. All the estimates have the expected signs, and all estimates are significant at the 5% level except size limit, and creel limit is significant at the 10% level only. In the design, the variables were arranged so that the interaction between the variables gear and bait was also estimable, and it was significant in the sense that if both attributes were changed to a more restrictive level at the same time then the support for these policies would decline even further. The results show that enacting gear and bait restrictions would be the least popular regulatory changes, while other regulations are more acceptable. With such knowledge resource managers can make more informed decisions between acceptability of regulations and their likely effects on the resource.

Attribute	**Estimate**	**Standard Error**	**t-value**
Intercept	2.033	0.045	45.446
Travel (same)	0.208	0.030	6.885
Travel (half)	0.147	0.019	7.797
Size limit (slot)	0.012	0.016	0.726
Creel limit (4 fish)	-0.030	0.016	-1.874
Gear (1 line)	-0.178	0.016	-11.345
Bait (artificial)	-0.298	0.017	-17.545
Season (short)	-0.087	0.016	-5.436
Exp_numb (many)	0.088	0.017	5.286
Exp_size (m. large)	0.159	0.017	9.537
Interaction Gear*Bait	0.096	0.019	4.994

Table 3: Results of the ice fishing study

A DECISION SUPPORT SYSTEM

In addition to documenting the part-worth utilities for each of the variable levels, the decompositional nature of the DCE also permits the instantaneous evaluation of any profile that can possibly be generated as a combination of the experimental variables. In other words one can model the joint effects of several changes simultaneously. This overall evaluation is based on the calculation of the probability of choice for one alternative over any other alternative(s), as suggested by the last equation above. The layout of such a decision support system (DSS) follows the original layout of the choice sets closely (Figure 1). It is interactive in the sense that any possible profile can be evaluated by simply changing any attribute levels in the interface window.

In the example of Figure 1, Lake A represents pretty well the current situation, except that the travel time is halved. Lake B contains several regulatory changes (a lower creel limit, only one line, artificial lures only, and a shorter season), while the expectations remain the same. As to be expected, Alternative B is considered much less attractive. Its market share reduces to 22%, while Alternative A's increases to 72%. The rate of non-anglers increases by almost 2%. One can now continue with the evaluative game and assume that such a drastic change in regulations would eventually improve the quality of the fishery. By adjusting the size and number of fish one can expect to catch to the more favorable levels, the share of Lake B would recover to a certain extent to 31.8%. Obviously one can play through several demographic or experience related criteria.

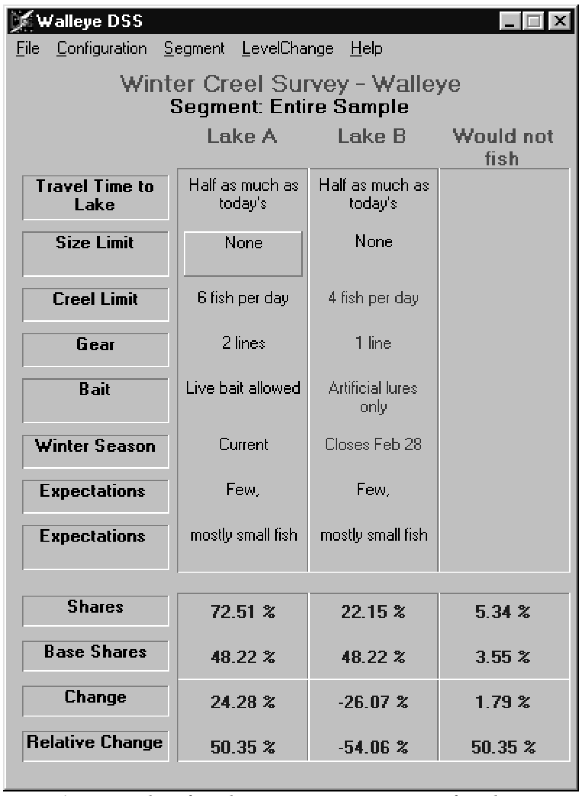

Figure 1: Example of a decision support system for the ice fishing study.

THE VERSATILITY OF DCES DURING APPLICATIONS

A DCE does not need to be constrained to a simple choice between two hypothetical scenarios. In the contrary, any one of its features can be adapted to suit the purpose of investigation. Several options will be explored below. The limited space available in these proceedings does not permit me to show examples for all these issues. These examples will be presented during the conference.

Number and types of scenarios in a choice set

Rather than asking respondents to choose among two alternatives, one may ask them to choose among several alternatives. Including more than two scenarios into a choice set may not be very useful in a generic model (i.e. the profiles are simply labeled A vs. B as in the example above). However, in many applications the realism of a choice set may increase by labeling the scenarios, which leads to an alternative specific design. Theoretically, any variable can take on the role of defining the alternatives. Usually one has a good reason for selecting an alternative specific variable, such as trip destinations (Haider and Ewing 1990), brand names such as sports equipment, or fish species (Aas et al. 2000; Fedler et al. 1999). One needs to estimate an intercept (constant) for each alternative, which amounts to an estimate for that variable.

Response tasks and use of base alternatives

In some situations it might be appropriate to consider an alternative to the simple binomial or multinomial choice task. Especially in recreation studies it frequently appears appropriate to model the repeated allocation of choice between different scenarios over the course of a season or for the duration of a trip. In such a case, one can ask respondents to allocate a total of, say, ten trips among the scenarios in one choice set. A respondent may then allocate five out of ten recreational day trips to a protected area among hiking, mountain biking, and kayaking. Depending on which other variables are associated with the study, the choice among these options might vary considerably from choice set to choice set. The advantages of such an allocation task are that one actually collects more data with the same amount of effort. Furthermore, depending on the circumstances, an allocation task might also be behaviorally more meaningful.

Depending on the respondent's decision making or choice context, it might be of interest to disaggregate the base alternative further. For example, if respondents do not find any of the scenarios presented in a choice acceptable, one might want to know if they would consider a different activity in the same location, or would rather search for an activity substitute in the vicinity, or would consider a substitute in a very different region, or would decide to abandon both activity and location. Obviously, the method can be used for designing sophisticated research on substitution behavior.

Interactions and Cross-effects

Modelling the interactions between variables is possible, if a design is set up accordingly from the beginning (see example above). Many designs have sufficient room for targeting a couple of two-way interactions. If one can anticipate the most salient interactions a priory, a design can be laid out in such a manner that the desired interaction will be estimated. Dellaert et al. (1995) present a rather elaborate study of interactions in an application to urban tourism.

In alternative specific models it might be of interest to determine potential effects from one alternative on the other. This phenomenon is referred to as the cross-effect, which also can be estimated. However, in praxis it is often difficult to interpret such cross-effects when they emerge as significant.

Alternative presentation of stimuli

In most cases the attributes and choice sets are simply presented as written statements. In recreation research, visual landscape components might constitute important determinants of choice. Such concerns might range from the attractivity of outstanding landscape features, and issues of crowding, to human effects such as logging. It is conceivable that one any one attribute can be presented visually. In one study on the effects of forest harvesting on tourism we presented the quality of the forested landscape in northern Ontario in digitally calibrated images (Orland et al 1995). The digital calibration of images refers to a much more rigorous design process, in which one or several variables describing the landscape become an integral component of the fractional factorial design, and then a digital imaging technique is used to create a photo-realistic landscape image that represents these attributes. Figure 2 shows one example of the calibration process for the study in northern Ontario. The two columns on the left list the eight variables that were created in the image. In this study we used a total of 64 different images, which where then embedded into each scenario. Other attributes described the type and quality of the fly-in fishing location, and the fishing quality.

Nested and partial designs

The basic assumption in most DCEs is that respondents process all information simultaneously. In certain recreation applications such an assumption may be incorrect, when recreationists might consider experience components separately. For example, a destination and a mode of transportation, both of which are multiattribute phenomena in their own right, may be considered sequentially or separately. In such a situation a hierarchical or nested model structure might be appropriate, in which respondents evaluate one

Scene 1

Attribute:	**Levels:**
Buffer Width -	100m
Residuals -	single conifers
Road -	no road
Forest Type -	conifer
Size -	large
Shape -	regular
# Blocks -	multiple
Colours -	fresh brown

Figure 2: An example of a digitally calibrated image

component before the other. Sometimes the number of attributes that a researcher desires to include in a study might be too large for presentation in one scenario. In that case, again a hierarchical design, or a partial design, in which only a subset of all variables appear in each choice set are elegant ways for building a larger model while still keeping the response task manageable. For a thorough discussion of many of these issues, see Dellaert et al. (1997) and Oppewal et al (1994).

CONCLUSIONS

The above presentation documents the versatility and adaptability of stated choice modeling to different behavioral context as well as to theoretical questions and applied issues. The main advantages associated with stated choice methods can be summarized as the following:

- respondents evaluate a recreation experience or the outcome of a management action as a whole, while the statistical analysis derive utility measures for each attribute;
- respondents think inevitably in terms of trade-offs, and whatever issue might be at the forefront of management concerns is somewhat disguised in the larger context;
- respondents may be better at expressing relative preferences than absolute ones;
- the statistical design ensures attributes are uncorrelated, obviating the problem of multicolinearity often encountered in revealed preference studies;
- the method allows the researcher to control the alternatives and choice sets presented to the respondent;
- truly different alternatives, some of which may not exist presently, can be evaluated.

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Monitoring and Management of Visitor Flows in Recreational and Protected Areas
Conference Proceedings ed by A. Arnberger, C. Brandenburg, A. Muhar 2002, pages 122-128

Segmentation of Outdoor Recreationists: A Comparison of Recreationists' Perceptions of Importance and Satisfaction Across Activities

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Abstract: The purpose of this study was to explore levels of importance and satisfaction with various attributes of customer service among selected segments of outdoor recreationists. The study also examined the nature of the relationships between satisfaction attributes and overall satisfaction. These relationships were tested for four dimensions of satisfaction (facilities, services, information, and recreation experience), across three water-based user groups (ramp users, campers, and day users). This study builds on previous customer satisfaction research conducted by both consumer behavior specialists and recreation researchers. In congruence with previous research on customer satisfaction, many of the constructs associated with quality in a recreation environment are intangible, elusive, and extremely difficult to measure. Study results showed that there are significant differences between different segments of users in reported levels of importance and satisfaction with various aspects of a recreational visit, but the nature of the relationships between the various domains and overall satisfaction varies little across the user segments.

INTRODUCTION

Recreation satisfaction has been examined from many different perspectives. Satisfaction has been identified as the principle product of the recreation experience (Driver & Tocher, 1970) and the major goal of recreation resource management (Lucas & Stankey, 1974). Zeithaml and Bitner (1996) describe satisfaction as a broad evaluation of a product or service that is influenced by perceptions of service quality, product quality and price, and other factors.

The notion of different levels of importance and satisfaction for distinctly different market segments or recreation user groups is examined in this paper. In a 1981 effort, Graefe identified different subgroups of anglers based on socio-economic differences, reasons for fishing, and participation levels. As early as 1978, Tinsley and Kass conducted research that focused on the differences in leisure activity needs between males and females, finding that leisure activities differ in their need satisfying properties.

Kuss, Graefe and Vaske (1990) examined the different needs of diverse user groups in outdoor recreation settings, based on the notion that a single management strategy cannot satisfy all visitors. This research effort attempted to develop visitor typologies, based on participation rates, preferences, demographics, and geographical location. Andereck and Caldwell (1994) examined segmentation in a public zoo setting, remarking that "understanding the diversity of participant needs and desires allows organizations to manage resources in the most efficient manner" (p. 19). Donnelly, Vaske, DeRuiter, and King (1996) pursued the notion of person-occasion segmentation, which focuses on not only the different user groups visiting the recreation area, but the different natural resource attributes of the area that they were visiting. Howat, Absher, Crilley and Milne (1996) measured visitor characteristics, demonstrating that variables such as gender, age, and disability status impact overall satisfaction levels of users to sporting events and leisure centers in Australia and New Zealand.

BACKGROUND

The purpose of this study was to explore the nature of customer satisfaction at US Army Corps of Engineers outdoor recreation settings. Data were collected as part of a larger study of customer satisfaction levels funded by the US Army Corps of Engineers Recreation Research Program. The parent study ran from mid 1995 to mid 1998, and resulted in a nationwide study of customer satisfaction levels at Corps lakes. Particular attention was placed on ensuring that the study was carried out at recreation sites dispersed throughout the country to capture the satisfaction levels of the Corps' nationwide water-based recreation customers.

Ten of the US Army Corps of Engineers' 465 lakes, located in ten different states, were selected for this study. These ten lakes were selected because of their broad range of surrounding populations, their dispersed geographical locations, their relatively high usage rates, and their representativeness of Corps recreation users in the United States.

A random sample of 2,933 recreationists at Corps of Engineers lakes were selected to participate in this study. The sample was stratified and conducted on-site at 67 individual recreation sites at the participating lakes. The interviews were collected in entirety through on-site, face-to-face interviews. Respondents were approached by the interviewers while they were in a recreation setting, such as a campground, boat ramp area, or day use area (beach, picnic area, etc.). Refusals were very limited (29 returned refusal sheets) due to the on-site methodology of the study.

The visitors were asked what recreational activities they were pursuing and then asked to rank those activities by listing their primary, secondary, and tertiary activities by level of importance. The respondents were categorized accordingly, falling into one of three primary user segments (ramp use, camping, or day use). Of the 2,933 respondents interviewed, 35% reported that their primary activity was day use, another 35% indicated that camping was their primary activity, and 30% reported ramp-use as their primary activity (Table 1).

Activity	N	%
Ramp use	720	30.3
Camping	820	34.5
Day use	837	35.2

Table 1. Primary Activity Frequencies.

INSTRUMENTATION

This study was designed to measure visitors' expectations and satisfaction with facilities, services, information, and their recreation experience. Customer satisfaction was measured using a battery of 19 items patterned after instruments developed by Parasuraman, Zeithaml, and Berry (1985) for use in consumer research, and MacKay and Crompton (1990) and Howat, Absher, Crilley and Milne (1996) in the outdoor recreation field. These researchers used several "domains" under which a battery of items was nested. The number of domains has ranged from three to ten, and the number of customer service items has ranged from 11 to 77 in different studies.

In this study, 19 items under four different domains were used to attempt to explain overall satisfaction (Table 2). Respondents were asked to rate both the importance of and their satisfaction with the attributes using a five point Likert scale ranging from "not at all important" to "extremely important" and "not at all satisfied" to "extremely satisfied."

To identify specific areas of satisfaction, each of the 19 items represented one of four satisfaction domains (facilities, services, information, and recreation experience). The satisfaction level associated with each of these four domains was also measured using a 5-point Likert scale. The final satisfaction measure was an overall measure of satisfaction, designed to query visitors as to their satisfaction with their overall experience on that visit. A 10-point scale, ranging from "1" to "10" (where 1 is worst and 10 is best) was used to measure overall satisfaction.

RESULTS

The mean importance and satisfaction scores were relatively high, with the highest importance score (safety and security at the area; mean = 4.50) found in the services domain, followed closely by appearance and maintenance of the area (4.47), in the facility domain (Table 2). The lowest importance scores were noted for the information domain, with the lowest individual item being nature/historical information about the area (3.33). The highest satisfaction indicator was found in the services domain (courteous and friendly staff; 4.34). The lowest satisfaction score was the same as the lowest importance item (nature/historical information about the area; 3.73).

Comparison of User Groups

For the purpose of this paper, recreation users were asked to indicate what their primary activity was (ramp use, camping, or day use) on the day they were interviewed at the recreation site (see Table 1). One-way analysis of variance was used to compare satisfaction levels for various aspects of the trip experience. Sheffe's post hoc analysis was used to examine the multiple comparisons of the mean scores.

Significant differences were noted for satisfaction within all four customer service domains (Table 3). In each case, the campers showed the highest mean scores among the three user groups. The greatest differences were noted in satisfaction with services. Campers showed the highest scores for this measure (mean = 4.28), followed by day users (4.09) and ramp users (4.06). Satisfaction with information showed the second greatest degree of difference across the three user groups, with campers (4.14) indicating the highest mean scores for this item, and no significant difference noted between ramp users (3.98) and day users (3.97). Similarly, campers showed the strongest satisfaction levels for satisfaction with

Satisfaction Domain	Item	Mean Importance	Mean Performance
Facilities	Accessibility for those with disabilities	3.67	3.88
Facilities	Sufficient number of recreation areas	4.24	4.04
Facilities	Appearance and maintenance of the area	4.47	4.26
Facilities	Value for fee paid	4.08	4.19
Services	Availability of staff to answer my questions	3.65	3.97
Services	Visibility of staff	3.72	4.05
Services	Safety and security at the area	4.50	4.27
Services	Courteous and friendly staff	4.24	4.34
Services	Opportunity to offer suggestions to the staff	3.60	3.97
Services	Adequate ranger/visitor assistance patrols	4.14	4.20
Information	General information about the area	3.56	3.89
Information	Nature/historical information about the area	3.33	3.73
Information	Safety information	3.98	3.94
Information	Ease of obtaining information	3.85	4.03
Information	Current and accurate information	3.92	4.04
Experience	Opportunity to recreate without feeling crowded	4.21	4.09
Experience	Opportunity to recreate without interference from other visitors	4.15	4.11
Experience	Compatibility of recreation activities at the area	3.87	4.11
Experience	Places to recreate without conflict from other visitors	4.35	4.26

Table 2. Mean Importance and Satisfaction Scores for Customer Service Items.

One-way ANOVA	Ramp Users	Campers	Day Users	
	Mean Values			F Value
Satisfaction with Facilities	4.18[a]	4.30[b]	4.27[ab]	4.84**
Satisfaction with Services	4.06[a]	4.28[b]	4.09[a]	18.78***
Satisfaction with Information	3.98[a]	4.14[b]	3.97[a]	11.30***
Satisfaction with Recreation Experience	4.32[a]	4.42[b]	4.35[a]	4.60**

***= Significant at p < .001 ** =Significant at p < .01 * =Significant at p < .05
a Means with different superscripts differ significantly at the .05 level

Table 3. Comparison of Satisfaction with Facilities, Services, Information, and Recreation Experience Domains, by Type of User.

facilities (4.30), followed closely by day users (4.27). The ramp users (4.18) were significantly less satisfied with facilities than the campers (4.30). The smallest differences were noted for satisfaction with the recreation experience, although campers again showed a slightly higher satisfaction score (4.42) than day users (4.35) and ramp users (4.32).

Further analyses compared the individual satisfaction attributes across the three user groups. Significant differences were noted between the three groups for each of the 19 importance items (Table 4). A clear pattern of campers reporting significantly different perceptions of importance was noted. Campers reported the highest importance scores for 16 of the 19 items, although one item was matched in importance by the ramp users. The accessibility for persons with disabilities stood out as being significantly more important to the day users (3.80) and campers (3.76) than to the ramp users (3.46). This item was an anomaly among the 19 items in that only a small proportion of respondents reported that they had a disability and answered the question.

The day users showed the lowest importance scores for 12 of the 19 items, while the ramp users reported the lowest importance scores for the remaining seven items. Only one clear pattern emerged across the four domains, with the day users

One-way ANOVA	Ramp Users	Campers	Day Users	
	Mean Values			F Value*
Facilities Domain				
Accessibility for those with disabilities	3.46 [a]	3.76 [b]	3.80 [b]	11.63
Sufficient number of recreation areas	4.21 [a]	4.37 [b]	4.08 [c]	26.68
Appearance and maintenance of the area	4.39 [a]	4.57 [b]	4.43 [c]	15.69
Value for fee paid	4.06 [a]	4.25 [b]	3.95 [a]	21.59
Services Domain				
Availability of staff to answer my questions	3.61 [a]	3.94 [b]	3.46 [c]	44.75
Visibility of staff	3.70 [a]	3.98 [b]	3.48 [c]	50.88
Safety and security at the area	4.40 [a]	4.61 [b]	4.44 [a]	21.55
Courteous and friendly staff	4.15 [a]	4.37 [b]	4.16 [a]	20.84
Opportunity to offer suggestions to the staff	3.66 [a]	3.74 [a]	3.34 [b]	35.26
Adequate ranger/visitor assistance patrols	4.13 [a]	4.38 [b]	3.95 [c]	46.65
Information Domain				
General information about the area	3.46 [a]	3.75 [b]	3.48 [a]	22.30
Nature/historical information about the area	3.14 [a]	3.42 [b]	3.33 [a]	11.94
Safety information	3.93 [a]	4.12 [b]	3.87 [a]	15.31
Ease of obtaining information	3.80 [a]	4.00 [b]	3.72 [a]	21.83
Current and accurate information	3.93 [a]	4.03 [a]	3.80 [b]	13.51
Recreation Experience Domain				
Opportunity to recreate without feeling crowded	4.25 [a]	4.30 [a]	4.11 [b]	10.92
Opportunity to recreate without interference from other visitors	4.21 [a]	4.18 [a]	4.06 [b]	5.94
Compatibility of recreation activities at the area	3.90 [a]	3.90 [a]	3.77 [b]	8.50
Places to recreate without conflict from other visitors	4.39 [a]	4.42 [a]	4.24 [b]	13.19

*= All F Values Significant at $p < .001$.
[a] Means with different superscripts differ significantly at the .05 level

Table 4. Comparison of Importance of Individual Customer Service Items, by Type of User.

One-way ANOVA	Ramp Users	Campers	Day Users	
	Mean Values			F Value
Facilities Domain				
Accessibility for those with disabilities	3.81	3.92	3.91	1.80
Sufficient number of recreation areas	3.93 [a]	4.11 [b]	4.13 [b]	10.24***
Appearance and maintenance of the area	4.24	4.34	4.26	3.26*
Value for fee paid	4.10 [a]	4.28 [b]	4.23 [b]	8.65***
Services Domain				
Availability of staff to answer my questions	3.94 [a]	4.16 [b]	3.83 [c]	29.94***
Visibility of staff	3.97 [a]	4.19 [b]	3.86 [c]	30.87***
Safety and security at the area	4.20 [a]	4.43 [b]	4.18 [a]	27.15***
Courteous and friendly staff	4.28 [a]	4.46 [b]	4.24 [a]	19.33***
Opportunity to offer suggestions to the staff	3.95 [a]	4.09 [b]	3.76 [c]	26.40***
Adequate ranger/visitor assistance patrols	4.15 [a]	4.36 [b]	4.07 [a]	25.12***
Information Domain				
General information about the area	3.83 [a]	4.00 [b]	3.83 [a]	11.44***
Nature/historical information about the area	3.68	3.76	3.70	1.43
Safety information	3.90 [a]	4.05 [b]	3.81 [a]	14.99***
Ease of obtaining information	3.98 [a]	4.21 [b]	3.87 [c]	34.91***
Current and accurate information	4.00 [a]	4.19 [b]	3.89 [c]	27.01***
Recreation Experience Domain				
Opportunity to recreate without feeling crowded	3.96 [a]	4.20 [b]	4.02 [a]	13.73***
Opportunity to recreate without interference from other visitors	3.98 [a]	4.22 [b]	4.09 [c]	14.42***
Compatibility of recreation activities at the area	4.07 [a]	4.16 [b]	4.06 [a]	4.16*
Places to recreate without conflict from other visitors	4.16 [a]	4.34 [b]	4.23 [a]	10.11***

***= Significant at p < .001 ** =Significant at p < .01 * =Significant at p < .05
[a] Means with different superscripts differ significantly at the .05 level

Table 5. Comparison of Satisfaction with Individual Customer Service Items, by Type of User.

Independent Variable	**Ramp Users**		Campers		Day Users	
	R	Beta	R	Beta	R	Beta
Satisfaction with Facilities	.27***	.07	.33***	.15*	.36***	.16*
Satisfaction with Services	.22***	-.00	.28***	.04	.35***	.12*
Satisfaction with Information	.30***	.16*	.33***	.14*	.38***	.16*
Satisfaction with Recreation Experience	.31***	.18*	.33***	.16*	.30***	.06
	R^2 = .12		R^2 = .15		R^2 = .17	
	F = 23.22***		F = 36.00***		F = 42.16***	

Dependent Variable = Overall Satisfaction
***= Significant at p < .001

Table 6. Multiple Regression of Overall Satisfaction with Facilities, Services, Information, and Recreation Experience Domain Satisfaction, by Type of User.

reporting the lowest mean importance scores for all four of the recreation experience items. Ramp users (mean = 4.21) and campers (mean = 4.18) indicated that the opportunity to recreate without interference from other visitors was more important to them than the day users (mean = 4.06). This same pattern held true for the remaining items within the recreation experience domain.

The examination of the item satisfaction scores showed some interesting patterns across the three user groups. As was noted in the importance analysis, the campers continued the trend of showing the highest mean satisfaction scores (Table 5). This was the case for all but one of the satisfaction items, where the day users showed higher satisfaction scores for "sufficient number of recreation areas." Several patterns emerged within the domains for the satisfaction items. The day users showed the lowest mean satisfaction scores for all six of the service items and three of the five information items (one item tied for lowest mean score between the ramp users and the day users). The ramp users showed the lowest satisfaction scores for all of the facilities items and for three of the four recreation experience domain items. As with the importance scores, the campers usually stood out as the most distinct group.

Predicting Overall Satisfaction

To understand the extent to which each of the domains was related to overall satisfaction, the four domain satisfaction scores were regressed against overall satisfaction for each of the three user groups (Table 6). In each instance there were at least two significant predictors of overall satisfaction, although the significant predictors varied for the three groups.

An examination of the ramp users showed that the recreation experience domain (*Beta* = .18) and the information domain (*Beta* = .16) were significant predictors of overall satisfaction. This model accounted for about 12% of the variance associated with overall satisfaction. The campers showed significant effects for the recreation experience domain (*Beta* = .16), the facilities domain (*Beta* = .15), and the information domain (*Beta* = .14). These independent variables accounted for about 15% of the variance in overall satisfaction. Day users' results also indicated three significant predictors of overall satisfaction. The facilities domain (*Beta* = .16), information domain (*Beta* = .16), and services domain (*Beta* = .12) together accounted for 17% of the variance associated with overall satisfaction.

One pattern that emerged from these regression models was that all three user groups showed a significant effect from the information domain. The facilities domain showed a significant influence for both the campers and the day users, while the ramp users and the campers showed a significant influence from the recreation experience domain. The services domain was significant for only one user group (day users).

A Fisher's Z test was used to test the significance of the differences between the correlations for the three different user groups. Few significant differences were noted between the three user groups. In the comparison of ramp users and day users, only the services domain score showed a significant difference (Z = 2.69, p = .007). Satisfaction with services was more strongly correlated with overall satisfaction for day users (r = .35) than for ramp users (r = .22). No other significant differences were found between the user groups with respect to the correlations between overall satisfaction and satisfaction with each of the domains.

CONCLUSIONS

This study examined three distinct recreation user groups to better understand the levels of importance and satisfaction for a battery of 19 items within four customer service domains. Respondents were segmented based on their self-described primary recreation activity (ramp use, camping, or day use). This was done to determine if the satisfaction model hypothesized in this study was an adequate measure of customer satisfaction for the three primary activities (ramp use, camping, or day use) that typically occur at Corps of Engineers recreation areas.

One clear pattern that emerged is that the campers were often significantly different from the ramp users and day users regarding their importance and satisfaction levels. When examining the individual satisfaction items and domains, one may note that a camper might have a completely different need associated with an item such as adequate ranger/visitor assistance patrols or visibility of staff than would a ramp user or day user. Campers are different from ramp users and day users in one key aspect: they sleep at the recreation site in tents, recreational vehicles, cabins, etc. Perhaps this commitment to stay at the recreation site leads to a closer evaluation of the importance variables, resulting in higher importance item ratings.

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Monitoring and Management of Visitor Flows in Recreational and Protected Areas
Conference Proceedings ed by A. Arnberger, C. Brandenburg, A. Muhar 2002, pages 129-135

Predictive Model of Responsible Environmental Behaviour: Application as a Visitor-Monitoring Tool

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Abstract: This working paper presents a framework for understanding responsible environmental behaviour as a visitor-monitoring tool. Visitor use data forms the basis of any successful visitor management plan to understand user knowledge, awareness and attitudes about pollution issues in order to develop management policies and actions that enhance appropriate visitor behaviour. A case study of the application of a predictive behavioural model on the Chesapeake Bay, Maryland, USA involving boater environmental behaviour as a social indicator is discussed. Results indicate that knowledge of water pollution issues, awareness of the consequences, equipment issues such as boat length and boat type, and situational factors that constrain or hinder appropriate behaviour were indicators of appropriate behaviour. A structural equation path diagram model was tested using AMOS student version 4.01 using up to seven of the eight predictors from boating behaviour case study to demonstrate the strength of a path analysis procedure. Results model those of the stepwise regression procedures used in the original study, yet the path diagrams demonstrate ease of interpreting the structural relationships among variables in a regression equation. Implications for management actions in the case study situation are given followed by a proposed research-monitoring program coupling social science techniques with the natural sciences.

INTRODUCTION

The environmental impacts of recreational boating in protected waters are recognised, but not well understood. Much of the available information is descriptive or anecdotal, with little hard data and analysis. Most studies are of a short-term nature, and long-term impacts are rarely addressed. The monitoring of environmental impacts of boating is not carried out in the majority of protected area marine parks in developing countries. There is rarely any baseline data with which to compare current situations, and neither is time-series data available for analysing trends. There is a lack of integrated monitoring and management, and no definition of indicators by which to evaluate the environmental performance of protected area tourism. It is recommended that simple social and environmental impact monitoring strategies are implemented, and controls on certain aspects of visitor and boater use are enforced (Goodwin et al., 1997). This paper examines specific issue responsible environmental behaviour as a social indicator in visitor monitoring within a marine resource setting. However, note that the concepts are intended for a broader context of visitor monitoring in protected areas.

Since the 1970's, the concern for the environmental quality of our planet has generated much research on the measurement of responsible environmental behaviour. From a social psychological perspective, environmental quality represents a collective action and a social norm problem (Heberlein, 1975). A litter-free beach zone, for instance, can only be achieved when the vast majority of sun-seekers dispose of their trash appropriately. Similarly, a pollution free marine park will not be realised if visitors do not collectively adhere to the regulations regarding waste disposal. General responsible environmental behaviour is defined as any individual or group action aimed to do what is right to help protect the environment in general daily practise – e.g., recycling (Sivek & Hungerford, 1989-1990). Meanwhile, specific responsible environmental behaviour is any behaviour that is more activity specific in nature (e.g., littering while backpacking in an alpine region) as related to rule compliance or illegal, inappropriate, or non-sustainable behaviour (Heberlein & Black, 1976; Hungerford & Volk, 1990). Although studies of attitudes towards specific issues are limited in overall generalisiability beyond the environmental issues under examination, the literature indicates that attitude measures specific to a given behaviour are better predictors of that behaviour than are more general measures (Cottrell & Graefe, 1997; Heberlein & Black, 1976; Hungerford & Volk, 1990; Marcinkowski, 1988). Yet, research implications imply that by including both, one can better predict behaviour from attitudes and show how actions and beliefs are part of a larger cognitive construct. By including both issue-specific and general attitudes within a predictive model, findings enhance further understanding of the interrelation between variables pertinent to the illegal or nonsustainable behaviour in question.

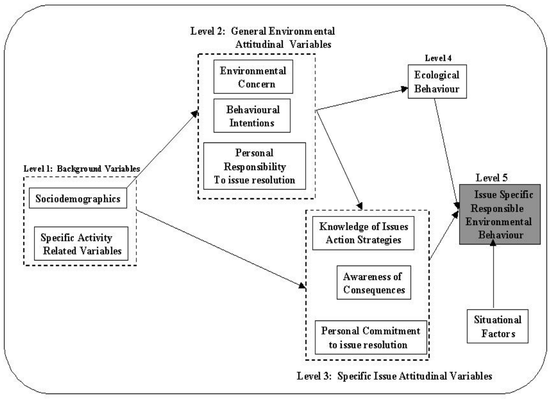
The purpose of this working paper is to present a framework for understanding responsible environmental behaviour as a visitor-monitoring tool (see Figure 1). The basis of a successful visitor management plan is the collection of visitor use data to understand user behaviour, needs, and expectations in order to develop management policies and actions that enhance appropriate visitor behaviour. Next follows a brief summary of a case study of boating impacts on the Chesapeake Bay in Maryland in which a similar predictive model was applied. A structural equation path diagram model was tested using AMOS student version 4.01 with up to seven of the eight predictors from the boating behaviour case study data to demonstrate the strength of a path analysis procedure. Results model those of the stepwise regression procedures used in the original study, yet the path diagrams demonstrate ease of interpretation of the structural relationships among variables in a regression equation. Finally, a proposed research design including visitor surveys of both observed and unobserved rule compliant boaters for comparison of results follow this up.

PREDICTIVE MODEL OF RESPONSIBLE ENVIRONMENTAL BEHAVIOR

This framework was based on recommendations found in the environmental behaviour literature to test a predictive model of responsible environmental behaviour including both general and specific issue behaviours (Hines et al., 1986/87; Hungerford & Volk, 1990; Sivek & Hungerford, 1989/90). Findings from previous testing (see Cottrell, 1993; Cottrell & Graefe, 1997) of a similar model imply that background variables (i.e., education and specific activity related variables), environmental concern, knowledge of environmental issues and awareness of the consequences of behaviour, were moderate to strong predictors of behaviour in both general and specific issue situations. Secondly, the more specific the indicator of behaviour, the better predictive ability that indicator had of specific behaviour. The author argues that a predictive model of responsible environmental behaviour is a useful tool for monitoring visitor behaviour pertinent to a greater understanding of behaviour leading to better visitor management planning.

Figure 1 shows five levels of variables arranged from left to right to represent an increasing strength of relationship between those variables and the primary dependent variable (specific issue responsible environmental behaviour (SREB)). Activity specific variables (i.e., activity type, equipment, skill level, participation, past experience), income, age, education, and political ideologies are some variables that comprise an individual's background. Background characteristics (level 1) precede other variables in the model and are necessary to understand responsible environmental behaviour (Cottrell & Graefe, 1997; Dunlap & Van Liere, 1984; Hines et al., 1987; Marcinskowski, 1988).

Figure 1. Predictive Framework of Responsible Environmental Behaviour (adapted from Cottrell, 1993).



The next two levels in the framework show two groups of variables: general environmental attitudinal and specific issue attitudinal variables. The general environmental group (level 2) includes environmental concern, behavioural intentions, and personal responsibility for issue resolution. As concern (item adopted from Dunlap & Van Liere, 1978) for different aspects of the environment develops, more specific attitudes about specific acts (e.g., water pollution) will evolve and influence feelings of personal responsibility toward an action and verbal commitment to an issue or problem resolution. Ajzen (1991) posed a theory of planned behaviour that has been used to examine indicators of responsible environmental behaviour (see Ajzen in Hrubes et al., 2001). In summary, his theory refers to human action that is guided by three forms of belief: behavioural – beliefs about the likely consequences of the behaviour, normative - beliefs about the normative expectations of others, and control - beliefs about the presence of factors that may further or hinder performance of the behaviour, a form of locus of control. Hrubes et al. (2001) argues that intentions remain a central indicator of actual behaviour and previous studies support their claim (Cottrell, 1993; Cottrell & Graefe, 1997).

An ecological behaviour scale is available and has been tested in a number of studies (Hartig, Kaiser, & Bowler, 2001; Kaiser, Ranney, Hartig, and Bowler, 1999). The scale consists of 51 items, which represent different types of ecological behaviour. This scale offers a more current construct of general environmental behaviour than used in Cottrell's (1993) dissertation and may result in a greater percentage of variance explained by the combined effect of the predictor variables in a regression model. In summary, the level 2 variables are shown to directly influence the specific issue group of variables (level 3) and to directly influence ecological behaviour (level 4), which in turn, influences specific REB (level 5).

The specific issue group of variables (level 3) includes knowledge of issues, which breaks down into three scales (i.e., knowledge about water pollution, knowledge about the laws pertinent to the specific issue and action strategies for rule compliance), awareness of consequences, and personal commitment to issue resolution. In order for an individual to act responsibly towards a given object or situation, a person must have some knowledge or information about it. For instance, to engage in recycling, they must know what they can recycle, where to take the recyclable, and when. Third, some awareness about consequences (e.g., threats to the marine environment) resulting from recycling may influence actual behaviour. Awareness of consequences of behaviour influences personal commitment for a particular action (Heberlein & Black, 1976). The stronger the sense of responsibility, the stronger the personal commitment to performing a particular act should be. Specific issue REB is shaded dark grey to denote its position as the primary dependent variable. Lastly, even though an individual's intentions to comply responsibly may be positive, certain situations and/or constraints might interfere with actual behaviour. Therefore, the variable category, situational factors, is shown in the diagram to influence actual behaviour.

BOATING CASE STUDY

The predictive model of responsible environmental behaviour was tested in an examination of responsible environmental boating behaviour on the Chesapeake Bay in Maryland (see Cottrell's dissertation, 1993). The following paragraphs summarise the main study results within the context of managing for sewage disposal from boaters as used by the Maryland State Boating Administration, USA.

Background

Recreational boating represents an important activity as it pertains to travel and tourism in the Chesapeake Region where there are an estimated 200,000-registered boats. Chesapeake Bay, the largest coastal embayment on the eastern seaboard, provides excellent opportunities for pleasure boating from sailing to sunbathing. The bay also provides areas for recreational claming, fishing, and crabbing. These recreational boating activities can have a potentially large impact on water quality via the dumping of raw sewage by boaters in high use areas (i.e., marinas, bays and lagoons) and pollution via hydrocarbon loading from boat exhausts. Sewage dumping is an important issue because of eutrophication caused by increased nutrient loads, hypoxia resulting from nutrient loading, high turbidity, and the release of coliform bacteria and other micro organisms of concern to human health. Marine toilets that directly discharge raw sewage are illegal in US territorial waters (i.e., within three miles of the coast). While the effect of a single boat may seem insignificant, the large number of boats on the water, especially during periods of peak use (weekends and holidays) lead to significant impacts on water quality. Marinas, boat anchorage's, and raft-up spots are typically located in quiet, protected waters such as small bays and inlets. Previous research has shown that these sites are frequently ecologically sensitive areas with restricted water flow, which means pollutants are flushed out slowly, thereby decreasing water quality. Recognising the threat of sewage from recreational boats to the quality of water in the Chesapeake Bay region, the General Assembly of Maryland passed legislation in 1988 to allow for use of waterway improvement funds to construct marine sewage pumpout facilities at public or private marinas (Arney, 1990; (Recreational Boat Pollution, 1991).

Problem clarification

Methods of proper disposal of sewage are common knowledge among owners of vessels with portable or marine toilets with holding tanks; yet, most vessel owner/operators generally discharge raw effluent within the three-mile limit. Multiple factors and/or constraints contribute to this behaviour: the inconvenience of travelling offshore, lack of sewage dump stations in the local area, lack of accessible and/or inconvenience of dump station locations, lack of adequate law enforcement, lack of knowledge about coastal marine laws and about the potential threat raw sewage imposes to public health and living resources, and a lack of responsible environmental attitudes (Recreational Boat Pollution, 1991). Another factor contributing to the illegal discharge of raw effluent is that most marine head holding tanks are limited in overall capacity (e.g., 15 gallon capacity on a 35 foot vessel); therefore, when used properly holding tanks fill rapidly, which requires frequent pumping out. The cruising vessel underway daily and travelling offshore while pleasure cruising is able to pump out a holding tank on a frequent basis. However, for those live-aboard vessels that remain indefinitely at a mooring, proper disposal of sewage is inconvenient, although sewage dump stations may be easily accessible (Cottrell, 1993). Thus, the discharge of human waste from recreational boats on the Chesapeake Bay is one aspect of marine pollution to confront as part of the overall problem of marine pollution in protected area waters.

Methods

This case study examined relationships between several of the variables depicted in Figure 1. Independent variables were age, boat length, boat type, years boating experience, knowledge about water pollution issues, awareness of the consequences of raw sewage on water quality, and the convenience of sewage pumpout station usage and the percent of human waste discharged in a sewage pumpout station (dependent variable - SREB). The methods used were:

- Household survey sent to 751 registered owners of boats 22 feet or longer to insure boats had a marine toilet. Sample was reduced to 713 due to insufficient addresses. Response was 41% (n=291), which was surprising due to self-reports of illegal behaviour (raw sewage discharge).
- Descriptive statistics, one-way analysis of variance, and multiple regression techniques were used to examine the predictive strength of the independent variables on the dependent variable (% sewage pumped in a pumpout station).

Note: for a complete overview of the analysis see Cottrell, 1993; Cottrell & Graefe, 1997.

Selected Results

Eight predictors of responsible environmental behaviour was determined accounting for 46% of the total variance explained in the % of waste pumped in a pumpout station (Cottrell & Graefe, 1994).

- As length of boat increased, % of waste pumped in a sewage pumpout station decreased[1].
- As years boating experience increased, sewage pumpout station usage decreased[1].
- As education & environmental concern increased, sewage pumpout station use decreased[1].
- As age of boaters increased, sewage pumpout station usage decreased[2]. Boaters 50 or less were more aware of the negative impacts raw sewage discharge has on water quality.

[1] Predictor variable(s) of specific behaviour in Cottrell, 1993.
[2] Correlate of specific behaviour only, Cottrell, 1993

Boat owners in this sample represent an affluent white middle/upper class group who have been boating a long time (average age=50; average years experience=21, boat length=31) and the implementation of a comprehensive SPS program in Maryland was recent at the time this study was conducted (1992). Findings indicate that there is a substantial difference between younger and older age boaters and their environmental attitudes and behaviour in this case study. Much of these results can be explained by situational factors – or in this case, those aspects of pumpout station usage that hinder appropriate behaviour. Although intentions to comply with certain laws or willingness to participate in pro-environmental behaviour may be high, each situation involves barriers or constraints to proactive behaviour (namely - cost, waiting in line, inconvenient location, closed facilities, and ease of use). To develop management implications requires an identification of those constraints to proactive behaviour. Thus, five constraints items combined to create a 5-point agreement scale to measure the convenience of SPS usage (mean=2.7). Reasons for the low mean score included cost, waiting in line, inconvenient location, closed facilities, and ease of use of pumpout stations.

Implications lead to further discussion about the convenience of SPS use and percentage of waste pumped into an SPS. In this case study, the convenience of SPS usage was significantly correlated with boat length. As length of boat increased, the convenience factor decreased, likewise, the percentage of waste pumped in an SPS decreased. Boat owners in this sample have relatively large boats (average length=31 feet). To manoeuvre a large boat within the confines of a marina setting is quite difficult at times. Thus, the degree of boating skill must be greater to bring a larger boat to an SPS location. In essence, to use a sanitation pumpout facility means that boaters must dock their boats twice, once to pump out and again on return to their dockage point. In sum, the larger the boat the less the boater used a sanitation pumpout station, and the more raw sewage was pumped in the Chesapeake Bay. Although an SPS in a marina is important, the convenience of SPS usage must be considered further on the part of marina management. For instance, mobile pumpout units are relatively inexpensive and easy to use, which may encourage further use by both older age cohorts and large boat owners.

- Upon examination of boat type, power boaters used an SPS (77% of waste pumped) significantly more than sailboaters (44%).

This finding relates to the convenience of use issue. Logic implies that powerboats are easier and quicker to manoeuvre than sailboats, which may influence the increased usage among powerboat owners.

Respondents were asked "what would make you use a pumpout station more often". Only 31% indicated that they use a pumpout station every time they go boating. Sixty-one percent said that more convenient hours would help and 42% felt that better designed facilities would encourage more use. Only 20% felt that shorter waiting lines would enhance more use; yet 51% thought that a lower cost to use a pumpout would be of benefit. 42% marked that availability of mobile pumpout units would facilitate more use (see Table 1).

	N	% Yes
Always use pumpout stations	213	31.5
Availability of mobile facilities	147	42.2
More convenient location	147	61.2
More convenient hours	147	42.2
Shorter waiting lines	147	19.7
Better designed facilities	147	42.2
Lower cost of using facilities	147	51.0

Table 1. Percentage of response to use pumpout more often

- As knowledge about water pollution issues, knowledge about the laws concerning discharge of waste at sea, and awareness of the consequences of human waste on water quality increased, sewage pumpout station usage increased; thereby indicating the strength of the knowledge and awareness related variables (note: predictor variables in Cottrell, 1993) .

In summary, these findings imply that public information and boater education may influence pro-environmental behaviour. Management implications suggest that a new approach is necessary to educate or encourage more SPS usage among this particular group of boaters (large boat owner's age 50 or greater).

Conclusions

From a monitoring of visitor behaviour perspective by focusing on responsible environmental behaviour as a social indicator of appropriate behaviour, Maryland State boating administration personal can see the need for alternative measures to encourage further use of pumpout stations in marinas. One conclusion was the need for more mobile pumpout units in large marinas occupied by elite boat owners. Secondly, location of fixed pumpout stations is critical to accessibility by larger boats. Thirdly, there was a large discrepancy between pumpout fees between marinas that participated in the federal grant reimbursement program ($5/pumpout) and those that did not ($15/pumpout). To pump raw sewage overboard from any location on the Chesapeake Bay is illegal. Due to the sensitive nature of this issue, measuring this specific behaviour (i.e., whether or not boaters pump raw effluent overboard) by self-reported methods was cause for some concern. Therefore, a replication of the study proposal is recommended (see study proposal later in the paper).

Structural Equation Modelling – an example

A structural equation path diagram (AMOS student version 4.01) was used to re-examine seven of the eight predictors of specific behaviour in the boating behaviour case study to demonstrate the strength of a path analysis procedure (See Cottrell & Graefe (1997) for the detailed operationalisation of the variables used in this analysis). ***Note*** that AMOS 4.01 student version limits the number of variables to eight total. Variables included were years boating experience, length of boat, formal education, knowledge of the law about discharge on inland waters, knowledge of water pollution issues, awareness of the consequences sewage has on water quality and environmental concern which explained 42% of the variance in the % of sewage pumped in a pumpout station on shore. Results resemble (see Figure 2) those of the stepwise regression procedures using SPSS software in the Cottrell & Graefe (1997) study (R^2 = .42; or 42% of the variance explained by seven variables), yet the path diagram demonstrates ease of interpretation of the structural relationships among variables in a regression equation. ***Note*** that the intent was not to report specific results of the path analysis but to demonstrate its potential as a statistical tool for analysis of complex relationships in visitor behaviour for monitoring purposes.

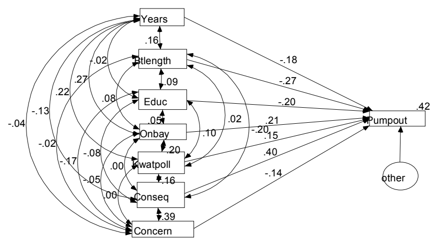


Figure 2. Path diagram of predictors of specific responsible environmental behavior

In Figure 2, the value -.18 between YEARS boating experience and PUMPOUT (the specific behaviour variable - % waste pumped in an SPS) is a standardised regression weight. The value .16 is the correlation between Years experience and Boatlength. The number .42 is the squared multiple correlation (R^2 value) of PUMPOUT with years experience, boatlength, formal education, knowledge of dumping laws on bay, knowledge of water pollution issues (KWATPOLL), awareness of the consequences of sewage discharge on water quality (CONSEQ), and environmental concern (CONCERN).

To further demonstrate path diagrams use as a statistical tool, three new variables (Awareness of Consequences; Ascription to Responsibility, and Behavioural Commitment) were introduced to the structural equation model replacing EDUC, CONCERN, and CONSEQ. The new variables (see Table 2) were operationalised as multiple item scales in accordance with recommendations of Vaske et al., (1997 unpublished) in their norm activation study of behaviour and introduced here on an exploratory basis.

Scaled item measures
Awareness of Consequences Scale [1]
• Sewage discharge from boats is significant enough to cause disease
• Sewage discharge from boats contributes to water pollution
• Disposing sewage at proper sanitation facility on shore will significantly reduce the amount of water pollution.
Ascription of Responsibility Scale[1]
• I think I am doing enough to reduce water pollution
• I feel my own actions do not cause water pollution
Behaviour Commitment Scale [1]
• Make a special effort to use a marine sewage pumpout station when I go boating.
• Used a sanitation facility every time holding tank was full

1. Variables coded on a 5-point scale from "strongly disagree" (1) to "strongly agree" (5).

Table 2. New variables examined in Figure 3 Model

This analysis was done in an attempt to increase the percentage of variance explained via the net effect of the seven variables. Years boating experience, boat length, onbay, and Kwatpoll remained in the diagram (see Figure 3).

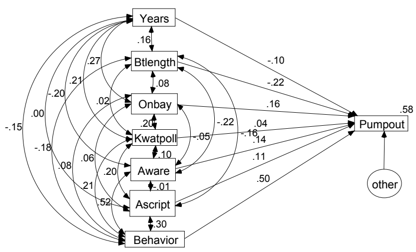


Figure 3. Path diagram of new predictors of specific responsible environmental behavior

Note that the squared multiple correlation value (R^2) increased from .42 in Figure 2 to .58 in Figure 3 indicating that the predictive strength of the seven variables combined explained 58% of the variance in the percentage of waste pumped in a PUMPOUT station on shore. In conclusion, AMOS path diagram software is useful to examine interrelationships between a set of attitudinal and behavioural variables to monitor visitor behaviour. By entering behavioural commitment, ascription to responsibility, and the reconstructed awareness of consequences variables the squared multiple correlation increased. Strength of other variables can be explored by entering them into the path diagram as well. Secondly, managers can examine those variables that have the greatest predictive strength - such as knowledge (onbay), awareness and behaviour commitment for instance, and the strength of the correlation between each to determine underlying relationships. In this case, as ascription of responsibility, behaviour commitment, and the awareness of consequences increased, the greater % of sewage boaters reported pumping in a pumpout station. Meanwhile, as boatlength increased the % of waste pumped decreased. The same holds true for years boating experience - which at first appears illogical. Therefore, examining the background variables becomes important to note differences in boater types, age, status, etc. In this case, as stated previously, affluent boaters with large boats need additional or alternative attention in terms of information and awareness raising measures to encourage a change in their behaviour.

STUDY PROPOSAL IN THE WORKS

This study proposes to couple social science techniques with the natural sciences in a comparative study of environmental behaviour among boaters on the Chesapeake Bay, USA and the IJsselmeer, The Netherlands. The project proposes to direct sustainable economic growth and water resource utilisation in a coastal marine embayment while preserving its environmental quality and aid in the design of effective strategies for the management of marine water resources for recreational boating. The study will apply the model discussed previously (Figure 1) in combination with water quality data and GIS to link spatially both data sets to provide marine resource managers information to make decisions on the sustainable management of Inland waters for public recreational use. Objectives are: 1) To examine the Maryland Pumpout Station Grant Incentive Program through assessing usage of the pumpout stations and the percentage of human waste recreational boaters pump legally and/or illegally. 2) To examine water quality and pollution from boat exhausts in selected high-use areas to determine the impact of recreational boaters in those areas (e.g., a number of large marinas and popular anchorage's in both rural and metropolitan areas). 3) To identify recreational boaters' perceptions about specific water quality problems resulting from the illegal disposal of human waste. 4) To develop recommendations for enhancing boater education about sewage pumpout usage and responsible environmental boating behaviour at both a regional and national level. 5) To develop a Geographic Information System (GIS) database for display and analysis of data collected in Objectives 1 and 2. Benefits include: GIS maps illustrating the usage of sewage pumpout stations and water quality in high-use waterways adjacent to pumpout stations, and a descriptive profile of the boaters and their perceptions about water quality. Results may be used by resource managers to make recommendations for further public educational efforts and water resource management. Maps of water quality data will elucidate the degree of boating impact on water resources in high-use areas where pumpout stations are available and will serve as a benchmark for further Bay-wide strategies for managing boating resources to maintain high water quality. A direct economic benefit of this project will be to substantiate the effectiveness of expenditures by the Maryland DNR pumpout grant program. Indirect but equally important economic benefits will be those guidelines determined for the maintenance of water quality levels needed to support fisheries and waterways for pleasure boaters.

Methods

Proposed *social science methods* are: 1) A multiple mail survey sent to registered boat owners of vessels 22 feet or greater to assess boater behaviour with regard to sewage pumpout usage. 2) A number of marinas (accepting funds for pumpout stations) will be selected, one representing each of 15 counties bordering the Chesapeake Bay. A mail survey will be sent to boaters observed using pumpout stations at the 15 locations. Similar techniques will be used along the IJsselmeer. 3) A mail survey of marina managers will be conducted of those marinas participating in the pumpout grant program. Data derived from boaters and marina managers will help to establish linkages between pumpout station usage, gallons of sewage removed, and boater/marina manager perceptions of pumpout grant program effectiveness. Qualitative methods include both in-depth interviews of boaters and marina mangers and participant observation of visitors to the area in question.

Natural science methods: To assess impacts on water quality, several sites representing the highest percentage of boating use will be selected and sampled. At each site, surface and bottom water samples will be taken at high slack tide and maximum ebb tide, both adjacent to the high-use area and at the mouth of the estuary (entrance to the Bay). At these sites and times, we will analyse for nutrients (nitrate, phosphate), dissolved oxygen, turbidity, and polyaromatic hydrocarbons (an indicator of oil and gas contamination). In addition at each station, a surface sample will be taken in a sterile bottle for counting of fecal coliform bacteria. A pre-season sample will be taken as a control measure followed by sampling on holiday weekends. Additional sampling will occur on non-- holiday weekends and during the week to compare results of peak versus normal use. In this way, we will assess the environmental impact of recreational boating in terms of nutrient loading and fecal contamination from sewage discharge and hydrocarbon emission from boat exhaust. Impacts on the high use waterways and their inputs into the main basin of the Bay can then be integrated into the statistical model and GIS maps.

Analysis procedures involve multiple regression, path analysis or structural equation modelling to determine the predictive strength of the associated variables in the model. Findings and implications can thus be linked directly with those facets of visitor behaviour noted as inappropriate, illegal, or nonsustainable to develop direct and indirect action strategies aimed towards influencing appropriate user behaviour among visitors.

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Monitoring and Management of Visitor Flows in Recreational and Protected Areas
Conference Proceedings ed by A. Arnberger, C. Brandenburg, A. Muhar 2002, pages 136-142

Integrating Multiple Wilderness Values into a Decision-Making Model for Denali National Park and Preserve

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Abstract: Decisions about how to manage wilderness recreation in Denali National Park and Preserve require managers to integrate a diverse set of public values, a process that typically involves balancing tradeoffs among multiple and often competing values. While decisions about how to manage wilderness are often contentious, previous research suggests that if managers are able to predict public support for various management alternatives the decisions become more tractable. This study develops a decision-making model that integrates social, resource, and managerial values associated with the Denali wilderness experience. Specifically, stated choice analysis is used to evaluate the choices overnight wilderness visitors make when faced with hypothetical tradeoffs among the conditions of social, resource, and management attributes of the Denali wilderness. Study findings offer an empirical approach for predicting and evaluating the likelihood of public support for Denali wilderness management alternatives.

INTRODUCTION

Recent research suggests that recreation use of wilderness is on the rise, particularly in the national parks (Cole, 1996). In the face of burgeoning public demand for outdoor recreation, national park and wilderness managers must make decisions that integrate a broad array of public values. Several decades of research suggest that wilderness recreationists' values span a range of social, ecological, and management factors (Manning, 1999). For example, wilderness recreationists value, to varying degrees, opportunities for solitude, pristine resource conditions, and recreation opportunities unconstrained by management restrictions. Decisions about how to integrate the diverse set of public wilderness values is complex and involve potential tradeoffs among competing values (Hall, 2001; Lawson & Manning, 2000a; 2000b; 2001a; 2001b; In press; Manning et al., 1999). For example, a fundamental tradeoff managers face among wilderness values is between providing public access to wilderness and protecting resource conditions and opportunities for solitude. Visitor use of a wilderness area could be limited through a permit system to protect resource conditions and opportunities for visitors to experience solitude, but fewer people would be allowed to enjoy the wilderness area. Conversely, managers could emphasize public access to a wilderness by reducing or eliminating use limits, but this might result in more resource impacts and diminish the quality of the visitor experience. While decisions about how to manage wilderness are often contentious, Cole, Watson, Hall, and Spildie (1997) and Shindler and Shelby (1993) suggest that if managers are able to predict public support for various management alternatives the decisions become more tractable.

This study develops a decision-making model that integrates wilderness values characterized by social, resource, and managerial attributes of the Denali wilderness experience. The model provides managers with a tool to predict public support for a range of wilderness management alternatives. Specifically, stated choice analysis is used to evaluate the choices overnight wilderness visitors in Denali National Park and Preserve make when faced with hypothetical tradeoffs among the conditions of selected social, resource, and management attributes of the wilderness portion of the park. By making the tradeoffs associated with Denali wilderness management explicit to respondents, this study measures what respondents think *ought to be managed for* given the relationships among multiple management objectives. Study results provide managers with insight into the relative importance visitors place on values associated with the Denali wilderness experience and allow managers to predict public support for management alternatives that emphasize those values to varying degrees.

DENALI NATIONAL PARK AND PRESERVE

In 1980, with the passage of the Alaska National Interest Lands Conservation Act, Mt. McKinley National Park was expanded from two million acres to six million acres, and renamed Denali National Park and Preserve. Most of the original two million acres of the park was designated wilderness, forming the core of Denali National Park and Preserve. Visitor use of the Denali wilderness is managed through a permit system to maintain the area's primitive, undeveloped character. Strict quotas on the number of overnight visitors issued a permit for each of 43 wilderness management units are used to control resource degradation and to provide visitors with opportunities to experience solitude. The primitive character of Denali's wilderness is maintained through other management techniques as well. For example, trails and bridges are not provided and there are no established campsites in the Denali wilderness.

Park managers and planners are currently formulating a new wilderness management plan for Denali. Revision will include decisions to maintain, reduce, or increase the number of permits issued for each of the Denali wilderness management units. Previous research (Bultena, Albrecht, & Womble, 1981) concluded that Denali visitors supported use limitations, but also suggested that future decisions will have to weigh the importance of protecting park resources and the quality of visitors' experiences against the benefit of granting more visitors access to the Denali wilderness. Our study uses stated choice analysis to provide park managers with information about overnight wilderness visitors' choices regarding such tradeoffs.

STATED CHOICE ANALYSIS

In stated choice analysis, respondents are asked to make choices among alternative configurations of a multi-attribute good (Louviere & Timmermans, 1990a). Each alternative configuration is defined by varying levels of selected attributes of the good (Mackenzie, 1993). For example, respondents may be asked to choose between alternative recreation settings that vary in the number of other groups encountered, the quality of the natural environment, and the intensity of management regulations imposed on visitors. Respondents' choices among the alternatives are evaluated to estimate the relative importance of each attribute to the overall utility derived from the recreational setting. Further, stated choice analysis models are used to estimate public preferences or support for alternative combinations of the attribute levels (Dennis, 1998).[1]

Stated choice analysis has been applied to study public preferences concerning a range of recreation-related issues (Adamowicz, Louviere, & Williams, 1994; Boxall, Adamowicz, Swait, Williams, & Louviere, 1996; Bullock, Elston, & Chalmers, 1998; Haider & Ewing, 1990; Louviere & Timmermans, 1990a; Louviere & Timmermans, 1990b; Louviere & Woodworth, 1985; Mackenzie, 1993; Schroeder, Dwyer, Louviere, & Anderson, 1990). A strength of choice models lies in their ability to predict how the public will respond to various policy alternatives, including arrangements of resources, facilities, and/or services that may not currently exist.

STUDY METHODS

Selection of Attributes and Levels

Research is helping to identify resource, social, and managerial setting attributes that reflect wilderness management objectives and influence the quality of the wilderness recreation experience (Merigliano, 1990; Roggenbuck, Williams, & Watson, 1993; Shindler & Shelby, 1992; Whittaker, 1992). Based on previous literature reviews (Manning, 1999) and consultation with Denali park staff a set of six wilderness setting attributes were selected to define the social, resource, and management conditions at Denali. Three levels were defined for each of the six wilderness setting attributes, based on recommendations from Park staff (see Table 1).

Experimental Design

Given three levels of each of the six study attributes, a full factorial design would produce a total of 3^6 (729) hypothetical Denali wilderness settings. Therefore, an orthogonal fractional factorial design was constructed containing 36 paired comparisons blocked into four questionnaire versions, each containing nine pairwise comparisons (Green & Srinivasan, 1978; Seiden, 1954).[2] An example of a wilderness setting comparison is presented in Figure 1.

Survey Administration

Overnight wilderness visitors in Denali are required to obtain a permit and a bear resistant food container from the Visitor Center prior to their backpacking trip. The stated choice analysis survey was administered to overnight wilderness visitors at the Visitor Center when they returned the bear resistant food container at the end of their backpacking trip. The survey was administered from July 24 through September 2, 2000. Study participants were randomly assigned to complete one of four versions of the questionnaire on a laptop computer. In each of the nine choice questions included in each version of the questionnaire, respondents were asked to read through each setting description (A and B) and indicate which they preferred. The response rate for the stated choice analysis survey was 81.2%, resulting in a total of 311 completed questionnaires (approximately 78 respondents for each version of the questionnaire) and 2,799 pairwise comparisons.

Effects coding was used to represent the wilderness setting attributes in the statistical model. For more information about the effects coding used in this study see Lawson and Manning (In press).

Social conditions
Number of other groups encountered per day while hiking:
Encounter 0 other groups per day while hiking
Encounter up to 2 other groups per day while hiking
Encounter up to 4 other groups per day while hiking
Opportunity to camp out of sight and sound of other groups:
Able to camp out of sight and sound of other groups all nights
Able to camp out of sight and sound of other groups most nights
Able to camp out of sight and sound of other groups a minority of nights
Resource conditions
Extent and character of hiking trails:
Hiking is along intermittent, animal like trails
Hiking is along continuous single track trails developed from prior human use
Hiking is along continuous trails with multiple tracks developed from prior human use
Signs of human use at camping sites:
Camping sites have little or no signs of human use
Camping sites have some signs of human use – light vegetation damage, a few moved rocks
Camping sites have extensive signs of human use – bare soil, many rocks moved for wind protection and cooking
Management conditions
Regulation of camping:
Allowed to camp in any zone on any night
Required to camp in specified zones
Required to camp in designated sites
Chance of receiving an overnight backcountry permit:
Most visitors are able to get a permit for their preferred trip
Most visitors are able to get a permit for at least their second choice trip
Only a minority of visitors are able to get a backcountry permit

Table 1. Denali Wilderness Setting Attributes and Levels

Backcountry Setting A	**Backcountry Setting B**
• Encounter up to 2 other groups per day while hiking.	• Encounter up to 4 other groups per day while hiking.
• Able to camp out of sight and sound of other groups *all* nights.	• Able to camp out of sight and sound of other groups *most* nights.
• Hiking is along continuous, *single track* trails developed from prior human use.	• Hiking is along intermittent, animal-like trails.
• Camping sites have *some* signs of human use – light vegetation damage, a few moved rocks.	• Camping sites have *some* signs of human use – light vegetation damage, a few moved rocks.
• Required to camp at *designated sites*.	• Required to camp at *designated sites*.

Figure 1. Example Denali wilderness setting comparison

Variable	Coefficient	Standard Error	Wald Chi-Square	P Value
Encounters with other groups per day while hiking:				
0 other groups	0.440*	-	-	-
Up to 2 other groups	0.065	0.043	2.246	0.134
Up to 4 other groups	-0.504	0.044	132.826	<0.001
Able to camp out of sight and sound of other groups:				
All nights	0.295*	-	-	-
Most nights	0.145	0.044	11.148	<0.001
A minority of nights	-0.440	0.045	94.814	<0.001
Hiking is along:				
Intermittent, animal like trails	0.319*	-	-	-
Single track trails developed from human use	-0.028	0.044	0.403	0.526
Multiple track trails developed from human use	-0.291	0.043	46.340	<0.001
Camping sites have:				
Little or no signs of human use	0.582*	-	-	-
Some signs of human use	0.207	0.044	22.151	<0.001
Extensive signs of human use	-0.790	0.049	264.972	<0.001
Regulation of camping:				
Allowed to camp in any zone on any night	0.072*	-	-	-
Required to camp in specified zones	0.140	0.048	8.620	0.003
Required to camp in designated sites	-0.212	0.045	21.948	<0.001
Chance visitors have of receiving a permit:				
Most get a permit for their preferred trip	0.073*	-	-	-
Most get a permit for at least their second choice	0.143	0.044	10.424	0.001
Only a minority get a permit	-0.216	0.043	24.656	<0.001

*Coefficients for the excluded level of the attribute were not estimated by the statistical model. They were calculated as the negative sum of the coefficients on the other two levels of the corresponding attribute.

Table 2. Coefficient Estimates for Wilderness Setting Attributes

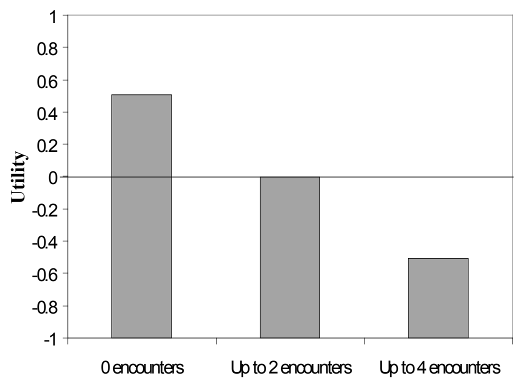
STUDY FINDINGS

Logistic regression was used to analyze the stated choice data. The coefficients of the utility difference function corresponding to the Denali wilderness setting attributes, together with their standard errors, Wald Chi-Square values, and P values are presented in Table 2. All coefficients are significantly different than zero at the <.001% level, except the coefficients on "Up to 2 other groups" and "Intermittent animal like trails". The overall fit of the model is supported by the results of the Hosmer and Lemeshow goodness of fit test (χ^2 = 3.492, p = 0.836).

The magnitude of the coefficients reflects the relative importance of the corresponding level of the attribute to wilderness visitors (Table 2). Signs of human use at campsites influence Denali overnight wilderness visitors' utility or satisfaction more than any other wilderness setting attribute considered. Solitude-related attributes represent a second tier of importance to Denali wilderness visitors (Table 2). The extent and character of trails, regulations concerning where visitors are allowed to camp in the Denali wilderness, and the availability of backcountry permits are less important to Denali overnight wilderness visitors, relative to campsite impacts and solitude-related attributes of the Denali wilderness.

The coefficients of the stated choice model can also be examined graphically. As an example, Figure 2 plots the coefficients of the attribute representing the number of other groups encountered while hiking. Values on the x-axis represent the level of the hiking encounters attribute. Values on the y-axis represent the amount by which the utility of the corresponding level of the attribute deviates from average utility or satisfaction associated with all possible combinations of the six Denali wilderness setting attributes. Levels of the attribute with high utility values are preferred to levels of the attribute with lower utility values. For plots of all six study attributes and further interpretation of the coefficients of the stated choice model see Lawson and Manning (In press).

Figure 2. Hiking Encounters per Day



As mentioned earlier in this paper, the stated choice model developed in this study can be used to predict visitor preferences for alternative wilderness management scenarios. For example, consider two hypothetical Denali wilderness management alternatives that emphasize potentially competing wilderness values; opportunities for solitude and freedom from management constraints. Under the "Solitude Alternative", overnight wilderness visitors would encounter zero other groups per day while hiking and be able to camp out of sight and sound of other groups all nights. However, visitors would be required to camp in designated sites and only a minority of visitors would be able to get a backcountry permit. Under the "Freedom Alternative", overnight wilderness visitors would be able to camp in any zone on any night, and most visitors would be able to get a permit for their preferred trip. However, visitors would encounter up to four other groups per day while hiking, and they would be able to camp out of sight and sound of other groups only a minority of nights. In both alternatives, the extent of social trails and the amount of impact to campsites would be fixed at the intermediate level. At the heart of the comparison between the "Solitude Alternative" and the "Freedom Alternative" are Denali overnight wilderness visitors' evaluations of the tradeoff between freedom of access to the Denali wilderness and the opportunity to experience solitude.

The maximum likelihood coefficients and the effects codes corresponding to the levels of the six wilderness setting attributes for each hypothetical alternative are presented in Table 3. The model predicts that in a hypothetical referendum, 75% of Denali overnight wilderness visitors would choose the "Solitude Alternative" and only 25% would choose the "Freedom Alternative". [3] This result implies that, in general, Denali overnight wilderness visitors would prefer to forgo some freedom from management to improve opportunities to experience solitude. These findings are suggestive of the balance overnight wilderness visitors think ought to be struck among these potentially competing wilderness values. In the context of this example, if Denali wilderness managers choose a balance of tradeoffs more consistent with the "Freedom Alternative", they may receive relatively little public support for their management actions as a consequence.

DISCUSSION AND CONCLUSIONS

In this study, stated choice analysis has been used to integrate a range of public wilderness values characterized by conditions of social, resource, and managerial attributes of the Denali wilderness into decisions about how to manage the park's wilderness. The results of the stated choice analysis presented in this paper have several potential implications for wilderness management at Denali and elsewhere.

Study findings provide Denali wilderness managers with information about the relative importance overnight wilderness visitors place on the attributes of the Denali wilderness experience selected for this study. For example, study results suggest that visitors would be willing to tolerate, and in fact support, management restrictions, including use limits, to achieve desired social and resource setting attribute conditions. Information concerning the relative importance of the attributes included in this study reflects how visitors think managers ought to prioritize the wilderness values

	Solitude Alternative	Freedom Alternative
Hiking Encounters:	0 groups per day	Up to 4 groups per day
Campsite Solitude:	All nights	A minority of nights
Hiking Trails:	Single track trails	Single track trails
Campsite Impacts:	Some signs of human use	Some signs of human use
Camping Regulations:	Designated sites	Any zone on any night
Availability of permits:	Only a minority of visitors receive a permit	Most get a permit for their preferred trip
Voting Proportion	75%	25%

Table 3- Scores for Two Hypothetical Denali Wilderness Management Alternatives

associated with the study attributes, given the relationships and inherent tradeoffs among these attributes.

The decision-making model developed in this study allows managers to predict Denali overnight wilderness visitors' support for alternative management scenarios. This allows managers to consider combinations of setting attributes that are not currently in place, but may offer a better alternative than the status quo. Additionally, alternatives being considered under the new wilderness management plan can be generalized to the model, and managers can predict the response of current users to each alternative. The results of the example application of the choice model provide evidence that visitors are willing to trade-off freedom from management restrictions for desired social conditions. Specifically, the results demonstrate that in a hypothetical referendum, Denali overnight wilderness visitors would prefer (by a margin of three to one) a wilderness setting that emphasizes solitude through relatively restrictive management actions over a more congested wilderness setting with limited management restrictions.

From a management perspective, these results suggest that the majority of Denali overnight wilderness visitors support backcountry permit quotas at Denali to protect the primitive character of the wilderness. Further, the results suggest that a moderately restrictive quota system that is designed to enhance overnight wilderness visitors' opportunities to experience solitude and to maintain relatively undisturbed campsite and trail conditions will receive substantial support from Denali overnight wilderness visitors. However, the results of the example application of the choice model suggest that there is also a substantial proportion of Denali overnight wilderness visitors (25.0%) that place high importance on freedom from management restrictions despite reduced opportunities to experience limited contact with other groups while hiking and camping. This finding suggests that Denali overnight wilderness visitors are at least somewhat diverse in their attitudes concerning the management of the Denali wilderness. Park managers could address this diversity through management of the Denali wilderness based on the concept of zoning to provide a spectrum of opportunities for visitors. For example, the quota system could be designed in such a way that quotas for most zones within the Denali wilderness are set at levels that emphasize opportunities for visitors to experience solitude, while quotas for a few zones of the wilderness are set at levels that provide greater visitor access.

Stated choice analysis shows promise as a tool to make complex and often controversial decisions of wilderness management more tractable. The decision-making model developed in this study provides managers with a means to predict support for various management alternatives, increasing the chances that wilderness management will reflect a balance among public values that visitors are likely to support. Further, by asking respondents to consider the tradeoffs associated with wilderness management, visitors may become more aware of the difficult task wilderness managers face in trying to balancing public wilderness values.

ACKNOWLEDGMENTS

Appreciation is expressed to Darryll Johnson and Mark Vande Kamp of the University of Washington for their help with the larger research project at Denali National Park and Preserve of which this study was a part. Park staff, especially Mike Tranel and Joe van Horn, were very helpful in designing and administering the study questionnaire. Don Anderson of StatDesign Consulting, Evergreen, Colorado, constructed the orthogonal fractional factorial design used in this study. Don Dennis of the U.S. Forest Service, Daniel Krymkowski of the University of Vermont, and Stephen Swallow of the University of Rhode Island assisted with the design of the study questionnaire and interpretation of the study results. Finally, this study was conducted under the auspices of the National Park Service's Conservation Study Institute housed at Marsh-Billings-Rockefeller National Historical Park. Appreciation is expressed to Nora Mitchell, Rolf Diamant, B.J. Dunn and Mea Arego for their administrative support.

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FOOTNOTES

[1] Decision making models developed using stated choice analysis are based on the theoretical framework of random utility. Refer to Hanemann (1984) and Opaluch, Swallow, Weaver, Wessells, and Wichelns (1993) for detailed presentations of the random utility framework.

[2] The orthogonal fractional factorial design was constructed by Don Anderson of StatDesign Consulting, Evergreen, Colorado.

[3] Refer to Opaluch, Swallow, Weaver, Wessells, and Wichelns (1993) for a presentation of the methods used to calculate scores for the hypothetical management alternatives.

Monitoring and Management of Visitor Flows in Recreational and Protected Areas
Conference Proceedings ed by A. Arnberger, C. Brandenburg, A. Muhar 2002, pages 143-149

Visitor Management and Ecological Integrity: One Example of an Integrated Management Approach Using Decision Analysis

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Abstract: In this paper we argue in favor of using a decision analysis framework for more integrated decision-making when managing protected areas. Such an approach will enable agencies to balance between the frequently conflicting goals of visitor management and ecological integrity. We present a case study from the West Coast Trail in Pacific Rim National Park Reserve, BC, Canada, in which we use ELECTRE and AHP to establish a ranking of several management options. We conclude by suggesting that such a more formal framework constitutes a more objective decision support tool, assists in framing relevant management questions and tradeoffs, and at the same time provides guidance for data collection.

INTRODUCTION

When managing protected areas, agencies typically need to balance several divergent objectives, such as striving for ecological integrity and ensuring visitor enjoyment. To assist in these tasks, ecosystem-based management has, over the last decade, been adopted by many agencies as their overarching management framework. This situation also applies to Parks Canada, the lead agency for managing National Parks in Canada.

In Canada, the National Parks Act (2000) recognises the mandate of ecological integrity as the primary objective. As a result, Parks Canada has adopted the concept of ecosystem-based management as its overarching management framework (Parks Canada, 2000). The concept acknowledges the inherent complexity of the task at hand, the need to integrate knowledge generated by several academic disciplines, and the need to accommodate aspects of uncertainty and risk in decision-making processes. Typically, this management approach strives to balance ecological, social and economic concerns (Grumbine, 1994; Slocombe, 1998).

However, the de facto management framework of Parks Canada is still dominated by a more traditional management structure, in which separate departments within the agency are charged with specific mandates, make their own decisions, and usually collect their own relevant information (Rudolphi 2000). For example, separate policies and guidelines direct visitor management, ecological monitoring, and impact assessment. Such a situation effectively impedes the implementation of a more integrated management framework for at least three reasons (Watson et al., 1987):

- Goal fragmentation and sliding of objectives;
- Costly duplications and overlapping efforts; and
- Low acceptance and compliance towards decisions made.

Given the lofty goal of ecosystem based management, we consider it essential that decision processes be provided with adequate and timely information for the tasks at hand. For that purpose, Parks Canada requires state-of-the-art 1) data gathering and information generating tools, 2) decision support tools, and 3) communication support tools.

Such tools will provide important support to all decision-making structures, whether they are more traditional top-down approaches that are formulated and implemented within an agency, or alternative participatory forms of decision-making. We would like to acknowledge at this point that many decisions involving Parks Canada are undertaken in a shared or participatory manner. Our critique is not directed towards the decision processes themselves, but at the processes that guide data and information gathering, as well as management, and presentation. In this paper we will argue that several methods in the field of decision analysis (DA) can assist Parks Canada, as well as many other land management agencies, in the task of collecting, synthesising, and presenting large amounts of information, as well as structuring decisions and evaluating alternatives.

The next section will provide a brief overview of DA, and present the specific methods we propose to use in our case study. Then we will explain the specific circumstances at the West Coast Trail in Pacific Rim National Park Reserve in British Columbia, Canada, followed by a brief example of how to work through such a data set. We will conclude with a discussion of the benefits that would accrue to a management agency by adopting

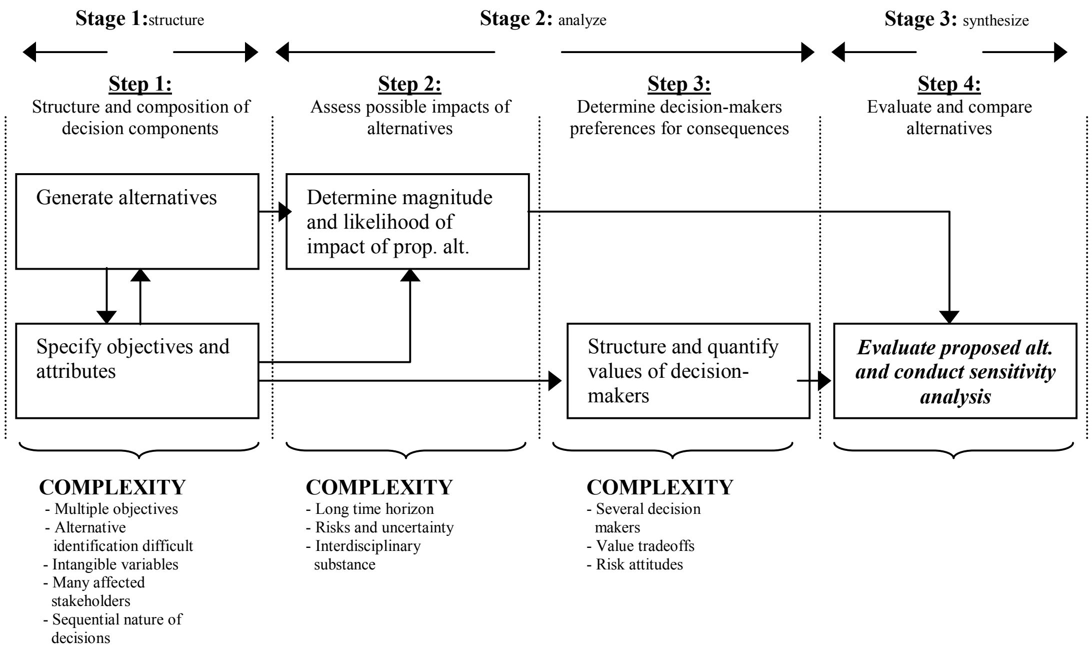

Figure 1: Schematic representation of a generic MADM process. Modified from Keeney (1982)

such a data and information and decision management methodology.

DECISION ANALYSIS

Decision Analysis refers to a diverse methodological field whose array of methods have in common that they all provide formal support for decision-makers in complex choice situations. In this paper we focus on Multi Attribute Decision Making (Vincke, 1992), and more specifically on two methods, the Analytical Hierarchy Process (AHP) (Saaty 1980) and the Elimination et choix traduisant la realite (ELECTRE) (Roy, 1990).

A typical MADM modelling process involves three iterative stages (Keeney, 1982) (Fig 1):

1) structuring -
2) analysis -
3) synthesis.

Structuring involves the specification of decision objectives, criteria and measurable attributes, and the identification of alternatives. To enhance transparency, these components are usually organized in a decision tree. During that stage, an initial screening of alternatives might discard unfeasible or inferior alternatives in order to trim the decision tree to a manageable size.

In the first step of analysis the potential magnitude, likelihood and uncertainty associated with the remaining alternatives are assessed. The second step in the analysis stage involves the elicitation of decision-makers' preferences for tradeoffs and/or willingness to take risks. It is on this latter point that many of the methods differ.

At the final stage, the alternatives' advantages and disadvantages are evaluated and compared against each other by amalgamating all available information (Keeney, 1982). Each alternative's situation specific efficacy is predicted using the preferences (utilities) determined earlier. The model will identify the alternative with the highest expected utility.

We will now present the two preference elicitation methods that we used in our case study. We decided on using elements of each of the two methods as each contains characteristics of particular importance to our application.

ELECTRE.

The Elimination et choix traduisant la realite (ELECTRE) method (Roy, 1990) is a widely used decision tool (e.g. Massam, 1980). The fundamental idea behind it's process is to establish rankings among several alternatives (Roy, 1990).

ELECTRE establishes the desirability of an alternative by using concordance and discordance analysis (Nijkamp and van Delft, 1977; Yoon, et al., 1995). The decision makers' preferences in regards to the objectives' and criteria's performance levels are used as indicators, forming importance thresholds for the objectives and criteria. An alternative's value is subsequently determined by the degree to which its attributes are in agreement (also referred to as being in "concordance"), minus disagreement (discordance), with the predetermined objectives/criteria and constraints (i.e. the thresholds). An alternative's ranking is then determined using the concept of outranking (Guitouni and Martel, 1998) as aggregation procedure. The set of alternatives that are non-dominated are singled out by associating the previously established thresholds, in combination with the criteria / objective weights, to an outranking relation, using status quo, or an ideal situation, as the reference point of comparison (ibid.).

The threshold levels are a subjective and influential ingredient in ELECTRE's outranking process. As these values are to serve as indicators for criteria performance in the subsequent concordance / discordance analysis, specifying one alternative's dominance over another, they should be given considerable attention and appointed with as much correctness and care as possible. Four different threshold levels (Vincke, 1990; Roy and Vincke, 1984) should be determined:

- Strong preference threshold, also referred to as the aspired range. This is the zone within which the decision makers find a criterion is preferred to be positioned.
- Weak preference threshold, or buffer zone. A performance range that represents the hesitation between the strong (above) and the indifference (below) threshold. Not a perfect place for a criterion to be located, but still acceptable.
- Indifference threshold. The acceptable range a measure can move within (+/-) before its deviation becomes significant to the decision makers.
- Veto threshold, or the minimum/maximum value. Any value placing itself above or below these thresholds would be considered unacceptable, as it would be affecting the situation too severely.

The Analytical Hierarchy Process (AHP)

Like ELECTRE, the AHP process has found wide application since the early 1980s (Saaty 1980) in many different decision-making processes (Gholomnezhad, 1981, Brown, et al., 2000). The main characteristic of the AHP method is its strong focus on identifying the underlying hierarchical structure for the decision problem at hand (Dyer, 1990) .

Preferences are not elicited for the alternatives directly, but for the attributes, objectives, and criteria, using a series of pairwise comparison evaluations. These evaluations then provide the weights for the decision trees (Saaty, 1980). The decision trees serve as the formal structure used to display the situation in an ordered and hierarchical manner, linking the situation's alternatives together with the goal(s), objectives, criteria, and attributes. The final aggregation procedure used by AHP, to rank one alternative over another, is, similar to ELECTRE, based on the concepts of outranking (Liang and Sheng, 1990). Combining AHP and ELECTRE will allow us to combine the most attractive aspects of either method.

STUDY AREA: THE WEST COAST TRAIL IN PACIFIC RIM NATIONAL PARK

The West Coast Trail (WCT) is a 75km long hiking trail along the Pacific Coast of British Columbia. It offers visitors encounters with sandy beaches and rocky headlands, bordered by a temperate coastal rainforest, and constitutes the main backcountry attraction of PCNPR. Thousands of hikers each year take between six and 10 days to hike the entire trail, or portions of it in single or two day hikes (Parks Canada, 1991). In 1992, Parks Canada introduced a reservation system to address concerns about environmental impacts, hikers' safety, and visitors' enjoyment (Parks Canada, 1994d). Now the trail is enjoyed by approximately 60 persons per day, resulting in about 8,000 hikers per season (ibid). Besides its ecological values and the experience related benefits provided to the visitors and residents of the area, the existence of the trail also supports business opportunities in the surrounding communities (Parks Canada, 1995).

In the case study below we take the current problem context of the West Coast Trail and structure the decision analysis based on hypothetical data.

SUGGESTED DECISION-ANALYSIS FRAMEWORK

Decision Problem

Obviously the large concentration of visitors in a relatively small and comparatively sensitive area, with many stakeholders and interest groups linked to its management, causes several direct and indirect impacts (e.g. trampling of vegetation, crowding, and cost of maintenance). The impacts are often paradoxical in that they frequently have a concurrent effect on environmental, social, and economical aspects, affecting the various stakeholders differently. Parks Canada needs to balance between concerns about the area's ecological integrity, various types of visitor requests, and a local businesses community which is dependent on a certain level of annual visitation. It would be in the interest of all parties involved to reach a long-term solution that balances conservation with the other social and economic interests.

IMPLEMENTING A DECISION ANALYSIS

We implemented our decision analysis in three stages.

Stage 1: Structure and composition of decision components - Defining management goals, objectives, and alternatives

The principal management goal at the West Coast Trail ought to be striving for maximum ecological integrity, as defined by the National

Parks Act of Canada. In addition to this overarching goal, the Field Unit of Pacific Rim National Park Reserve also needs to accommodate economic and social objectives. In this study, we identified these measures from relevant published literature. These objectives and criteria can be tabulated concisely in an assessment table for each respective group involved in the decision-making process (Table 1). Given the space limitations, we present the table for the parks management group and the visitor group only. The content of the table would look similar for the other groups participating in the decision making process (the local business community, and NGOs). Most of the objectives and criteria have been identified as relevant in the respective literature.

Based on these objectives and measurement criteria, one can define management alternatives (Table 2). Options 1 – 13 vary the attributes number of visitors per season, length and timing of season, and size and distribution of visitor groups. The remaining four alternatives vary according to the reallocation of the recreational activities to other parts in the study area, changes in the types of activities, and the construction of physical features. Before any analysis is undertaken, one can eliminate dominant alternatives during an initial screening procedure. During this initial screening, alternatives 14 to 17 were identified as lying outside Park Canada's mandate, and therefore eliminated from further analysis.

Stage 2: Analysis of alternatives

In the first step of this stage, the likelihood of an event occurring, the associated uncertainty, and the magnitude of each criterion associated with each alternative is estimated in one table (not shown here).

In a second step, first the ELECTRE method is applied to identify the preference benchmarks of strong preference, weak preference, indifference point, and veto level are identified for each criterion through formal interviews with decision-makers. Conceptually, these benchmarks resemble the concerns that are addressed in the Limits of Acceptable Change Process (Stankey et al, 1984).

Second, the pairwise comparison method of AHP is used to determine the criteria's relative importance (Table 3). These present values form the "base case", representing the present situation. Notably, the park management group's present values take precedence, except for criteria 8, 9, and 10. This assumption simplifies subsequent calculations, and could be changed if desirable. The criteria thresholds have been explained before. The indifference values are expressed in %-change relative to the base case. The second last column (W%) contains the relative weights for each criterion, and the last column represents the aggregated criteria weights (AW%).

DM group	Ecological aspect	Social aspect	Economical aspect
Park Management group: General management objectives	**Ecosystem Health**	**Serving Canadians**	**Wise and efficient management of funds**
Represented in this study by:	*Ecosystem Processes and Ecosystem Structures*	*Client satisfaction*	*Trail maintenance costs*
Measured in this study by:	Unconsolidated organic matter: Recorded % of trail segment's unconsolidated or loose organic matter not covered by vegetation on location (e.g. needles, leaves, twigs, pine cones). Extent of erosion: Recorded % of camping area eroded. Natural and human induced erosion separated when possible. Fauna abundance: Recorded # of individuals/spp X along trail segment.	Fire rings: # of fire rings, new and old, present within the campsite. Size of parties of people: Largest size of backpacker parties present on trail/day .	Seasonal $ maintenance cost: Direct cost, including items such as staff costs, material, time, etc. for trail maintenance related to the campsite and trail segment. Seasonal rescue cost: Rescue specific cost * number of rescues.
Visitors group: General management objectives	**Ecosystem Health**	**Trip Satisfaction**	**Willingness to Pay**
Represented in this study by:	*Perceived degradation*	*Privacy and wilderness experience*	*User fees*
Measured in this study by:	Unconsolidated organic matter: Same as above but measured by % encountered on trail segment/trip. Extent of Erosion: Same as above but measured by % encountered at campsite/trip. Fauna Abundance: Same as above but measured by # encounters/trip.	Fire rings encounters: Same as above but measured by # encounters at campsite/trip. Parties of people encountered: Same as above but measured by # encounters/day.	Level of user fees: Amount of trail user fee/person, including reservation fee, park use fee, two ferry fees.

Table 1: Group objectives and criteria for the case study (NGOs and business community are excluded).

Alternative	Number of visitors/season	Length and time of season	Size and distribution of groups	Reallocation or change of activity, and/or construct. Initiatives
Option 1 Base Case	**8 000**	**5 months May – September**	▪ **30% of groups ≤ 3 people, 55% of groups ≤ 8 people, 15% of groups up to 10 people** ▪ **maximum of 10 groups/5 km** ▪ **maximum of 10 groups/camp**	**N/A**
Option 2	75% of base case: (6 500)	▪ as base case	▪ as base case	N/A
Option 3	75% of base case: (6 500)	▪ 3 months (June – August)	▪ as base case	N/A
Option 4	75% of base case: (6 500)	▪ 3 months (June – August)	▪ 35% of groups ≤ 3 people, 60% of groups ≤ 8 people, 5% of groups up to 10 people ▪ maximum of 8 groups/5 km ▪ maximum of 6 groups/camp	N/A
Option 5	75% of base case: (6 5000)	▪ 6 months (May – October)	▪ as base case	N/A
Option 6	75% of base case: (6 5000)	▪ 6 months (May – October)	▪ 25% of groups ≤ 3 people, 50% of groups ≤ 8 people, 25% of groups up to 10 people ▪ maximum of 8 groups/5 km ▪ maximum of 10 groups/camp	N/A
Option 7	110% of base case: (8 800)	▪ as base case	▪ as base case	N/A
Option 8	110% of base case: (8 800)	▪ 3 months (June – August)	▪ as base case	N/A
Option 9	110% of base case: (8 800)	▪ 3 months (June – August)	▪ 40% of groups ≤ 3 people, 50% of groups ≤ 8 people, 10% of groups up to 10 people ▪ maximum of 8 groups/5 km ▪ maximum of 6 groups/camp	N/A
Option 10	110% of base case: (8 800)	▪ 6 months (June – August)	▪ as base case	N/A
Option 11	110% of base case: (8 000)	▪ 6 months (June – August)	▪ 20% of groups ≤ 3 people, 60% of groups ≤ 8 people, 20% of groups up to 10 people ▪ maximum of 8 groups/5 km ▪ maximum of 10 groups/camp	N/A
Option 12	50% of base case: (4 000)	▪ 2 months (June – July)	▪ 100% of groups ≤ 3 people ▪ maximum of 4 groups/5km ▪ maximum of 4 groups/camp	N/A
Option 13	200% of base case: (16 000)	▪ 8 months (March – September)	▪ 80% of groups ≤ 3 people, 20% of groups ≤ 8 people ▪ maximum of 10 groups/5 km ▪ maximum of 10 groups/camp	N/A
Option 14	as base case	▪ as base case	▪ as base case	Reallocation of present recreational activities during June-July.
Option 15	as base case	▪ as base case	▪ as base case	Option 14 + extension of the information centre at the trail head.
Option 16	as base case	▪ as base case	▪ as base case	Introducing mountain biking as a recreational activity along the trail (for ½ of the allowed quota).
Option 17	as base case	▪ as base case	▪ as base case	Construction of elevated boardwalks for especially exposed and vulnerable trail segments.

Table 2: Management Alternatives for the case study

Stage 3: Synthesis of information

Concordance and discordance matrices (not shown here) provide the formal base for comparing alternatives objectively. By combining the concordance and discordance measures, one can calculate a credibility matrix, which contains the ranking of the remaining alternatives (Table 5.8). The matrix reveals that only alternatives 1, 2, 3, 4, 5, 6, 7, and 10 reach a performance on each criterion so that no single veto level is violated, i.e. holds a credibility high enough to be interesting to pursue at this point. As such, the credibility matrix does provide a certain outranking in itself, indicating each alternative's strength over another. However, the analysis should also take into account the alternatives' performance significance levels, by relating the entries in the credibility matrix with the established levels of significance (i.e. the thresholds of indifference). This is the final step, in the ranking procedure that is, removing those alternatives from consideration that are not performing significantly better than at least one other alternative on at least one criterion.

DM groups and their respective objectives	Criteria; Indicators	Present value	Criteria threshold levels				W % (k)	AW (%)
			Strong (P)	Weak (Q)	Veto (V)	Indif. (I)		
Visitors group:								
Ecosystem Health								
Perceived degradation	Unconsolidated organic matter	35	0-30	31-59	60%	-1.15%	21	14
	Extent of Erosion:	15	0-10	11-59	60%	-2.00%	7	20
	Fauna Abundance:	5	5-7	3-4/ 8-20	2/21	+0%	30	20
Trip Satisfaction								
Privacy and wilderness experience	Fire rings encounters:	5	5-7	3-4/ 8-9	2/10	-1.50%	4	11
	Parties of people encountered:	12	6-7	4-5/ 8-14	3/15	-1.20%	27	14
Willingness to Pay								
User fees	Level of user fees:	125	-18% (and less)	+/-17	+18%	-0%	12	3

Table 3: Aggregated preference levels and criteria importance ratings for the DM groups (Parks Management, NGOs and business community are excluded)..

	BC	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13
BC		0.2073	0.2169	0.2073	0.2092	0.2146	0.2022	-	-	0.2022	-	-	-
A2	0.2138		0.2146	0.2109	0.2037	0.2141	0.2022	-	-	0.2022	-	-	-
A3	0.2047	0.2059		0.2059	0.2058	0.2138	0.1950	-	-	0.1950	-	-	-
A4	0.2138	0.2109	0.2146		0.2037	0.2128	0.2022	-	-	0.2022	-	-	-
A5	0.2135	0.2106	0.2143	0.2106		0.2138	0.2022	-	-	0.2022	-	-	-
A6	0.2064	0.2065	0.2077	0.2051	0.2063		0.1950	-	-	0.1950	-	-	-
A7	0.2081	0.2092	0.2102	0.2092	0.2087	0.2102		-	-	0.2072	-	-	-
A8	-	-	-	-	-	-	-		-	-	-	-	-
A9	-	-	-	-	-	-	-	-		-	-	-	-
A10	0.2081	0.2092	0.2102	0.2092	0.2087	0.2102	0.2072	-	-		-	-	-
A11	-	-	-	-	-	-	-	-	-	-		-	-
A12	-	-	-	-	-	-	-	-	-	-	-		-
A13	-	-	-	-	-	-	-	-	-	-	-	-	

Table 4: Credibility matrix

DISCUSSION & CONCLUSIONS

The hypothetical case study showed how a formal decision analysis framework can be applied to Park Canada's decision-making processes when complex decisions between several divergent objectives need to be made.

ELECTRE has been selected as the specific analytical tool because it includes different types of preferences, including threshold and veto options, which make it very attractive for modelling ecological concerns. AHP provides the final weighting of the alternatives. That combination constitutes an objective evaluative framework for pending decisions.

Such a decision support framework will improve the soundness and effectiveness of Parks Canada's decision-making and communication structures. The framework also facilitates the formal integration of existing data and information bases. The framework promotes:

- sound documentation practices, which increase the acceptance of and compliance with actual decisions;
- a formal and consistent method of assessment for various management situations;
- an increased ability to co-operate across various stakeholder interest, increasing the awareness of different management agendas and critical issues surrounding protected area management, and consequently decreasing the likelihood of goal fragmentation and sliding of objectives; and
- an increased ability to capitalise on existing data and information while identifying data gaps for further analysis, which reduces the risk of costly duplications and overlapping efforts. In addition, situation specific data and information becomes more readily available.

In conclusion, we would like to reiterate, that despite its name, decision analysis does not actually make decisions automatically. Plenty of thought needs to go into the design of such a framework, which we would rather label a more objective and integrated management and decision support tool, to be used in traditional as well as participatory decision processes.

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Destination Choice Modelling of Leisure Trips: The Case of Switzerland

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Abstract: In this paper the destination choice of Swiss within Switzerland is analysed. Information about variables influencing destination choice for different activity should be the result of the modelling process.
The analyses are based on three pillars. A detailed database for all Swiss municipalities is the first pillar, nation wide demand data the second pillar. Additionally a suitable method is necessary. Because destination choice is a choice between discrete alternatives, Multi-nominal Logit models are used.
Models for three different activity types - skiing, climbing and hiking respectively walking and swimming are estimated. In all models the importance of the distance between origin and destination becomes visible.

INTRODUCTION

Leisure has become the most important trip purpose. In 1994 60% of all person kilometres respectively 80 billion person kilometres travelled by the residents of Switzerland were made for the purpose leisure; half of those kilometres were performed abroad. Most of these leisure trips (66% of all trips made by Swiss in Switzerland) were made by private car. Therefore leisure traffic is a major contributor to the well known negative effects of motorised traffic. Especially in tourist areas leisure traffic has serious ecological and social impacts.

To analyse leisure traffic is not only interesting because of its volume, but also because of an other special feature. Leisure traffic is very heterogeneous - especially compared to work trips. Different leisure activities like sports, cultural sightseeing or visiting friends are carried out at the same destination; at the same time similar activities are carried out at different destinations. Additionally leisure activities are generally characterised by less rigid temporal constraints than for example work or school activities.

In contrast to the significant contributions of leisure traffic to overall traffic, it has received relatively little attention in travel modelling practice - mostly because of its heterogeneity and consequently the problems connected with analysing leisure trips. However, some recent studies have underscored the need to model leisure trips and predict visitor flows more systematically and to recognise the behavioural differences underlying travel decisions for different types of leisure trips (Bhat, 1998; Pozsgay and Bhat, forthcoming).

The aim of this paper is to contribute towards this growing literature on leisure travel. It especially focuses on destination choice within Switzerland for different activity types. Destination choice is a choice between discrete alternatives. Therefore the method of discrete choice models, which can analyse the choice of a destination dependent on the type of destination and the personal situation of the travellers, is appropriate here. Based on the results of the models conclusions can be drawn about how a municipality can act to reach its goal with regard to leisure and tourism. It is of special interest to investigate the influence of the quality of the natural environment on those choices.

The remainder of this paper is structured as follows: This foreword is followed by an introduction to the theory of the method used - discrete choice models. The next section presents very briefly the data base used. Then the different steps during the development and specification of the models presented are introduced. The fifth section shows the empirical results. The final section summarises the findings from the models and discusses the relevance of these findings.

DISCRETE CHOICE MODELS

Participation in traffic always forces persons to choose one alternative out of a set of alternatives which exclude each other mutually (for example mode choice: One cannot choose the car and ride a bike at the same time). Qualitative choices out of a set of distinct and non divisible alternatives can be modelled using *random utility discrete choice models*.

Theory

Discrete choice models are based on the assumption, that persons are trying to maximise the utility of their performed activities and therefore choose that alternative out of all possible activities which is likely to offer them the highest utility. Although it is obvious that this assumption is an oversimplification of human behaviour, models based on this assumption obtain results which are much more realistic than models based on gravitation or entropy theory. A more detailed description of discrete choice models can be found in Ben-Akiva and Lerman (1985), Maier and Weiss (1990), Ortúzar and Willumsen (1994); the basic ideas were developed by McFadden (1973).

There are different types of discrete choice models. All of them share the assumption, that out of a set of alternatives each person *q* expects a different utility (*U*). Each alternative *j* can be described by different characteristics *x*, whose values vary across different alternatives. Each utility depends on the different judgements of those characteristics. The judgements can at least partially be derived from different personal factors *p*, for example gender or age. Additionally the evaluation of the utility of an alternative depends on the situational factors *s*, for example the weather conditions or the travel time, which vary between different persons and alternatives.

As it is neither possible to know all relevant characteristics or choice alternatives nor to measure them exactly, the judgement is composed out of a deterministic and a (at least from the analyst's point of view) stochastic part. The total utility can thus be calculated as:

$$U_{jq} = V_{jq} + \varepsilon_{jq}$$

with V_{jq} as systematic and measurable part which describes the objective utility of alternative *j* for person *q* and the random error ε_{jq}, which modifies V_{jq} with regard to the individual judgements of a decision maker and possible errors in observation or measurement. The systematic utility is a function of characteristics describing the individuals, the situation and the alternative

$$V(X_{kjq}) = \alpha_j + \quad \beta_{k''j}\, p_{k''q} + \quad \beta_{k'j}\, s_{k'q} + \quad \beta_{kj}\, x_{kjq}$$

The stochastic part of the utility function depends on the assumption about its distribution which is at the same time the distinguishing mark between the different model types. The most simple and according to Maier and Weiss (1989) most commonly used version of discrete choice modelling is the *Multinominal Logit* (MNL), which is based on the assumption that ε_{jq} is *independent and identically gumbel distributed* (Ben-Akiva and Lerman, 1985). This so-called IIA-assumption (independence of irrelevant alternatives) implies some constraints on the application of the model which can be released in other model types. The linear utility function represents a further model restriction.

The probability *P* that an alternative *j* of a Person *q* is ranked first can be calculated as the utility of this alternative in relation to the sum of all alternatives (see equation 3). In the MNL the relationship between utility and probability of an alternative is described as follows. The alternative with the highest probability is chosen.

$$P_{jq} = \frac{e^{V_{jq}}}{\sum_{\forall n} e^{V_{nq}}}$$

Destination choice

Destination choice models are rarer then mode choice models. With the choice of a specific destination for a leisure trip the decision making person excludes the choice of other destinations due to spatial and temporal constraints. Therefore the MNL model seems to be an appropriate method here. But it is important to mention a view particularities of destination choice.

- **IIA-assumption**: This assumption implies that the error terms of the utility function for all possible alternatives are independent and identically distributed with a gumbel distribution. If the error terms are independent, no common unobserved factors have any impact on the different alternatives. The assumption of identical distribution means that the level of impact of the factors, which were not detected, is identical across all alternatives. This assumption is often not fulfilled in destination choice. For example, the impact of different levels of comfort is different in a luxurious area compared to a camping region.
- **Homogeneity of travellers**: In a MNL it is assumed that different persons react homogeneously in response to attributes of alternatives regardless of their socio-demographic background. This assumption is also often violated for destination choice. For example, for some people it is important to go to a destination very far away in their holidays because of the image of such trips. Other people may avoid such trips in order to reduce their travel time.
- **Spatial issues**: Travel demand is influenced by at least three different spatial issues: spatial dependency, spatial heterogeneity and spatial heteroscedasticity (Bhat and Zhao, 2001). The spatial dependency describes the presence of unobserved spatial factors influencing travel behaviour - for example a beautiful landscape. The second issue, spatial heterogeneity, proposes that the relationship between the dependent variable and the independent one varies across spatial units - as a consequence, it may be possible that there is no single global relationship, but different local ones. The last possible source of biases is spatial heteroscedasticity, which reflects the fact that the variance of the unobserved influences may be different across spatial units.

Due to these limitations the MNL estimates give only first approximations about the impacts of different characteristics, but it should be kept in mind that its results may be biased and that more complicated models should be developed in the future.

DATA BASE

The aim of this paper is to estimate models describing destination choice within Switzerland for different activities at the municipal level. Destination choice is dependent on the characteristics of the alternatives and of the travellers. Therefore, it is necessary to have information about the demand and the supply side for the whole investigated area. Additionally the distance between the origin and the destination has to be considered (see Choice Set).

Supply side

A detailed data set was produced to describe the destinations and their supply. The data set contains detailed information about the residents, the supply in the leisure and tourist sector, the tourist demand as well as the allocation of the space to different purposes (hectare data bank). The hectare data bank includes even information about different vegetation types (for example open and closed forest or vines). The municipal level was chosen as investigation level, because it is the lowest level at which information for a whole nation can be collected.

There is a problem inherent in this investigation level. The travellers respectively visitors think in destination units rather than in municipal units. Sometimes this unit is much smaller than a municipality. The consideration of such small destinations would create an enormous number of different alternatives which would make the modelling process too difficult. At the same time, different municipalities are sometimes viewed as one destination. Especially for skiing holidays people visit a complete valley or ski region rather than a municipality. However, the municipality level is a compromise between these different requests, which seems to be a sufficient approximation of the reality.

Demand side

A nation wide analysis of destination choice requires demand information for the same area. In Switzerland several nation wide travel surveys exist – of those the *KEP* ('Kontinuierliche Erhebung zum Personenverkehr') and the *Zusatzmodul Reiseverhalten* are available and appropriate. They were pooled for this analysis.

- **KEP** (SBB CFF - Direktion Personenverkehr, 1996): The SBB (Swiss Federal Railways) are responsible for the KEP, which covers the travel behaviour of Swiss adults. During one year about 17'000 persons are interviewed. The KEP has been conducted yearly since the 80ies, but the destinations of car trips have only been coded in the last two years, while this was done longer for rail trips. Therefore just the survey years 2000 and 2001 are used which already includes about 120.000 trips.
- Information about the personal situation of the travellers and about their trips over three kilometres distance and a municipal boundary during the last week is collected. For each trip the destination is known except for trips abroad which are just coded as destination outside Switzerland. Attention should also be paid to the fact, that for public transport trips the rail station is assumed to be the final destination.
- **Zusatzmodul Reiseverhalten** (Bundesamt für Statistik, 1999): This survey was conducted by the BfS (Swiss federal statistical office) within the context of the Swiss income and consumption census in 1998. Therefore not only the trip characteristics and the typical person variables are available, but also information about a variety of other interesting variables, for example the living situation or the purchase of expensive consumer goods. Approximately 7.300 persons reported over 23.000 trips which were either a holiday trip within the last 6 months, a trip with up to three overnight stays within the last three months or an excursion within the last two weeks. Unfortunately only the destinations of the excursion are known.

MODEL PREPARATIONS

Several assumptions must be made, before models can be estimated. On the one hand the choice set must be generated. Because of the great number of possible alternatives this step is not trivial. On the other hand the variables used in the models must be selected. Here theoretical considerations and the availability of variables are decisive.

Basic idea

The models are based on the idea that leisure consists of very different activities which satisfy different desires and are influenced by completely different impacts. As leisure is so diverse, it is necessary to concentrate on different types of leisure activities. Three different activity groups, which represent popular outdoor activities, were chosen for the models presented here. **Skiing** is used as a representative of a winter activity, because it is one of the most important leisure activities in Switzerland. According to Brandner, Hirsch, Meier-Dallach, Sauvain and Stalder (1995) it is performed by approximately 20% of all Swiss at least once a year.

In summer the activity groups - **climbing and hiking** as well as **walking and swimming** - were chosen in order to avoid activities that are performed by just a very small subgroup of the population. The division in two different types was necessary, because a brief look at the visited destinations has shown that two different types of places were the most frequent visited destinations. One group consisted of places at lakes, which are suitable for walks as well as for swimming, the second group of popular places is located in the mountain regions.

Choice set

According to Swait (2001) the true choice set of travellers is normally unknown to the analysts, as only the chosen alternative can be observed. Consequently a choice set has to be constructed by the analyst. Biases in the choice set can occur, if an alternative is present that in reality is impossible for the traveller to choose. The alternatives inherent in a choice set can mostly be described by a variety of different variables, whereby the potential variables are dependent on the considered purpose.

Generation of alternatives

Modelling destination choice at the municipal level has to deal with the problem that a large number of alternatives is conceivable. One possibility to cope with this situation is to draw a subset of alternatives from the universal choice set for each trip. If the error terms are identically and independently distributed, this procedure is acceptable (McFadden, 1978). Ben Akiva, Gunn and Silman (1985) presented several methods how a subset can be drawn. The simplest approach which was adopted for example by Pozsgay and Bhat (forthcoming) is to add a random sample of non-chosen alternatives to the alternative which was indeed chosen.

This approach was also adopted here by adding nine randomly selected destinations, which were different from the chosen alternative, to the chosen alternative. As Switzerland consists of very different structured municipalities, the set of possible alternatives was restricted according to the considered activity types.

- **Model for skiing**: It was assumed that the destination of a trip with the purpose skiing must be a skiing resort. A municipality is regarded as a skiing resort if it has access to lifts - either directly or through a skibus. 176 municipalities fulfilled this criterion.
- **Model for hiking and climbing**: It was assumed that these activities are performed in municipalities located over 800 meters. Most of the sampled municipalities – in total 555 - are located in the Alps, which are popular for this kind of activities.
- **Model for walking and swimming**: It was assumed that municipalities located below 600 meters, which are not a town, are predestined for these activities. 1'716 municipalities were selected.

Selection of personal and situational variables

For the activity skiing objective factors, like price level, snow conditions, accessibility or number of lifts, as well as subjective factors, like the atmosphere or the friendliness of the other guests and residents, are important (Klassen, 2001; Klenosky, Gengler and Mulvey, 1993). A study about the price level of different Swiss skiing resorts has shown, that much variability can be explained by objective factors (Berwert, Bignasca and Filippini, 1995-1996). But the ski facilities themselves are not the only attraction for the tourists. Brandner, Hirsch, Meier-Dallach, Sauvain and Stalder (1995) pointed out, that new offers for special sport segments like snowboarding, aprés ski facilities and non-ski facilities in case of bad weather (for example public indoor pools) are also crucial for ski areas to attract tourists.

Most of these objective variables are in the data set, whereby height is used as indicator of the probability of good snow conditions. Additionally variables describing the subjective quality of the resort were added. These variables are based on a five point scale concerning the quality of the alpine ski tracks, the quality of snow board facilities, the quality of cross country ski tracks, the quality of aprés-ski and the presence of a skibus (ADAC, 2001).

Describing the supply for the summer activities is much more difficult than describing the supply for skiing, because these activities are not so dependent on a specific infrastructure. Additionally the literature is not as rich as in the case of skiing. Nevertheless it is necessary to make an attempt to model these activities, because hiking is the most popular outdoor leisure activity. Characteristics of this activity are that it is carried out unorganised, that beautiful landscapes are preferred and that people like to combine this activity with other activities (Mielke, 1994).

Although the destinations are not as easy to identify as for skiing, there are in summer municipalities which are more frequent visited than others. This observation suggests that there are natural elements respectively facilities which determine the attractiveness of a municipality as a destination for an excursion. A beautiful landscape, sport, cultural and eating facilities or bathing possibilities are conceivable variables whereby it is assumed that their influence differs with regards to the chosen activity (climbing and hiking versus walking and swimming).

Selection of personal and situational variables

The underlying utility function of discrete choice models distinguishes between variables characterising the destination (see 4.1), the travelling person and the actual situation. Each of these groups of variables is described separately, as relevant variables are identified based on former studies which have analysed factors influencing travel behaviour in general and destination choice in particular.

The demand data are not only used for describing the travellers, but also to restrict the data set. It was assumed that skiing trips were only carried out in the winter months (December, January, February, March), and trips for the summer activities in the summer months (June, July, August September), whereby only the defined subset of alternatives was allowed as destination. A further restriction refers to the kind of trip. Different leisure trip purposes were asked in the KEP, but only the categories 'excursion' and 'holiday' were considered in the following analyses

Persons

The participation in a special activity is the result of humans trying to satisfy their needs and maximise the utility of their behaviour. But the behaviour is limited due to different constraints. These constraints can be distinguished for leisure activities in intrapersonal and structural constraints (Crawford, Jackson and Godbey, 1991). The intrapersonal constraints include personal skills and abilities, while the structural constraints include spatial, temporal or financial constraints. Gilbert and Hudson (2000) certified this theory for skiing participation and showed that the intrapersonal constraints are responsible for the question if a person goes skiing at all, while the structural constraints are more important for the choice of a destination.

Temporal and spatial constraints depend to a large extend on different socio-demographic factors. The variables age, gender, employment status, time budget, car-availability, income, number and age of children were found to be important for leisure travel (Lu and Pas, 1999; Zängler, 2000; Lücking and Meyrat-Schlee, 1994). Additionally, different studies – either based on empirical findings or on theoretical considerations – pointed out that the living situation (Fuhrer and Kaiser, 1994), general values and preferences (Götz, Jahn and Schultz, 1997), the social context and friends (Blinde and Schlich, 2000), previous journeys (Oppermann, 1991) and the level of information of travellers (Klassen, 2000) also influence travel behaviour. Unfortunately, the last mentioned factors are not available in the used database.

Travel situation

The situational variables are connected to each trip and change, if a person goes to another destination (unlike the personal variables) or if different persons go to the same destination (unlike the variables describing the destination). Possible situational variables are the travel situation, the weather, the season or the type of day. Because of data restrictions only the influence of the travel situation is tested here.

The most important variables to describe the travel situation are the generalised costs between the origin and the destination. They are a measure for the impedance to go from one place to another. The most common forms to incorporate the generalised costs into the utility function are the linear form and the log-linear form (Fotheringham, 1983). A linear function would imply that the utility decreases proportional to increasing generalised costs - regardless whether the generalised costs are already high or not. A log-linear form suggests instead that the utility still decreases with increasing generalised costs, but the marginal utility decrease is lower for higher generalised costs.

The generalised costs were calculated with the software VISUM (© PTV AG, Karlsruhe). At this stage only the distances between two municipalities were considered, because the travel times between the municipalities are at the municipal level only available for the mode car, because not all municipalities have rail access. The shortest path - distances (time) were calculated using a national road network available at the IVT.

RESULTS

Based on the theory and the preparations steps models for the three activity types could be estimated. Starting point of the estimations was a model including the mentioned spatial variables, the travel distances between origin and destination as well as variables describing the person. The last group of variables can not directly be integrated in the model, but must be used either alternative specific or in conjunction with a generic variable (Maier and Weiss, 1990). The second possibility was chosen because of the nature of the choice set (always different alternatives), whereby theoretical meaningful combinations were tested.

The selection of variables was not only based on theoretical considerations and the availability of variables, but also on the correlations between the variables. Because variables which are highly correlated can cause problems during the estimation process, pairs of variables with a correlation coefficient greater than 0.6 were tested in greater detail. Mostly the inclusion of both variables in one modell was avoided.

This first models were modified according to the model results, whereby any modification was based on a-prior understanding and was not guided by the model results alone. The first attempts already showed some interesting results. On the hand, the person variables had very low, if any influence on the model results. So nearly all of them had to be omitted. The only exception was the ratio of inhabitants at the destination to the number of inhabitants at the origin. On the other hand the great importance of the distance variable became visible. So it seemed useful to present results with and without this variable. The log-linear function of the distance variable performed better than the linear function.

Model for skiing

The final model (see table 2) consists of a variety of different variables and has a high quality, whereby the fit of the model with the distance variable is much higher than the fit of the other model. This means that the distance between origin and destination is able to explain 40% of the model's variability. Destinations further away are less interesting than nearby skiing resorts.

The choice of a destination is additionally influenced by variables describing the quality of the skiing resort and by variables exceeding the traditional skiing supply. Interesting is that the influence of the variables 'length of alpine tracks' and 'quality of alpine skiing area' is negative. This kind of relationship could also be seen in respective scatter plots. By way of contrast the influence of the price level, entertainment and other sport facilities is positive. Especially the availability of a public indoor pool and indoor tennis courts increase the attractiveness of a municipality.

Furthermore it is interesting to analyse how the change of a variable influences the choice of an alternative. An appropriate tool for doing this are elasticities which specify the proportional demand increase or decrease caused by an one-percent change in a variable. The elasticities were computed for four chosen variables. The results (see table 1) confirm the importance of the distance variable.

Alternatives	***Distance***	***Price***	***Ski tracks***	***Indoor pool***
Not chosen alternative	***0.823***	***-0.525***	***0.111***	***-0.431***
Chosen alternative	***-1.589***	***0.380***	***-0.075***	***0.240***

Table 1 Elasticities for chosen variables of the skiing model

Model for climbing and hiking

As the model for skiing this model has a good model fit (see table 3), but this is again mainly due to the high explanatory power of the distance variable. The model for climbing and hiking contains variables describing the vegetation as well as variables describing the leisure infrastructure. All infrastructural variables have a positive impact on the choice of a specific destination. Especially the possibility of swimming seems to attract people. The situation is different in the case of the vegetation variables. Some of them have no significant effect (for example area with closed forest), some of them a negative one (for example area with open forest), some of them a positive one (for example area without vegetation).

	Models with distance		Models without distance	
	Coefficient	t-statistics	Coefficient	t-statistics
Height of municipality	0.002	6.30	-0.000	-2.57
Unvegetated or unproductive area [ha]	0.000	7.18	0.000	7.96
Employees in entertainment facilities	0.014	3.57	0.010	3.52
Inhabitants at destination/inh. at origin	-0.007	-2.74	-0.019	-4.97
Log of distance [km]	-2.429	-19.02		
Price for a one week ticket	0.004	1.79	0.003	2.26
Total length of alpine tracks	-0.001	-1.36	-0.002	-2.31
Quality of alpine skiing area	-0.182	-1.46	-0.143	-1.56
Quality of après-ski	0.217	2.71	0.191	3.24
Belonging to the skiing area	0.510	3.57	0.440	4.24
Nr. of public indoor tennis courts	1.025	7.08	0.750	6.86
Nr. of public indoor pools	0.269	6.96	0.261	8.95
Sample Size [trips]	715		715	
Log likelihood function [β]	-682.681		-1298.842	
ρ^2	0.585		0.211	

Table 2 Coefficients, t-statistics and model fit of the skiing models

Model for walking and swimming

This model is the model with the highest ρ^2 compared to the others, whereby the differences between the models are higher for the model type including the distance variable (see table 4). This means that in the model for walking and swimming even more variability can be explained by the distance variable. The two models - with and without - do not only differ in the values of the ρ^2s, but also in the significance of the coefficients and even in the signs.

The choice of a destination is positively influenced by all variables describing the supply in a municipality. Especially swimming facilities attract people. Nearly as important as the possibility to swim is the possibility to walk. Cultural facilities also tends to increase the probability of a destination to be chosen.

	Models with distance		*Models without distance*	
	Coefficient	***t-statistics***	***Coefficient***	***t-statistics***
Height of municipality	***0.002***	***4.82***	***0.000***	***0.96***
Area with open forest [ha]	***-0.003***	***-2.12***	***-0.003***	***-4.19***
Area with bushes [ha]	***0.002***	***3.16***	***0.001***	***2.53***
Area with copses [ha]	***0.008***	***4.91***	***0.005***	***6.20***
Area without vegetation [ha]	***0.000***	***1.73***	***0.000***	***0.85***
Area with meadows [ha]	***-0.004***	***-4.38***	***-0.004***	***-6.78***
Log of distance [km]	***-2.181***	***-16.72***		
Hiking paths [km]	***0.004***	***1.61***	***0.005***	***3.73***
Employees in gastronomy facilities	***0.010***	***2.05***	***0.001***	***4.71***
Nr.of bath in lake	***0.770***	***2.58***	***0.415***	***2.63***
Nr. of public outdoor pools	***0.369***	***3,94***	***0.322***	***6.15***
Sample Size [trips]	***570***		***570***	
Log likelihood function [β]	***-266.422***		***-984.452***	
ρ^2	***0.797***		***0.250***	

Table 3 Coefficients, t-statistics and model fit of the climbing and hinking models

	Models with distance		*Models without distance*	
	Coefficient	***t-statistics***	***Coefficient***	***t-statistics***
Nr. of inhabitants	***0.000***	***-3.98***	***0.000***	***14.70***
Area with closed forest [ha]	***0.000***	***2.17***	***0.000***	***0.59***
Area with parks [ha]	***0.071***	***6.77***	***0.016***	***2.520***
Inhabitants at destination/ inh. At origin	***-0.041***	***-4.01***	***-0.122***	***-13.75***
Log of distance [km]	***-2.001***	***-44.58***		
Hiking paths [km]	***0.015***	***8.18***	***0.008***	***7.82***
Employee ins gastronomy facilities	***0.001***	***4.40***	***-0.000***	***-0.09***
Nr. of cultural facilities	***0.060***	***2.71***	***0.029***	***2.14***
Nr.of bath in lake	***0.546***	***9.64***	***0.350***	***11.27***
Nr. of public outdoor pools	***0.407***	***13.10***	***0.259***	***15.11***
Sample Size [trips]	***3210***		***3210***	
Log likelihood function [β]	***-1378.253***		***-5339.539***	
ρ^2	***0.814***		***0.278***	

Table 4 Coefficients, t-statistics and model fit of the walking and swimming models

Interpretation

The low influence of the person variables on the model results support the statement of Gilbert an Hudson (2000) that the intrapersonal constraints are responsible for the question if a person carries out an activity at all, while the structural constraints are more important for the choice of a destination. Because only realised trips are regarded, differences in the socio-demography can not be seen. If a trip is carried out, the choice of a destination is mainly dependent on the destination specific characteristics.

The importance of the distance is another for all models valid result. It shows how sensitive people are to the distance they must travel. If the distance variable is omitted from the models, its influence is captured by other variables - sometimes leading to changes in the signs.

Besides these general findings each model contains further information

- **Skiing model**: One - perhaps surprising - result is that the availability of entertainment and additional sport facilities have a positive and greater impact on the choice of a destination than the skiing supply itself, but further functional forms need to be tested before this can be generalised.
- **Hiking and climbing model**: Whereas people clearly reward a good leisure infrastructure, there exist only trends with regard to the natural environment. Those vegetation types are interesting for people which are typical for alpine regions, for example areas without vegetation. Vegetation types, which can also be found in lower areas, are less appealing. This interpretation is supported by the fact that the height has a positive impact on the choice of a destination.
- **Walking and swimming**: Interesting in this model is the comparatively high explanatory power of the distance variable compared to the other models indicating that people are more distance sensitive for activities which more easily can be carried near the origin. A further finding is the importance of the infrastructure compared to the nature.

The unexpected results with regards to the skiing infrastructure and the general lack of explanatory power of the socio-demographic variables ask for further study. The heterogeneity of the persons can make point-estimates a difficult and potential misleading proposition. Mixed logit estimates (random parameter logit) will be performed in the future to account for these variabilities in taste between persons and contexts.

CONCLUSION

Modelling destination choice is at the moment a relative undeveloped area in transport modelling. But it is necessary to make progresses in this area, because leisure travel has become the most important trip purpose and the consequences of leisure travel are far reaching. The destinations themselves, especially small municipalities in the Alps, as well as municipalities on the main routes are often dominated by leisure travel. The carrying out of activities also has influence on the structure of municipalities.

Modelling destination choice requires suitable data sets and tools. Because the choice of a destination is a choice between discrete alternatives, one common form of discrete choice modelling - the MNL - was used here - knowing that not all particularities of destination choice can be captured and that further developments are desirable. But the results obtained give interesting hints on the relationships between the variables and the choice of a destination which are useful for planers and persons responsible for the supply in a municipality.

One main result of the models was that the choice of a destination is heavily influenced by the distance between origin and destination. Travellers weigh the attractiveness of a destination against the impedance between their origin and a potential alternative. This means that municipalities further away from the main cities must have a very attractive supply to attract people. Against this background the wish of many municipalities to have access to the main (road) network becomes understandable.

Most leisure activities require a respective infrastructure for carrying out them. For example skiing is not conceivable without lifts, walking is not conceivable without hiking paths. Therefore it is highly probable that a good infrastructure would be attractive for the potential users. In the case of skiing the initial model results do not support this hypothesis. The direct skiing infrastructure is not as important as other facilities - like a public indoor pool or aprés facilities - for the choice of a skiing resort. The length of ski tracks has even a negative impact. But at the same time the price of a ticket has a positive impact on the choice of destination - perhaps indicating the image of a skiing resort. However, in the case of walking the length of the hiking paths has a positive effect on the choice of a destination. But once again other facilities, like pools, possess a higher explanatory power.

In the skiing and walking model different types of infrastructural facilities determine the attractiveness of a municipality - of course dependent on the distance. The environment plays a subordinate role. The situation is different in the case of hiking. Besides the infrastructure vegetation types which are typical for higher located municipalities tend to attract people.

To sum up - the model results show the importance of a good accessibility and varied infrastructure. What do these results mean for planners and sellers of tourist services. Is the conclusion admissible that a tourism dependent municipality can only survive if it continuously improve its supply and its access. To some extent this conclusion is right, especially because the competition between destinations is becoming fiercer. But it should also be kept in mind that a nation wide analysis has no place for smaller innovations. For example, a municipality like Ardez will never reach the visitor numbers of the world-famous St. Moritz, but it can be successful in attracting a specific type of tourists. So the results should not be understood as an excuse for further, but not well considered extensions of the tourist infrastructures.

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Monitoring and Management of Visitor Flows in Recreational and Protected Areas
Conference Proceedings ed by A. Arnberger, C. Brandenburg, A. Muhar 2002, pages 159-165

Modelling Visitor Flow from the Visitor Perspective: The Psychology of Landscape Navigation

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Abstract: This paper reviews basic issues underlying the monitoring and modeling of the movements of visitors in large-scale natural parks and recreation areas. Modeling of "visitor flow" is related to research and methods in associated fields, including environmental preference, environmental values/attitudes and wayfinding. Relevant psychophysiological and neurological research and theory is also reviewed to reveal the fundamental basis of dissociations between verbal reports and actions. It is argued that traditional verbal survey methods cannot in principle provide an adequate basis for models of human landscape navigation.

The need for "visitor management" at the world's major natural parks and protected areas is obvious to everyone. Certainly those charged with the management of such areas recognize that the "human dimension" is at once the most potent and the most problematic of the forces with which they must contend. The physical and biological forces of wind, fire, flood, insects and drought can be overwhelming and catastrophic, but natural systems have evolved in the context of just such disturbances, and generally adapt to them rather well. The onslaught of increasing multitudes of adoring human tourists, recreationists and seasonal residents, while perhaps not as dramatic as a hurricane or a flood, has proven much more relentless. Natural systems have not had the millennia required to evolve suitable adaptive responses to this very recent and sometimes erratic disturbance agent.

How can natural parks and protected areas be saved from being loved to death?

One obvious answer is to close the gate and keep people out altogether. But this policy is likely to be very unpopular when it is the public that is being kept out of public lands, and public support (financial and political) is essential for providing the resources required to maintain and protect these areas. Moreover, there are substantial benefits to individuals and to society of having people visit and recreate in these special natural places, benefits that can not be readily replaced by other experiences and activities. But unbridled access could degrade or destroy the natural environmental settings that are essential to these desired experiences. Clearly, as generations of park managers and the participants at this conference realize, a balance between public use and environmental protection is needed.

In the face of increasing populations and increasing demands on natural parks and protected areas, protection of threatened plants and wildlife species, sensitive ecosystems, and biodiversity on the planet justifies limitations of human access and use. The question is, how much limitation? In recent years policy has tended toward *providing acceptable (satisfactory) visitor benefits, so long as it does not threaten the long-term sustainability of sensitive environmental/ecological resources*. Visitor numbers are limited by the estimated "carrying capacity" of the park environment. The visitor is placed in the position of being guilty until proven innocent—that is, excluded unless it can be shown that his/her admission would not harm the environment. In contrast, a policy that leans more in the direction of meeting visitor wants and needs might be *providing the maximum visitor benefits consistent with conserving the sustainability of essential environmental/ecological resources and systems*. By this policy the visitor is innocent until proven guilty—that is, admitted unless it can be shown that doing so would injure the environment.

There is considerable room for reasoned debate about where on the environmental protection-visitor satisfaction dimension public park management policies should stand in the 21st Century, both in general terms and on a place by place basis. Wherever one may chose to draw that line, however, rational policy development and implementation requires some fundamental information about visitors, about their needs and wants from the park environment, and about the impacts of their visits/uses on that environment. Following the well established lead of the physical and biological dimensions of park management, these human dimension/visitor management information needs should be met through the application of careful and rigorous science. This must entail a thorough investigation and analysis of past visitor-environment interactions, an appropriately detailed inventory of current visitor-environment conditions, and the development of scientific theory and models sufficient to make precise and reliable predictions of the outcomes of future visitor-environment interactions for a range of relevant park policy and management scenarios. The conveners and participants at this conference are demonstrably dedicated to just such a cause.

There is, of course, already a considerable history of recreation and tourism research that can, and has, advised visitor management policies. The best developed areas of park visitor science have focused on the visitor. Much is known about visitor demographics, perceptions, attitudes, expectations and beliefs, reflecting the interests and perspectives of the social scientists that have been drawn to this field of research. There is also considerable knowledge about visitors' general satisfaction with park visits, and growing understanding of how that is affected by various biological, social and managerial features of parks and recreation areas. Less is known about how specific park features affect particular individual and social benefits of visitation, and less still is known about specific and cumulative impacts of individual and collective visitor activities on park environments, especially where complex ecosystem disturbances are of concern.

In short, while there is considerable knowledge about park visitors and park environments in general, and about some important interactions, much less is known about specific visitor-environment relationships. Visitor demand for the experiences and activities that natural parks and protected areas provide continues to increase. At the same time, the supply and resilience of quality park environments remains mostly fixed or declines. In this context, information about specific visitor-environment relationships will be essential to achieving balanced park management policies that are biologically and socially sustainable. For example, general carrying capacity concepts (number of visitors per park) are not sufficient for attaining balanced allocations of visitor access to parks and protected areas. Many heavily used parks already apply spatially and temporally specific limits on visitation, restricting specific uses in designated areas at particular times to control both environmental impacts (as on nesting birds) and social conflicts (as between snowmobiles and cross country skiers). When successfully applied, such temporal-spatial zoning can enable parks to meet increasing visitor demand while at the same time reducing adverse impacts on sensitive environmental resources and enhancing the quality of visitor experience. But this level of specificity in park management demands the support of more precise and more detailed park visitor science. Gross tallies of visitors and general characterizations of visitor-environment interactions will not be sufficient. Meeting these needs will require answers to a chain of W questions that are near to the heart of this conference on Visitor Flow.

WHO/WHERE/WHEN/WHAT?

Who is Where When, doing What? Answering this question correctly and with sufficient precision is essential to effective park visitor management. Knowing W/W/W/W, between and within parks and protected areas is the most basic data required for the development of a valid and useful park visitor science, and for more effective visitor management. W/W/W/W data is prerequisite to understanding visitor-environment relationships (from quality of visitor experience/satisfaction to visitor impacts on the park environment) and visitor-visitor relationships (from solitude to crowding). Knowing W/W/W/W now and in the past provides the building blocks for models and theories that enable predicting changes in W/W/W/W in the future, and for understanding *Why* those changes occur. Yet surprisingly few parks and protected areas can answer the W/W/W/W question with any precision or certainty in either the past or the present, and far fewer have any scientific basis for predicting the W/W/W/W implications for the alternative futures among which they must be prepared to choose.

Answering W/W/W/W is the goal of the Visitor Flow monitoring and modeling efforts represented at this conference. The papers presented here represent some of the world's most imaginative and innovative approaches to this question. Advanced monitoring and remote sensing, geo-referencing and geographic information processing, and computer simulation and modeling technologies have been enlisted, adapted and combined to locate visitors in time and space and to track their movements and actions with unprecedented precision. But this has not been the traditional approach to visitor research. More often, when managers and investigators wanted to answer the W/W/W/W question (or, more correctly, subsets of that question), they have just asked, and in more or less sophisticated ways, written down what visitors said. That is, the vast majority of W/W/W/W data has been collected using one form or another of the verbal survey.

Verbal surveys have been and will continue to be an essential tool for park visitor science. Many important questions can most efficiently and effectively be addressed by posing questions and obtaining answers in words. Some important questions can only be addressed this way. Moreover, in some venues (especially politics and public relations), what people say can be more important than what they do. But the verbal survey has become so ubiquitous that "human dimensions" research (and much of social science in general) has acquired a reputation as "paper and pencil science" (with commensurate expectations about equipment budgets). However, for answering the more basic W/W/W/W question for actual visitors in actual natural (park) environments, verbal surveys may be particularly inappropriate.

The empirical data base indicating that people do not always do what they say or say what they do, is large and venerable. The dissociation between verbally expressed "attitudes" and overt behavior is legendary in the social and behavioral sciences (Nisbitt and Wilson, 1977). Indeed, this observation has achieved recognition at the most basic levels in the colloquial distinction between "talk'n the talk" and "walk'n the walk."

Park visitor/recreator research is not immune from this general pattern of dissociation between what people say and what they do. The mismatch between words and deeds can at times be due to genuine failures of perception and/or memory (visitors don't always accurately know where they are or remember later what they did there), and at times it may derive from intentional deceit (e.g., "we did not go into the restricted area"). Recent psychophysiological and neurological research, however, provides evidence that word-action dissociations may be characteristic of humans, a result of the fundamental "modular" architecture of the mind/brain. Little or none of this basic research has involved visitors in natural parks or protected areas, of course. Indeed much of the work has used animals or human subjects manifesting specific neurological disorders. Healthy human subjects have been studied, but mostly in very constrained laboratory situations designed to identify the neurological substrates of perceptions, thoughts, feelings and actions. Still, this research potentially has important implications for determining the necessary and sufficient conditions for answering the W/W/W/W question that is basic to Visitor Flow. The brief (and superficial) review of research below argues for shifting park visitor research beyond verbal surveys to include greater use of more direct spatially and temporally precise monitoring and modeling of visitor behavior, i.e. to increase emphasis on Visitor Flow. At the very least, this research provides support for expanding park visitor-research equipment budgets beyond paper and pencils.

WORDS VERSUS ENVIRONMENTS

It is not uncommon for assessments of public responses to different environments or environmental conditions to be based on verbal descriptions of (or just labels for) those environments or conditions. Is there any evidence that such verbal descriptions are capable of supporting valid assessments? That is, are answers to such questions consistent with responses based on direct experience of the actual environments (or conditions) the questions intend to represent?

Environmental preference--Few studies have directly compared environmental preferences based on verbal descriptions with preferences based on direct experience (Daniel & Ittelson, 1981, provides an indirect comparison). In fact the environmental perception/environmental preference literature seems to have bypassed this question entirely on the way to asking whether photographs are a sufficient representation for obtaining valid responses to such questions (Daniel & Boster, 1976; Shutleworth, 1980; Sheppard, 1989; Stamps, 1990; Zube, et al, 1987).

For many relevant environmental preference questions, the weight of the evidence is that obtaining valid answers requires highly realistic visual representations (e.g., photographs) of the environments/conditions at issue. Even then, important limitations have been noted. For example, environments with significant dynamic elements (e.g., flowing rivers) may require dynamic (animated/motion) representations (Brown & Daniel, 1991). If sensory modalities other than vision are important in the environments (or conditions) being assessed, additional features (e.g., the sound of flowing water) may need to be added to the representation as well (Hetherington, et al 1994). More recent environmental representation studies have focused on the sufficiency of emerging computer-graphic/computer-simulation techniques. Environmental preferences (and other perceptual judgments) have been studied for computer representations ranging from still video images/montages to interactive virtual reality systems (Bergen et al, 1995; Bishop & Leahy, 1989; Daniel & Meitner, 2001; Oh, 1994; Orland, 1993; Vining & Orland, 1989). The indications are that very high levels of color and texture fidelity (viz the environments represented) are needed to achieve valid responses.

Wayfinding-- Going beyond assessments of passive environmental experiences to address questions about navigation through, and destination selection within the three-dimensional environment (issues much closer to Visitor Flow), the environmental representation standards would appear to increase. Verbal versus "pictorial" representations have been studied directly in the context of wayfinding, especially studies comparing the effectiveness of verbally presented directions (route descriptions) versus maps as aides to learning and navigating spaces. Studies have compared verbal and map-directed route navigation in real and simulated environments, with the general finding that both can lead to successful performance (e.g., Evans & Pezdek, 1980; Franklin & Tversky, 1990; Thorndike & Hayes-Roth, 1982). However, map representations are generally superior in supporting configural knowledge, as indicated by superior performance when the navigator is required to go off the primary route to avoid a roadblock, to get back on track after a navigational error, to find a successful shortcut, or to reverse the route.

Of course, both maps and verbal descriptions are abstractions of the environment, and learning routes by either of these means is not the same process, and often does not produce the same outcomes as learning by direct exploration of the environment.

This difference, between secondary (from maps and words) and primary (direct experience) spatial learning (Presson & Hazelrigg, 1984), affects knowledge of the space and performance on a number of navigation-related tasks. Learning from both verbal and map representations, for example, tends to distort actual spaces toward a more Cartesian reference system and to shift perception/memory of oblique intersections and curved paths toward right angles and straight paths (e.g., Evans & Pezdek, 1980).

The great majority of outdoor way-finding studies have been conducted in built environments (especially in and around college campuses), where streets (sidewalks) provide primary routes and buildings and other architectural features are the principal landmarks. Fewer studies address navigation in natural environmental settings where trails or passage ways would be less regular and changes in topography and/or vegetation would be principal landmarks. An exception is the small set of studies on "orienteering" (e.g., Malinowski & Gellespie, 2001), but subjects in these studies typically have access to verbal descriptions, maps and compasses, and they are trained in the use of navigational aides.

A number of investigators have noted the potential advantages of using virtual environments to study wayfinding (e.g., Bishop, 2001; Rohrmann & Bishop, in press). Computer simulation/VR research, like the preference research discussed above, has apparently by-passed the question of whether verbal descriptions would suffice to represent the virtual environments with which their subjects interact. As in the preference literature, texture and color fidelity/realism in environmental representations have been found (or assumed) to be important. In addition, studies using "walk-through" (or "drive-through") simulations have been especially concerned about motion parameters, both the depiction of movement of the navigator/viewer through the environment and the motion of dynamic elements in the environments represented. Indications are that, in addition to rather high levels of form and color realism, realistic movement/motion is also necessary for valid environmental responses. In particular, interactive capabilities must be sufficient to allow the subject to explore visually, and in depth, the environment represented (Bishop, 2001; Bishop et al, 2001). Moreover, efforts are increasing to develop more natural response options for VR systems. Based more on intuitions than on actual empirical study, verbal responses, and even mouse or joy stick systems, have apparently been judged inadequate to support valid conclusions about human navigation in three-dimensional environments.

Psychophysiological-neurological research— There is wide spread belief that exposure to natural environments, in either active or passive pursuits, is psychologically and physically beneficial, especially for highly stressed, urbanized humans (e.g., Parsons, 1991; Ulrich, 1983). Consistent with this belief, it has been shown that viewing natural environments (directly, in photographs or in video) can produce rapid and substantial physiological recovery from stress (e.g., Hartig et al, 1991; Parsons et al, 1998). As for the environmental preference research described above, there do not appear to be any studies that have directly investigated whether verbal descriptions (read or heard) of these environments would have similar effects. A recent review, however, suggests that concern about environmental representation in this context has instead focused on whether even high quality visual representations (photographs, video tapes and high-realism computer simulations) are sufficient to support the restoration effects of direct environmental experience (Parsons & Hartig, 2001).

There is long-standing evidence that visual/perceptual and verbal processing systems may be supported by somewhat independent brain/neurological systems in humans (e.g., Gazzaniga, 1985). Perhaps the most popular version of this distinction has been the notion that the left and right hemispheres of the brain are differentially specialized for verbal (left hemisphere, for right handed people) and visual/perceptual (right hemisphere, for right handed persons) processing. Fascinating studies with "split brain" subjects (persons whose left and right hemispheres have been separated by accidents or as a surgical treatment for severe epilepsy, for example) have revealed astonishing differences in the capabilities of the two sides of the brain (e.g., Gazzaniga, 1984; Sperry, 1968). For example, words presented only to the left side of the visual field (and thus only activating the right side of the brain in split brain subjects) can neither be read nor (in the case of instructions for action) responded to appropriately (such as selecting the named object from a set of objects). In contrast, when pictures of objects are exposed in the left visual field the subject can not name the object, but can accurately select the depicted object with the left hand (the hand primarily controlled by the right hemisphere). In normal (intact) brains stimulation from both sides of the visual field is neurologically simultaneously transmitted to both hemispheres, but careful experiments have revealed that the separation in verbal versus visual/perceptual function persists, and has important implications for normal cognition and behavior.

Studies of the neurological substrates of spatial learning and navigation in three-dimensional environments also indicate that only rather high-realism environmental representations are sufficient to produce neurological activation patterns that are similar to those that would be expected to occur in actual environmental encounters. For example, brain scans of subjects learning relatively abstract virtual mazes or towns differ from those of subjects learning from richer, more realistically depicted environments, and it is the latter representations that produce patterns of neural activity most consistent with those expected for direct spatial learning (Parsons & Hartig, 2001). One possible counter example cited by Parsons and Hartig was a study of experienced London taxi drivers who were instructed to imagine driving familiar routes through the city. Brain scans of the drivers showed patterns of neural activity substantially similar to those expected for navigation in actual environments. Whether novice drivers less familiar with the environment in question would produce similar results is not known.

The simple two-hemisphere, visual-versus-verbal dichotomy is no longer held, as recent work has indicated considerably more complex patterns of separation and sharing of verbal and perceptual and other functions between the hemispheres. Perhaps more importantly, neurological research has identified a much larger number of autonomous or semi-autonomous anatomical/functional distinctions. One such distinction that may be significant for understanding aspects of Visitor Flow is the separation of neurological systems for perception-for-representation (as for encoding objects into memory or for verbally describing a perceived object) versus perception-for-action (as for avoiding a collision or for grasping an object).

WORDS VERSUS ACTIONS

In some circumstances asking people verbally to report where they have been and what they did there may be sufficient. But there are many circumstances where this would not be an appropriate procedure. For an obvious example, while lost persons do exhibit consistent and predictable navigational patterns (Malinkowski & Gillespie, 2001), it would seem on the face of it to be inappropriate to ask them where they have been. Young children are quite capable of navigating though complex environments, but they are unlikely to have the verbal skills to describe sufficiently where they have gone/would go or how they would get there. In fact, there is some evidence that young children may only be able to indicate the extent of their spatial understanding through responses that are basically similar to actual navigation. In one study (Lehnung, et al 2001) preschool children performed significantly below older elementary school children on a spatial learning task when configural knowledge was assessed by moving a compass-like pointer to indicate the direction of a learned landmark (not in sight). However, when the same children were allowed to indicate the direction by orienting their body and pointing with an extended arm, the young children preformed as well as the older children. This finding is consistent with the fact that implied spatial learning and navigational ability for adult subjects can depend considerably on the tasks/responses used to assess that ability (e.g., Kitchin, 1996).

Saying versus doing the "right" thing--There are many contexts in which verbal reports and actions are inconsistent. Dissociations between self-reports of attitudes and behavioral intentions versus behavior have been the subject of a large number of psychological and social experiments. Studies of health promoting/protecting behaviors are one important example where stated intentions versus actions inconsistencies are notorious, especially with respect to diet, exercise, smoking and unprotected sexual behavior. In the environmental domain pervasive discrepancies have been reported between self-reports and actions regarding energy conservation and recycling (e.g., Ebreo & Vining, 1994; Corral-Verdugo, 1997). In the Corral-Verdugo study if was found that self reports of recycling were associated with reported agreement with conventional beliefs about the value of conservation and recycling practices, but self reports were not significantly correlated with behaviorally assessed personal motivations or competencies required for recycling behaviors. In contrast, recycling behavior (confirmed by direct observations) for the same respondents depended upon personal motivations and competencies, but was independent of expressed beliefs about the value of conservation and recycling.

It is tempting to attribute the above discrepancies between words and actions to insincere subjects, i.e., subjects strategically saying what they believe the experimenter (and society more generally) wants to hear. Such "task demand" effects are very likely important in many situations characteristic of verbal attitude surveys. But there is evidence that similar dissociations between words and actions may be much more fundamental.

Environmental affordances--No hiker would be surprised that people routinely overestimate the steepness of a hill they are about to climb, especially when burdened by a backpack. What may be more surprising is the finding that such exaggerations, consistently found in verbal reports, are not found when people indicate estimated steepness by their actions. For example, when people estimate the steepness of a hill by adjusting an unseen platform with their hand, the exaggeration goes away and slope estimates are much more accurate (e.g., Bhalla & Proffitt, 1997; Crème & Proffitt, 1998; Proffitt, et al 1995). A related experiment (Wraga, et al 2000) used an environmental-scale representation of the Muller-Lyer illusion, in which a line segment extending between two circles is consistently judged to be shorter than it is. When this illusion was arranged so that the line (between the circles) extended in front of the observer as a "path," verbal estimates of the length of the path showed the expected underestimation. When subjects were blindfolded and asked to walk to the end of the path, however, the bias in length estimation did not occur. These findings are consistent with the view that mental representations of environmental objects that support explicit memory or verbal reports are anatomically and functionally separate from the implicit representations that guide actions toward those objects (Milner & Goodale, 1995).

Psychophysiological and neurological bases—Consider the following observation: a woman is shown two objects, one a tall thin vertical rectangle and the other a much shorter-wider cube. When asked about the objects, she is unable to consistently tell the experimenter whether the two objects are the same or different. On the other hand, when asked to reach out and pick up one of the objects, she does so quickly and with ease. Further, video tape recordings of her action reveals that both the orientation and the extent (width) of her grasp were appropriately adjusted to fit the object being picked up well before her hand came in contact with the object (Milner & Goodale, 1995).

The behavior in the study described above is, of course, not normal. The subject in the experiment suffers from a particular neurological disorder caused by brain injury. But a large body of related studies with both brain damaged and normal subjects has lead psychologists and neuroscientists to make important distinctions between the processes of cognition and action. The perceptual and cognitive processes for representing objects for the purposes of remembering them and/or reporting about them versus the processes that direct actions toward the same objects appear to be associated with distinct and substantially independent underlying neurological systems in the brain. As the studies by Proffitt and his associates described above reveal, such dissociations between words and actions are not restricted to people with brain damage. Indeed, such word-action dissociations are very likely characteristic of many environmental perceptions and judgments that underlie the W/W/W/W questions that are central to understanding Visitor Flow.

IMPLICATIONS FOR VISITOR FLOW

The research outlined above indicates that it is very unlikely that verbal descriptions can provide valid environmental representations for the study of Visitor Flow. Indications are that for assessing visitor's aesthetic and other environmental preferences, only high fidelity, realistic environmental representations will suffice. For questions regarding visitor's navigation through the environment, representational standards are likely to be even higher, including high fidelity representations of movement parameters (for both the visitor and dynamic environmental components) and high levels of interactivity to support active exploration of the environments represented. The pervasive dissociations between words and actions that have generally plagued verbal surveys of attitudes, beliefs and intentions are increasingly believed to be a reflection of the fundamental architecture of the human mind/brain. Thus, verbal reports alone are unlikely ever to provide a valid basis for ascertaining visitor's preferences for and/or reactions to environmental conditions in parks and protected areas. At a minimum, the research outlined above strongly affirms the need for thorough empirical confirmation of the validity of any study that purports to answer the W/W/W/W questions that are most basic to understanding Visitor Flow. That is, it must be demonstrated that answers to W/W/W/W questions based on the environmental representations used and the responses obtained in the assessment are consistent with W/W/W/W answers for actual visitors in actual parks. Of course, making this comparison requires information about the actual behavior of visitors in actual parks and protected areas--that is information about Vistor Flow.

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Monitoring and Management of Visitor Flows in Recreational and Protected Areas
Conference Proceedings ed by A. Arnberger, C. Brandenburg, A. Muhar 2002, pages 166-172

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.

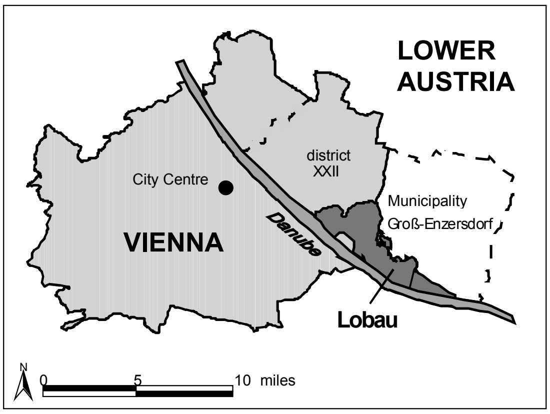

Figure 1: Study area: Lobau, the Viennese part of the Danube Floodplains National Park (Hinterberger, 2000, modified)

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).

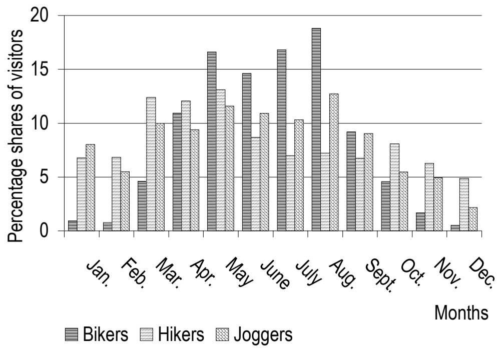

Figure 2: Relative Distribution of User Types over the Year 1998 - 1999, Data source: Video monitoring .09.1998-.08.1999

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.

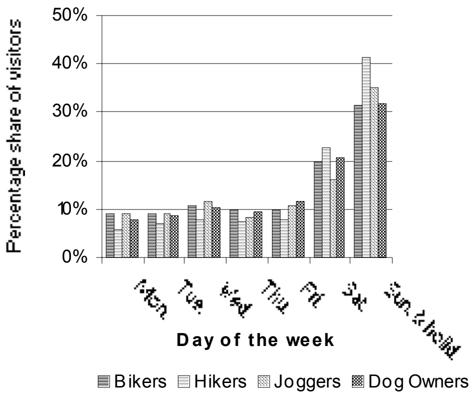

Figure 3: Visits per day of the week, Data source: Video monitoring .09.1998-.08.1999

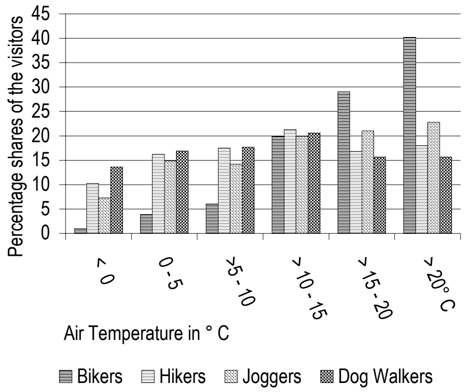

Figure 4: The Influence of Air Temperature on Visits to the Lobau, Data source: Video monitoring and ZAMG .09.1998-.08.1999

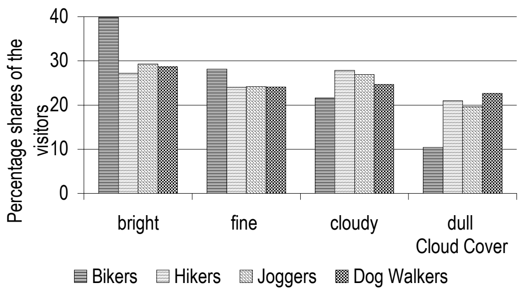

Figure 5: The Influence of Cloud Cover on Visits to the Lobau, Data source: Video monitoring and ZAMG .09.1998-.08.1999

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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Conference Proceedings ed by A. Arnberger, C. Brandenburg, A. Muhar 2002, pages 173-179

Serial Experiences : Monitoring, Modelling and Visualising the Free Independent Traveller in New Zealand at Multiple Scales with GIS

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Abstract: This paper outlines a number of approaches and methodologies, based on utilising itinerary analysis and Geographic Information Systems, which have sought to explore tourism flows and their impacts at a range of temporal and spatial resolutions. As such its basic records are the sequential movement patterns of individual tourists, either from night to night or from stop to stop. It draws from a data base of some 50,000 journeys nationally, and three major regional surveys in Northland, the West Coast and Rotorua conducted between 1997 and 2001. The paper initially deals with analysis and integration issues relating to existing national data sets on international and domestic visitors and their overnight stays. It then describes and critiques the development of map-based sample surveys applied to detailed information on intra-regional flows, with reference to work in both Tai Tokerau (Northland) and the South Island's West Coast. These surveys record the 'informal' stopping behaviour of visitors in greater detail, and allow initial analysis of movement and positioning of tourists at various times of the day. Insights gained from these data are explored, and their relationship to other data sets such as attraction visitation and accommodation usage surveys are reviewed. Finally, the significance of the data for tourism (in areas such as development strategies and impact assessment) and for wider geo-demographic applications are discussed, as are new data collection opportunities for recording itineraries and flows.

NEW ZEALAND'S CONTEXT FOR FLOW RESEARCH

As a cluster of sizeable but isolated islands, blessed with sufficient attractions to attract substantial international visitor interest, New Zealand represents an almost ideal context for defining and researching tourist flows. With the nearest land mass three and a half hours flying time away, and with closely-monitored entry and exit points, few visits are incidental or casual trans-border excursions, and assessing gross patterns of visitation is straightforward. All visitors are recorded by entry and exit cards, and the great majority (well over 95%) arrive by plane at one of three sites: Auckland, Christchurch and Wellington. Auckland, with direct flights to Asia, the Americas and Pacific Islands, dominates traffic, while Wellington, with links only to a few Australian cities, plays a small but important role. Setting aside Australia, which is a significant but not dominant generator of visitors, most tourists either visit New Zealand as a solo destination (for 3 to 6 weeks typically) or combine New Zealand with a comprehensive tour including one or more of South East Asia, Australia or the Pacific Islands.

The International Visitor Survey

In terms of identifying the total number of international visitors, and thus having a robust sampling frame for surveying the composition of

Figure 1: New Zealand Context Map

visitor flows, New Zealand is thus in a highly favoured position. Since the late 1980s knowledge of gross flows has been used to collect additional information from international visitors through the *International Visitor Survey* (IVS). This has run annualy, initially with some 4,500 respondents each year and latterly with close to 5,500. This survey has evolved over the years, but the methodology has constantly used an exit survey drawn from known departure patterns, and which has featured the collection of detailed marketing information, trip purpose and respondent (and companion) profiles. It has also collected information on internal activities while in New Zealand, including a sequential record of places where overnight stops were made, and their duration. These data were largely used to record total nights spent at specific locations, but in 1993 the first re-casting of the data was undertaken to illustrate regional flows, which resulted in the publication of a national map of international tourist flows (NZTB 1994). Broken down by categories of visitor and by country of origin, it revealed quite clearly the different travel patterns of visitors originating from different countries in the 1992-1993 survey (Figure 2).

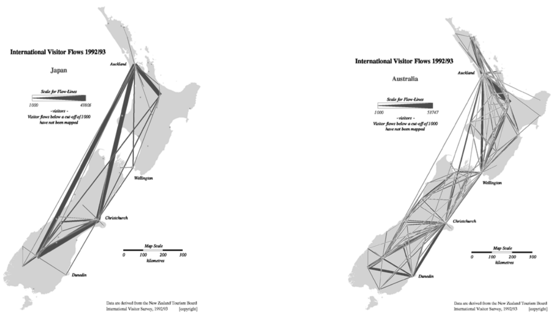

Figure 2: Comparative Flow Patterns, Japanese (left) and Australian (right) visitors. Source NZTB 1994

A knowledge of internal international visitor flows is important for understanding New Zealand tourism, partly because compared to many countries the free independent traveler, and the philosophy of touring holidays rather than single destination ones, are dominant aspects of tourist behaviour and impact. Touring by coach was once a major aspect of these flows (Forer and Pearce 1984), but increasingly car hire and independent and flexible travel behaviour have come to dominate in all but a few markets. The different behaviour of visitors from different markets, revealed by maps such as Figure 2, also gathers significance in terms of relating national marketing effort and focus to issues of regional development and involvement in tourism. For areas such as the West Coast of the South Island, growth in visitors from Australia or Germany, for instance, is worth considerably more than growth from Japan or Korea. These regional patterns also have significance in terms of influencing negative impact on New Zealand's natural assets, particularly the National Parks which have grown in number to fourteen and to constitute over 10% of the national land area. As international tourism numbers have grown consistently to over 1.5 mn in 2000, so concern with the potential impacts of tourism on national parks and other environmental attractions has increased, and answers are sought at the regional and local level rather than the national.

The Domestic Tourism Monitor

However, any significant understanding of impacts will also depend on domestic activity, which had been monitored infrequently from 1970 to 1998. In that year a pilot survey of the domestic sector was undertaken through Lincoln University, and in 1999 a full-fledged *Domestic Tourism Monitor* (DTM) was commenced surveying close to 17,000 people a year by telephone. This retrospectively recorded a single household member's travel patterns in the month prior, including day trips over 40 kms distant and overnight trips. The survey revealed that, in sum, the tourist activity from New Zealand's almost 4 mn residents generated slightly more economic turnover than the international sector, with a very different pattern of demand and trip duration. The DTM has been funded for further years, and it may become a more integrated exercise with the IVS through the design of questionnaires which use a compatible coding framework.

The initial mapping of IVS flows within New Zealand represented not simply a mapping exercise but also the substantial re-modelling of data into a compatible form for deployment within a Geographic Information System. Work by Forer and Oberdries (NZTB 1994) recast the sequential tabulation of destinations into the sectors of the intinerary followed by a particular respondent, largely to allow quick tabulation of flow levels between centres, and to automate flow representation. Researchers at the University of Auckland and Lincoln University extended this process by utilizing innovations in dynamic segmentation and routing that became available in the late 1990s to transform the itineraries into forms which could provide a much wider range of queries about flows and their constituent parts. This development also offered means to allocate tourist flows along specific highway routes (Figure 3), or simply link the itineraries by desire lines, as used in Figure 2.

These developments offered two new areas of enquiry. One was a better and more flexible approach to estimating regional demand as evidenced by tourist visitor numbers within local areas. The other was a greatly enhanced means of querying flows not just by composition but also by time elements, such as who was where on what day of their holiday or where people had been to prior to any specific place. While the limitations of sample size compromised drilling down too far, these data now provided a better means to identify local demand through parameters such as the origin or nature of the visitors. Combined with parallel data sets, such as the New Zealand Accommodation Survey (which records data on visitors in formal accommodation establishments) these data sets now provide a good initial estimate of regional patterns of visitation. They have formed significant inputs into ongoing work on environmental impacts and energy and material flows (Becken et al 2000), and provide a very useful national planning tool.

TOURISM FLOW DATA FOR EVALUATING IMPACT

The insights to be gained from the IVS and DTM have yet to be fully revealed, since there have historically been some technical issues in combining the two, and to date the surveys have been analysed only on an annual tabular basis. However, the two data sets provide a substantial framework for identifying gross patterns of demand and recreational activity. A real issue is whether spatially finer patterns of demand can be revealed either by analyzing these data sets in new ways or by combining them with other data sets.

This question is of relevance to work under way through the TRECC group at Lincoln University and Landcare Crown Research Institute, which is targeted at finding a framework to monitor and assess environmental impacts at various kinds of natural attractions. For specific sites, this work is seeking to develop key indicators of acceptable change for different kinds of attractions. Consequent from this, the research needs to identify the likelihood of unacceptable change in specific areas, which involves identifying specific critical usage levels for specific sites. It particularly requires the prediction of future use regimes so that, hopefully, negative impacts can be pre-empted.

One approach to modeling future impact on attractions is to use a three level model of probable activity levels. National patterns of tourism are now quite well documented, and a number of studies exist that offer predictions of the most volatile element in New Zealand tourism, namely future international demand. These predictions, usually aimed at market analysis, typically offer likely changes of visitor number over the medium term disaggregated by country of origin or some other significant categorization. If sufficient is known about the specific nature of regional activity, then these disaggregated predictions can be propagated through to the regions using the national data sets described above. Such a development gets us some way to forecasting use and impact levels of facilities in an area, but to link the management of local impact to the likely level of demand requires three extra steps. One is a finer level of robust demand measurement, so that smaller (sub)regions can be modeled, and the likely pool of visitors to a local system of attractions can be estimated. A second is a better understanding of the activity that occurs between accommodation stops, since this is typically the active periods in which impact occurs. The last, and most problematic, issue is to link local levels of visitor demand to specific behaviour within local systems of attractions (and thus specific impacts on specific attractions). This paper is concerned only with the first two issues, that centre on how to get a better local understanding of flow-generated local demand within a model that is operating at three spatial scales.

The research described here is experimenting with ways to extend our ability to describe, and to some degree forecast, local sub-regional tourism demand, and then identify its significance for specific categories of sites, and for this it is using small sub-regions on the West Coast of the South Island as a case study area. The West Coast contains large areas that are of high environmental value and sensitivity (including parts of five National Parks and one World Heritage Area). The strategy is to identify likely fluctuations in visitor numbers in sub regions by visitor type, using a recreational opportunity spectrum (ROS) classification, and then as a separate exercise to model within sub-regions how demand growth reflects in use of specific attractions. This structure will be elaborated on later on in this paper, but clearly the IVS and DTM are starting points in trying to identify sub-regional demand. They are also problematic for this purpose for several reasons.

LIMITATIONS WITH THE IVS AND DTM NATIONAL DATA SETS

While the national data sets form a powerful contribution to monitoring, and to some degree predicting, changes in tourist demand (both aggregated and to some degree disaggregated) they have several limitations in respect of being able to make links to actual impact on the ground, and especially to impacts in remote areas such as National Parks. These specifically relate to five aspects of the data sets: spatial resolution, sample size, absence of intervening corridors, absence of specific visitation data and limited local detail of movements.

Spatial Resolution

During its history the IVS has evolved a relatively coarse spatial coding, featuring some 130 points initially and closer to 180 in the 2000 survey. Furthermore the actual places coded have changed over time, so that some have disappeared while others have been amalgamated or added. The coding has generally been undertaken in the light of the respondent's recollection of stops visited, with major destinations such as Rotorua being recorded as a clear node, while unusual or infrequently visited locations have sometimes been amalgamated into somewhat ambiguous areas. By contrast the DTM uses free-response coding of named features at present involving a gazetteer of some 1800 places, all of which are punctiform.

Sample size

Although the surveys involve quite large numbers of respondents, the sample size for any year places limits upon many of the disaggregations that are actually desirable for reporting, whether by attribute classes or by regions. This is usually restricted to defining areas of substantial visitation or population, such as New Zealand's Regional Council areas.

Limited Knowledge of Corridors of Impact

Both the IVS and DTM surveys deal primarily with destinations, rather than routes. In the case of the IVS a destination is an overnight destination, while for the DTM it is that or the main activity centre of a day trip from home. Although the IVS has increasingly sought to capture some additional information on 'significant stops' or side trips from major centres (for instance day trips to Te Anau while based at Queenstown) , there is little explicitly recorded on where people are when they are not in their accommodation centre. Yet with Free Independent Tourists (FITs) the majority of their awake time, and a substantial component of their expenditure or impact, may occur between such stops. Furthermore, the impacts are likely to be close to the road route(s) between the two night stops.

Limited Knowledge of Stopping Patterns

Some of the great attractions of New Zealand, whether in National Parks or not, can be found well away from any accommodation centre. Examples include Cape Reinga, the Northernmost point of New Zealand, and Tane Mahuta, the largest surviving kauri tree, both of which attract large numbers of visitors but are some distance from significant accommodation. Many other more minor attractions influence visitors to stop and walk. Some major attractions, such as the Glaciers in the West Coast of the South Island, are visited by transient visitors while also attracting overnighters. Neither the IVS nor DTM reveals a great deal about such patterns.

Imperfect knowledge of specific route taken.

While knowing the overnight stops for any day may enable one to identify the likely corridor of impacts for a touring visitor, there are many cases where major or minor options may exist for route choice. A significant example is the option for tourists traversing the North Island of passing East or West of Lake Taupo, or similarly passing East or West of the Tongariro National Park. Without some intervening information it is problematic to get a more accurate idea of the likely zones of impact or of activity. This concern is likely to be addressed by better knowledge of where visitors stop, since this will provide key reference points on possible routes

EXTENDED SAMPLING BY SPECIALIST SURVEYS

This section briefly describes two aspects of work that seeks to address some of the shortcomings identified above, using examples from Tai Tokerau, and the West Coast study areas (Figure 1). The intention in both examples is to provide a better description of both where visitors actually travel, and where they can be found at transient stops during the day. The first, on its own, simply provides a better grasp of where potential visitors to natural attractions might be found, rather than any definite indication that they are actually present. The second indicates definite stopping points, and with refinement can even yield details of behaviour at that point (including the nature of any activity and its timing).

Tai Tokerau and the West Coast Surveys

Tai Tokerau (Figure 3) provides the first example, based on project work active in 1998 (SJHMRC 1998,), which was intended to provide better detail of movements in the Northland Peninsula. This area possesses several significant accommodation stops recognized by the IVS, notably Pahia, Russel and the Bay of Islands, but also Whangarei and Kaiataia. Typical IVS records for the area record dominant links from Auckland to the Bay of Island/Pahia/Russell centre, with a few trips to the smaller centres. Although the coding varies by year, it is generally true that few or no movements are recorded on the West side of Northland, if accommodation is used as a measure of movement. Yet the West, with its outstanding kauri forests, and to a lesser degree Cape Reinga in the North, are not only significant loci of tourist activities but are both fragile areas in terms of tourist experience and impact.

To broaden the picture, additional data were gathered to provide better indicators for actual patterns on the ground. These data comprised the outcome from a survey conducted over two 3 week periods of 780 car drivers on holiday. The respondents were approached at a number of parking sites between Whangarei and Pahia and asked about their trip or planned movement, including any night stops and 'significant day stops'. This was not a complete route specification, but the points for each survey could nevertheless be fed into a route building algorithm in ArcInfo to generate multiple itineraries that could then be questioned and aggregated. The points could also be analysed to show a surface of stopping points.

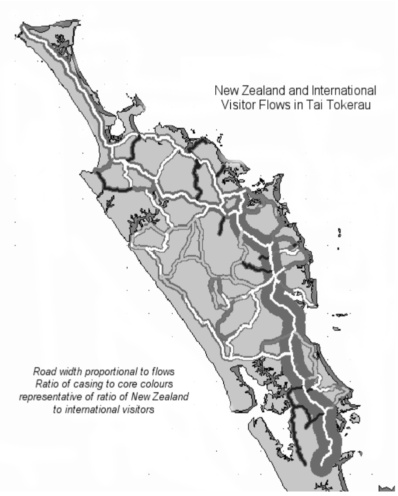

Figure 3a: Flows mapped to road network in Tai Tokerau.

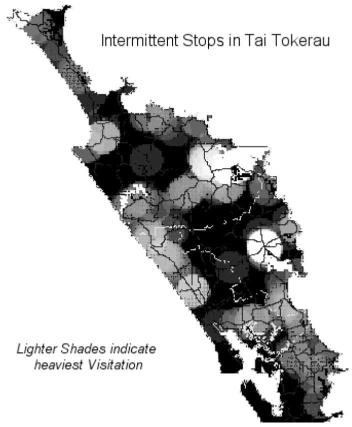

Figure 3b: Patterns of non-overnight stopping

Figure 3a) shows a sample of the route analysis, indicating the level of flows on the West and East Coast, and the nature of the tourists involved.
Figure 3b) shows an example visitation surface. Two useful additional insights to come from this analysis are the documentation of the balance of East versus West Coast flows, including some information on domestic and international visitor ratios, and the significance of totally different areas than overnight accommodation would reveal.

The Tai Tokerau study provided some enhanced information, and a better and more integrated description of spatial demand than the various alternative partial data sets available at the time. It also more than tripled the sample size of visitors available for analysis via the IVS (but closely mirrored its parameters when validated against country of origin from that survey). However, data were missing on the actual activities undertaken at significant stops (and any mention of short stops was also missing). Profile and attitudinal data on respondents was only partial, and timing and duration was not recorded.

The later West Coast study was developed to provide a richer augmentation of the IVS flow data, as well as to specifically address questions of the kind of visitors present and how they might behave, especially in a region where much of the attraction and experience lies in the travel and intermediate stops more than in the major accommodation sites. As figure 4 shows, the West Coast study area is long and thin. It fails to show two things important to understanding travel in the area, however. One is that the Southern Alps form a massive and rugged barrier between the West Coast and the rest of the island, which is breached for vehicular traffic in only three locations. The other is that while there are close to a million visits to the Coast each year, there are barely 30,000 residents, most of whom live in the mid-Northern quarter. Fuller details of this study can be found in Forer, Fairweather and Simmons (2000), but essentially it recorded the travel experience of some 2,700 visitors who holidayed on the West Coast between December 1999 and January 2001. Unlike the Northland exercise full itineraries were requested through either reflective or diary oriented survey instruments, and respondents were asked to record all stops of over 5 minutes including details of timing and the activity undertaken. The intention was to provide enhanced modeling options to augment the more generalized data from the IVS and DTM, and to provide sub-regional demand estimates by tourist category.

The West Coast survey was undertaken over five sample periods between early December 1999 and late January 2001, but the nature of the survey instruments (diary and retrospective) mean that the journeys recorded start as early as October 1999 and end as late as March 2001. During the nine weeks that survey teams were in the field tourists were sampled within the three entry zones to the West Coast, both going in and coming out. Those entering were invited to undertake a diary survey, while those leaving were asked to fill out a questionnaire on the spot. In the end, approximately equal numbers of each instrument were completed, and when compared appear to have performed with equal capabilities, in that comparison of the data from each shows a strong concurrence.

Both instruments collected data on visitor profiles, their attitudes, their overnight stops on the Coast, and intermediate (between accommodation) stops. For intermediate stops information was requested on the arrival time, the duration, the purpose, and food eaten or expenditure made, and any extra transport used (for instance helicopter transport onto ski-fields). While compliance with the request for time data was not complete, a significant amount was provided and considerably more could be inferred. For all stops, of course, location was also requested, both as a name or description and as a point on the A3 map provided with the survey. This process allowed the utmost flexibility in identifying stopping points, which are by nature often serendipitous decisions at various points within natural features such as the 25 km long Buller Gorge. In all some 27,000 stops were identified, over a total of approximately six hundred specific locations. Figure 4 shows the location of these stops with over 5 visits, the relative number of people stopping at each location, the extent of the study area and the location of the three main portals.

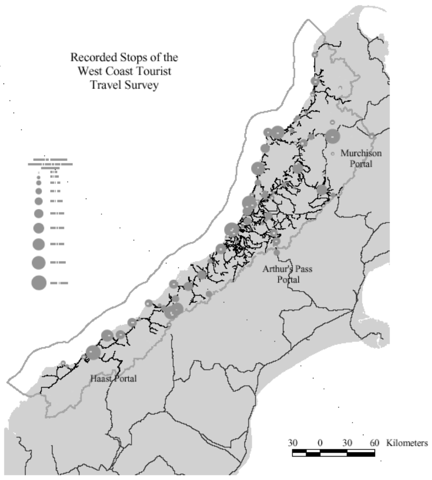

Figure 4: The West Coast Study Area and distribution of respondent's reported stops

What is striking, but hardly unexpected, is that the distribution of tourist stop events shows very limited relationship to the distribution of the population or available accommodation. The anomalous areas can be largely identified as those of outstanding beauty, particularly areas in, or close to, the National Parks. It is the development of better knowledge of the nature and degree of these visitations, in relationship to the trips in which they are embedded, which is a prime goal of the entire survey. It is hypothesized that, as visitors progress up or down the Coast, their stopping behaviour, and on-the-spot activities are very much conditioned by the duration of their total visit to the Coast and by the specific priorities they place on spending time at icon sites as opposed to meandering and diffuse visitations. To explore the influence of these possible factors the analysis of the data is focusing on identifying the way in which visitor patterns at specific locations reflect factors such as geographic position relative to entry point or previous night's accommodation, as well as the attractions at that site and the characteristics of the visitors. The significance of the direction of travel (North to South or vice versa) is also investigated.

The complexity and scope of this data base offers much room for analysis, and work is under way by Zhao to develop various flow-mapping techniques to visualize aspects of the flows and stopping behaviour at different scales of aggregation from the individual itinerary upwards. This is complemented by Chan and Chen's investigation of the influence of certain factors on revealed patterns of trips (Chan and Chen 2001). They have specifically reviewed ways in which length of trip, country of origin or entry point affect the pattern of stops, although as yet the interaction between these factors has not been investigated. One interesting finding however is the tendency for Northward travelers to stop less frequently and stay less long than South-bound ones. Whether this is due to the 'returning traveler' syndrome, i.e. most such trips represent the start of the journey to Auckland or Christchurch and then home, or due to timing issues is still to be clarified.

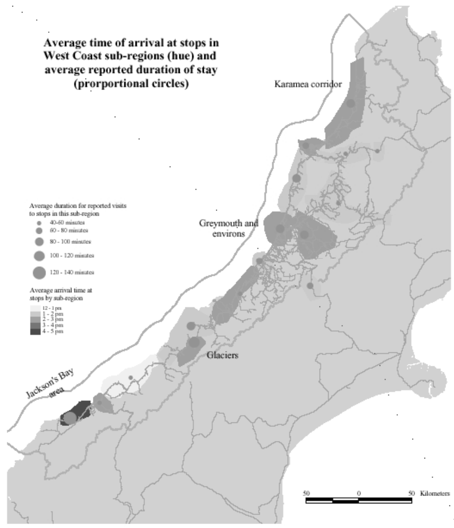

Figure 5: Temporal Aspects of West Coast Flows, showing proposed sub-regional demand zones

Investigations of individual movements using the most fine spatial scale available, however, are not directly useful for sub-regional forecasts, where more aggregate information is needed, particularly on how long tourists typically spend in an area, and incidentally when they arrive. Figure 5 shows some initial analysis of the full data set in terms of a set of sub-regions that are being considered for ongoing modeling. These divide the West Coast into 19 regions (not all are shown here) which include the main settlements and their immediate environment (such as Westport and Greymouth), icon sites (such as Punakaiki and the Glaciers), back country zones, and corridors (such as South Westland and the Buller Gorge). The map illustrates the average time of arrival at stops in these areas, but also the average time spent at sites within the areas (not including overnight stays). The role of Haast/Jackson's Bay as a significant stop, but also as an 'anchor' to people's days, is clear, as is the influence of Karamea's isolated position in the North.

When compared with figure 4, the prevalence of multiple, short stops in many of the less inhabited areas is quite clear. The next stage of work is targeted at mapping in more detail the patterns of stops relative to visitor and trip characteristics, and to assessing at what scale regions exist with adequate sample sizes to allow useful additional modeling.

The Tai Tokerau and West Coast surveys both represent relatively simple flow systems, largely linear and with limited access. It is hoped that they can yield more insights into basic flow behaviour governing intermittent stopping and route selection on a wider scale. Certain regularities, such as stopping frequency or propensity to stop after specific time lengths, may then be applicable to national movements and activities. More complex flow situations certainly exist, of which Rotorua is perhaps the best example. It is the major North Island tourist centre, with diverse markets amongst both domestic and international visitors, and it is position astride a wide web of flows that come to the area from all directions. A data set collected for Rotorua is to be the test bed for validating findings from the West Coast.

LIMITATIONS AND OPPORTUNITIES FOR LOCAL SURVEYS AS ADJUNCTS TO NATIONAL DATA SETS

This paper has discussed the IVS and DTM as national data sets which can be given added value by integration with surveys of finer detail, and it should also acknowledge the value of the national sets in validating the sampling of local surveys. While the IVS and DTM enjoy stable sampling frames, most local surveys are faced by well known practical problems of maintaining a constant sampling fractions with interviews, as well as weighting problems with establishing just what the extent is of the universe of flows which they are sampling. In New Zealand several additional sources useful for data validation exist. The national monthly census of accommodation usage was referred to earlier, and it assists with establishing total raw numbers of visitors as well as a quarterly breakdown by origin of them. Other data include traffic flow counts, car registration owner details, and attraction visitation numbers from the Department of Conservation, all of which provide an guides to the validity of sampled patterns. These different data sets have different spatial and temporal granularity, and different properties and precision, but together they provide a reasonable confirmatory web of cross references.

The other major issues with local surveys are compliance and cost. Concern for both restrict the information collected, and an additional aspect of the survey work to date is an analysis of the specific benefits accruing from specific questions and techniques relative to their cost of capture.

SIGNIFICANCE OF LOCAL FLOW SURVEYS AND FUTURE DIRECTIONS

The local flow surveys described here are part of a much wider research agenda in tourism flows, and in human movement and environmental interaction. They have been presented as a way to address the issues of calculating small area tourism demand, and the nature of places in regional tourist circuits. At a wider scale, they also offer a better insight into how active FITs allocate the substantial portion of their time, and significant portion of their expenditure, that is not spent in 'destination/ overnight' centres. There are substantial aspects of regional development, facility development and tourism demand management which are better understood when patterns of sequential flows are acknowledged. Related work has pointed out the potential value of a better understanding of issues in health and bio-security that can come from a knowledge of flows, and the work by Beken (2000) to link flows to energy and material impacts on the environment offers a topical perspective on how tourism affects the triple bottom line. Future work will address how flows can be interpreted into a classification of linear landscape experiences.

While the research agenda for flow analysis is attractive, at both micro, meso and national level, data capture remains a major barrier. Two trends offer hopes of cheaper and better ways to capture movement data. One is the growing interest in time geography, 'tracks' and the (x,y,t,a) trace (CSISS 2001), which might well offer new analytical tools and insights. The other is use of new technologies, specifically position aware devices (PADs), which are becoming far more commonplace, and intelligent map-server based Web questionnaires that ease the burden of personal data collection of space-time data (Glen, Huisman and Forer 2001).

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Conference Proceedings ed by A. Arnberger, C. Brandenburg, A. Muhar 2002, pages 180-186

Deriving Artificial Models of Visitors From Dispersed Patterns of Use in Sierra Nevada Wilderness

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Abstract: Natural resource managers are faced with a complex problem of understanding human use patterns and associated impacts in dispersed recreation wilderness settings. This is further complicated by the subsequent synthesis and modeling of those behaviors that affect such patterns of use. While conventional approaches to modeling have limited use in acquiring and understanding such complex associations, spatial simulation models have been proposed as an alternative. The purpose of this paper is to describe a project whose focus is on a dispersed recreation context of backpacking trips and commercial packstock operations in the John Muir Wilderness in the Sierra Nevada Mountains in California. This paper will discuss the data collection and synthesis to derive agent profiles and rules as a precursor to the development of a dynamic, agent based model that represent the spatial distribution of visitation patterns.

INTRODUCTION

Backcountry use from both packstock outfitters and backpackers in the John Muir and Ansel Adams wilderness areas of the Inyo National Forest is an excellent example of how increasing human uses impact a sensitive, dynamic ecosystem and threaten to degrade the quality of experience of human visitors. Over 21,000 permits are granted every season to individuals and guides to travel through sections of the Inyo National Forest. While packstock trips have been a permitted use of the wilderness areas for many years, concerns over both the environmental and social impacts have been raised. More importantly to this study are the interactions of packstock with visitors. Packstock have been shown to influence a visitor's wilderness experience by introducing smells, sounds, and sights that conflict or accord with their wilderness values (McClaren et al., 1993).

Studies by (Lucus, 1980) have clearly demonstrated that the progress of individual trips is affected by interactions with packstock and other hiking parties, and there is a general assumption (based on early research) that encounters degrade the 'wilderness character' of the trip, and that they have adverse effects on the quality of experience for individual visitors.

In (McClaren et al., 1993) they conclude that not only monitoring and management should focus on impacts of packstock use, but that visitors should be informed of what to expect in specific areas, and where they might travel to avoid unsatisfactory experiences, such as packstock encounters. The problem is that very little is known about how to predict or control the numbers of encounters (except generally to limit the number of people/packstock parties along the trails), or whether all encounters are alike regardless of the types of parties involved, the locations on the trail and campsites and the contexts in which they occur. In addition, pressures from the public and from commercial outfitters are increasing; demand for more wilderness trips is very high. The effects of increasing trips or altering schedules are difficult to predict or evaluate due to the complexity of the variables involved, and the ambiguity about what factors affect the quality of the wilderness experience and/or the levels of adverse impacts on the wilderness environment. Environmental impacts at popular camping sites are already of great concern to the forest.

Backcountry use of the Inyo National Forest presents a number of complex human-environment interaction problems; large numbers of visitors and commercial operations seek activities and experiences that depend upon the unique environment of the Inyo National Forest; quality of the wilderness experience is affected by the participants' personal characteristics (abilities and intentions), by perceptions of and responses to features of the wilderness landscape, and by perception of and responses to encounters with other recreationists in the wilderness; and individual and cumulative impacts of recreation activities threaten the fragile forest environmentDecision makers and natural resource managers recognize the need for baseline visitor use data and more sophisticated tools to help them understand the human-environment interactions in the wilderness, and to effectively respond to their mandate to manage this unique environment and the highly valued human experiences it supports. While techniques have been available to managers to guide recreation management such as the Recreation Opportunity Spectrum (ROS) and Limits of Acceptable Change (LAC), limited use of computer simulation models have been employed to resolve such complex human/landscape problems. Studies such as those by (Hull & Stewart, 1992) have shown that time, and space (location), have a profound effect on levels of encounters, perceived crowding, and satisfaction and associated recreation impacts. It is surprising that computer simulation has not been more extensively used.

Computer simulation is not a new concept in studying natural processes and in particular recreation. Models such as the Wilderness Use Simulation Model (WSUM) (Shechter & Lucus 1978) have been available to assist natural resource managers in assessing wilderness use by recreationists. The simulator was developed and successfully tested in both Spanish Peaks Primitive Area in Montana (Smith et al., 1976) and the Desolution Wilderness in California (Smith et al., 1976) and subsequently modified for river recreation management for use on the Green and Yampa Rivers in Dinosaur National Monument (McCool, Lime and Anderson, 1977) and the Colorado River in the Grand Canyon (Underhill et al., 1986). This simulation tool provided a reliable way to examine both perceived and actual encounters along the trails and rivers. It seemed particularly useful as an aid to river recreation planning and management for conducting tests of a variety of alternative policies. These models while ahead of their time suffered from ease in interpreting outputs of the model and depended heavily on field observers to supply visitor use information as input into the model.

Work by (Wang and Manning, 1989) and others have used dynamic modeling frameworks such as Extend to model recreation use in national park settings with success. While these frameworks are useful in modeling relatively homogeneous and “lumped” phenomena, they are not so easily applied to highly variable spatial phenomena. In addition, this work heavily relies on observers, capturing data about perceived use and numbers of visitors in various settings.

To improve a manager’s ability to more effectively understand highly variable spatial phenomena such the distribution of visitors in a wilderness setting, researchers have been exploring the use of agent-based modeling. This contemporary approach to modeling moves away from the mix master universe of homogeneous populations down to modeling the individual. Although potentially computationally expensive, such flexibility provides a mechanism to represent many types of entities that embody variability within them selves. For example, such agents may represent individual visitors or vehicles. A predetermined set of rules, attributes and behaviors are applied to individual agents that motivate their desire to move through the landscape. Example personalities include backcountry hiker, motoring tourist or mountain biker. In order to provide input into agent-based models that attempts to mimic visitors and their associated behaviors in a local setting, studies must be conducted in the field to capture this baseline data.

Researchers such as (Daniel & Gimblett, 2000; Gimblett et al., 2000); Itami et al., 2000) and others have been exploring the use of agent simulations integrated with a Geographic Information System (GIS) that are designed to be used as a general management evaluation tools for any recreation setting. In these simulations, resource managers can explore the consequences of change to one or more variables so that the quality of visitor experience is maintained or improved. The simulation model generates statistical measures of visitor experience to document the performance of any given management scenario. Management scenarios are saved in a database so they can be reviewed and revised. All of these simulation efforts provide information on current and future conditions so park managers can identify points of over crowding, bottle necks in circulation systems, and conflicts between different user groups. All this with the hopes of more effective visitor management with the added benefit of improved monitoring and data collection methodologies.

While all of the simulation efforts mentioned above have been developed for a variety of purposes, all have resulted in varying degrees of success. In fact it can be said that because these models provide such sophisticated ways to model spatial phenomena, their utility is only inhibited by our ability to collect meaningful spatial/temporal data about visitors in complex wilderness landscapes. The challenge to researchers and resource managers alike is to develop methods to collect spatial/temporal data about visitor use patterns that is reliable, statistically valid and defensible. This information while providing resource managers with information critical to managing visitor use can alternatively be used as input to such models as described above. It is the challenge of valid, defensible data that is the impetus for this paper. Itami in these proceedings will describe the agent-modeling framework and it’s various measures and outputs.

This paper focuses on exploring a methodology for understanding the spatial and temporal patterns of dispersed recreation in the context of backpacking trips, and commercial packstock operations in the John Muir Wilderness in the Sierra Nevada Mountains in California. Herein is discussed the data collection and statistical synthesis to characterize wilderness visitors from which could be derived agent profiles and rules that will be used in the development of an agent-based model representing the spatial distribution of visitation patterns.

METHODS

Conventional survey and interview methodologies used to characterize the recreation experience have yielded useful information about the visitor. While this information is important to understanding the general profile of visitors to a region, it does little to enhance our understanding of the spatial/temporal distribution of a visitor and their associated social and ecological impacts in the landscape. Managers require information on the spatial nature of the visitor to adequately manage for both the experience and to protect the recreation setting. This information includes the destination, arrival and departure times, number of visitors in a party, type of activity, nights camping etc. These spatial dynamic parameters likewise are imperative for constructing models to represent current conditions and testing out future management scenarios to reduce social and ecological impacts in a setting.

Some have attempted over the years to collect such data in wilderness settings. Researchers such as (Lucus & Kovalilcky, 1981) conclude in their study that the most accurate wilderness use data come from a self-issued, mandatory permit systems. This method can be one of the most effective ways for understanding recreational use in most wilderness areas. While compliance varies from wilderness to wilderness (Lucus et al., 1981) found that mandatory permit systems far outweigh trail registers or other forms of data collection. While observing a sample of trailheads on sample days produces accurate estimates of those entering the wilderness, it is labor and time intensive and tends to lead to a limited sample. Other wilderness areas have gone to agency-issued permits. While having some disadvantages such as inconveniencing the visitor and expensive to manage, this system does provide a mechanism for ensuring the visitor comes in to the agency office to pick up the permit and provide information about where they plan to go. While each of these methods has its advantages and disadvantages, the sampling methodology in this study employs a combination of techniques for acquiring an accurate, representative sample of both spatial and temporal use patterns in wilderness settings.

This study utilizes a map diary approach that is distributed to each visitor when they pick up their agency-issued permit. The diary consists of a space to capture basic trip characteristic data, a map of trails and natural features, a brief set of questions on visitor satisfaction and instructions on how to record and denote a spatial location of the types of encounters, numbers of those encountered and nightly campsite locations (See Figures 1 & 2). Data that was essential to this study was duration of visit, number in party, type of activity and spatial location of trailhead, physical encounters with other parties, type and numbers and nightly destinations (ie. campsites). In addition to being given out to all permittees, the diary is distributed at each trailhead as part of a self-administered system and hand delivered to all commercial packstock operators with instructions on how to distribute to their clientele and return to the research team.

The map diary can be dropped off at the FS station upon completion of the trip, or mailed back in self-addressed envelopes provided. While compliance is an issue with this type of distribution method, issuing the map diary with the permit provides numbers on total distribution size and when comparing to those returned, a compliance rate can easily be computed.

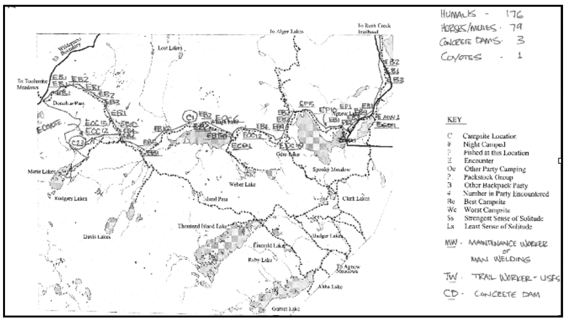

Figure 1 - An Example of the inside of the map diary used to capture overnight use

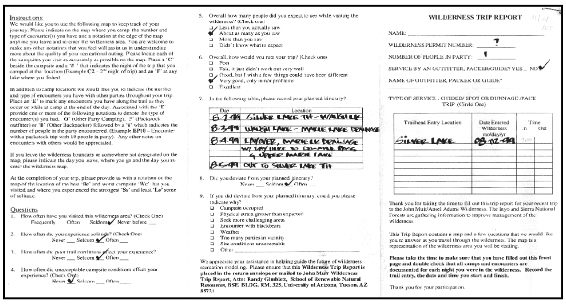

Figure 2 - An Example of the outside of the map diary used to capture overnight use

In addition, summer students randomly sampled each of the trailheads, spending days observing visitors entering the wilderness and stopping visitors to ensure they had a map diary in hand and urged others to deposit them in the return box or collected them directly from the visitor.

In May 1999, a study was undertaken to collect spatial/temporal data in nine different study areas in both the east and west sides of the Sierras. This included 3 areas of east/west complexity- Humphrey's basin, Mono Creek, and Silver Divide; and 6 areas of moderate use levels Ansel Adams West, Agnew Meadows, Cottonwood Lakes, North Fork Lone Pine, North Fork Big Pine and Rush Creek. The latter were of interest for understanding the extent of visitor use concentration in moderately used and complex areas. The primary driver of the study was the need to augment current use data for the management planning. Adequate data existed on levels of use by entry acquired by observation and permits, but assessments on distribution, congestion points, or patterns of use, encounters etc. were not confidently known, particularly the influences of east and west side entry into the large and topographically complex interior.

Secondarily, there was a desire to integrate resource data with patterns derived from the visitor use data as a mechanism for developing and evaluating management techniques. This also seemed to be a critical set of information in evaluating risks. Identifying areas of potential congestion in combination with visitor use impact data such as campsite conditions, trail use, or trail conditions, or relevant resource information on TEPS (threatened, endangered, petitioned or sensitive) species habitats, populations or potential habitats, provides decision makers with reasonable information for evaluating consequences of management actions.

Upon receiving the map diaries, all point locations denoting encounters etc. were entered into a spatial database for further analysis and all other data characterizing the party were entered into an electronic relational database. Both of these sets of data were interchangeable allowing both spatial and/or relational analysis of the data. ARC View 3.1 with the spatial analyst extension and Microsoft's database ACCESS was used in this study. Information entered into the database included:

RESULTS FROM VISITOR DATA COLLECTION

Figure 3 provides an illustration of the overall compliance rates in the nine wilderness areas studied in 1999. The highest return rate was from the Mono Creek wilderness area at 44.7% survey return. The lowest was from the Rush Creek area, with a survey return rate of only 16.1%. A the right hand side of Figure 3 can be seen a summary of the return rates as measured against the number of permits issued for the nine wilderness areas. Of the total permits issued (n=5467) for 1999 in the nine wilderness areas studied, (n=1371) or 25% complete and useful trip diaries were returned and entered into the database. While by conventional survey standards this may appear low, for wilderness areas and using this non-mandatory survey technique, 25% is considered a statistically representative sample.

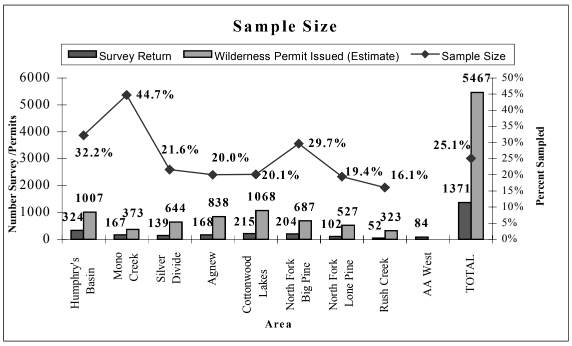

Figure 3 - Return Rate on Map Diary for all Wilderness Areas Studied

While the relational database does not provide information on the major destinations of each party, queries can be made to acquire a better understanding of the typical number of visitors per party entering and the total numbers in each of the wilderness areas. Table 1 describes the range of party sizes in each of the wilderness areas, the number of parties taking trips into each area, and the percentage of visitors visiting each area compared to the total number of visitors utilizing the wilderness in 1999.

Area	Mean # Party	# of Parties	% of Parties	Total # of Visit	% of Visits
Total	3	1455	----	4465	----
AA	4	84	5.8 %	331	7.4 %
Ag	3	168	11.5 %	538	12.0%
CL	3	215	14.8 %	646	14.5%
H	3	324	22.3 %	966	22.3%
MC	3	167	11.5 %	550	12.3 %
NFBP	3	204	14.0 %	549	12.3 %
NFLP	3	102	7.0 %	284	6.4 %
RC	3	52	3.6 %	173	3.9 %
SD	3	139	9.5 %	428	9.6 %

Table 1 – Visitors Utilizing the Nine Wilderness Areas in 1999.

The range of party size for all the areas was from (n=1 to n=15) visitors per party. In fact, there was only one area that did not have a maximum party number of (n=15). The North Fork Lone Pine recorded a maximum party size of nine. The largest mean party number came from the Ansel Adams West wilderness area with a value of four. However, this area only accounted for 5.8% of the total trips taken in 1999. There were a total of (n=4465) visitors entering all the wilderness areas that were captured in this study.

Humphrey's Basin was the most heavily used area during the 1999 season. Trips taken into the Humphrey's Basin area captured in this study totaled (n= 324) or (22.3% of the total). This, in turn, also made Humphrey's Basin the area that contributed the highest number of visitors (n=966) or 22.3% visiting all the wilderness areas in 1999. Figure 4 illustrates the tremendous increase in trips taken to the Humphrey's Basin wilderness area from mid-July to mid-September.

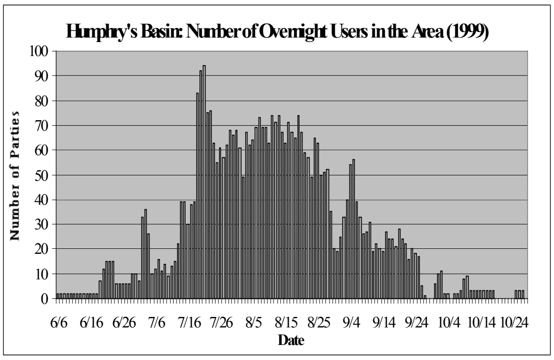

Figure 4 – Humphrey's Basin Visitor Statistics

Figure 4 provides some inside for Inyo National Forest managers are to the peak periods of use in the wilderness area. Snow pack usually limits access to the backcountry with the typical visitation periods ranging from Early June thru the beginning of October. The number of parties visiting the area increases from around 10 in early July to almost 100 toward the end of July. This number drops a little at the end of July, but is consistently above 60 parties through August when it drops through September and even more into October. Visitor information is particularly useful to managers as they can easily see that the season of visitation is short and intense in many areas. This information (percentage and intensity of use) coupled with the spatial data (destinations, duration of visit and encounter rates) provides needed information to focus management and construct policies to reduce impacts in each of the areas.

SPATIAL DATA INFORMATION ABOUT VISITOR DISTRIBUTION

One of the advantages of using a diary approach to acquire information on the spatial distribution of visitation is that once compiled the information can be visualized in many forms. For example, information about individual parties can be displayed, total number of parties summarized per locale or destination, the location of each night camped and in particular the spatial location, identity and number of reported encounters with other parties. Each trip can be dissected to observe not just the patterns of use, but assessed to identify and characterize typical types of trips that utilize the backcountry. Such as two party trips that camp in areas absent of others, typically seeking solitude and spend a minimum of five days in the backcountry. While this may seem logical, it provides valuable information to the manager as to the typical visitor that frequents specific locales and provides information that can be used in the agent-based simulations to develop virtual agents that are representative of their human counterparts.

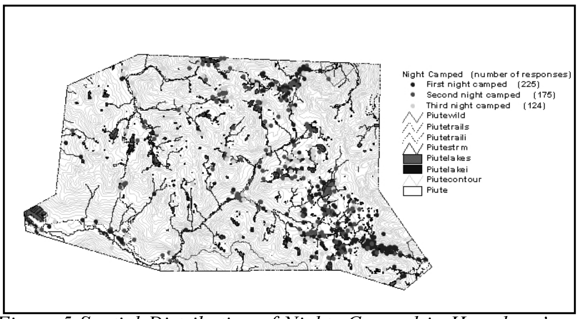

Figure 5 Spatial Distribution of Nights Camped in Humphrey's Basin

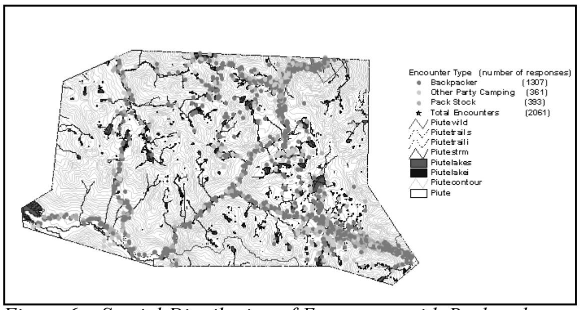

Figure 6 – Spatial Distribution of Encounters with Backpackers, Packstock and Other Parties Camping in Humphrey's Basin

Figure 1 seen previously is an example of a typical diary returned in 1999. As noted on the map, C1 indicates the location of first night camped followed by, C2, 3 where the party spent the second and third nights. The 'E' marking followed by 'B' and a number such as two indicates that this party had an encounter with another backpacking party that consisted of two. Four variables on the map serve as a measure the parties degree of satisfaction. These measures are documented on the map as Ss and Ls (Strong and Least sense of Solitude) and Bc and Wc (Best and Worst campsite). Once all diaries are compiled with this type of spatial information, areas of high concentrations of visitors can be discovered, potential conflicts between and within recreation use groups and correlated with recreation impact data can provide insight into opportunities for creative management. Figures 5 & 6 are examples of this type of output. For example, figure 5 illustrates the patterns of 1st, 2nd and 3rd nights camped in the Humphrey's basin. Aside from tight clustering of campsite nights this type of spatial information illustrates the age-old hypothesis that backcountry visitors typically camp near trails. Visitors in Humphrey's basin tend not to stray far from the trails and logically camp near high elevation lake destinations.

Trip Type	Responses	Tot.Responses
Guided	n=0	0%
Spot	n=15	1%
Dunnage	n=42	3%
pack trip	n=219	15%
backpackers	n=1179	81%
Total n for 1999	1455	
Party Size	**Responses**	
1-2 visitors	n=1032	71%
3-5 visitors	n=237	16%
6+ visitors	n=186	13%
Total n for 1999	1455	
Trip Duration	**Responses**	
1-2 days	n=961	66%
3-4 days	n=231	16%
5+ days	n=263	18%
Total n for 1999	1455	

Table 2 – Summary of Visitor in Cluster Analysis

Figure 6 illustrates the spatial distribution of encounters with backpackers, packstock and other parties camping in Humphrey's Basin. It is clear from the spatial information that there are considerable numbers of encounters with stock along the trails and at specific locations. As is true of other backpackers frequenting the backcountry. While this analysis says nothing about the quality of the encounters it does indicate the spatial patterns along the trails and at destinations where and how many per party intercept each other. This analysis provides three important sources of information to the manager. First it provides information on locations where one would expect to find varying degrees of use patterns in the backcountry. Second, it provides information on where more detailed monitoring should occur to examine both social and ecological conditions. This would include both conflicts between and within recreation activities and their associated impacts. Finally, the mapped information coupled with the information gathered about the typical trips provides a more accurately way to characterize the behaviors of visitors using the backcountry.

DERIVING VISITOR PROFILES FOR CHARACTERIZING AGENTS

The information provided by the diary has immediate value to the manager for understanding spatial use patterns of their management settings. In addition, this information is valuable in characterizing the visitor and their associate behavior. To do so this study utilized analytical procedures on the visitor information to determine statistically characterize and derive typical groups/visitor profiles. This information will be used in the future in agent-based models for simulation alternative management scenarios. A visitor profile is a combination of information, both categorical and quantitative, to describe the wilderness trip, visitor, and length of

trip. In other words, it is a way of simplifying a wilderness experience surveys into a few groups of similar features.

Data used for statistically deriving visitor profiles for characterizing agents were number in party, type of trip (commercial/non –commercial), and trip duration. Trip duration was not a direct question asked on the survey. It was calculated by computing the difference between the entry and exit dates logged on the surveys. Over the twelve-month survey in 1999, 1455 trips were sampled in the John Muir and Ansel Adams Wilderness areas. K-Means Cluster analysis was performed to combine the trips into groups of similar party size, trip type, and trip duration. In terms of party size, out of the (n=1455) trips surveyed, (n=1032), 71% were classified as 1-2 visitor parties. Out of the same number of surveys, (n=1179), 81% were classified as backpackers, and (n=961), 66% were trips of 1-2 days in length (See Table 2)

Summarized in Table 3 are the results of the K-Means Cluster analysis run on each of the nine wilderness areas in the Ansel Adams and John Muir Wilderness Areas. This analysis was undertaken to statistically aggregate trips according to party size, trip type, and trip duration. The cluster analysis for each of the wilderness areas were aggregated down to three statistically significant clusters that represent all trips documented in the data base. These clusters are represented in Table 3 and depicted are Group 1 thru 3. Each group consisted of a coding based on the three variable entered into the cluster analysis ie. number in party, trip type and duration of visit. For example, after running the cluster analysis for Humphrey's Basin and aggregated to three clusters or group types. The first statistically significant cluster consists of the numbers 2,5,2 which represents two visitors in the party, backpackers and spending a total of two nights in the backcountry.

Area	Mean # Party	# of Parties	% of Parties	Total # of Visit	% of Visits
Total	3	1455	----	4465	----
AA	4	84	5.8 %	331	7.4 %
Ag	3	168	11.5 %	538	12.0%
CL	3	215	14.8 %	646	14.5%
H	3	324	22.3 %	966	22.3%
MC	3	167	11.5 %	550	12.3 %
NFBP	3	204	14.0 %	549	12.3 %
NFLP	3	102	7.0 %	284	6.4 %
RC	3	52	3.6 %	173	3.9 %
SD	3	139	9.5 %	428	9.6 %

Table 3 – K-Means Cluster Analysis Summary

Cluster 2 is represented by eight visitors per party, being serviced by a packstation, and on a four-day trip. Finally Cluster 3 is a three visitor party, backpackers and duration

An analysis of trips across all wilderness areas studied reveals that 65% of all visits to the wilderness areas can be accounted for by two person parties on backpack trips, typically spending two days. This is an interesting result considering the perceived need for increased commercial use in many wilderness settings.

From the cluster analysis it can clearly be seen that visitors can be aggregated into groups that share common trip characteristics in wilderness areas tested. Discussed earlier in this paper was the idea of using visitors as surrogates for agent-based simulations for developing and testing out management scenarios. While the simulations have not been discussed in this paper, Table 3 provides statistically significant information that could be used to characterize agents based on trip type, number in the party and trip duration. These three variables say little about visitor satisfaction or even preferences for recreation settings, but results of this study do suggest consistency in the patterns in which the backcountry is explored. More research obviously needs to be undertaken to tease out more salient factors that effect behavior in these settings from which rules could be develop for the agent-based simulations.

CONCLUSION

This purpose of this paper was to develop a methodology for acquiring data on dispersed recreation in the John Muir Wilderness in the Sierra Nevada Mountains. Results of this study clearly illustrate that reliable and valid sampling can be used to obtain representative information from visitors reporting information about their trips in the nine different wilderness areas in the Sierras. Further this paper has presented the case for collecting spatial/temporal data about visitor use patterns in wilderness settings. This information not only can aid managers to better understand both social and ecological impacts in their respective settings, it can alternatively be synthesized to characterize wilderness visitors as surrogates for agent-based simulations. Agent-based simulations are exploratory, but as discussed earlier in this paper have produced excellent results in evaluating management actions. Finally using spatial/temporal information collected in the field coupled with agent-based modeling techniques reveals where varying degrees of use patterns exist and can serve to direct managers to these areas resulting in more cost effective methods for long term monitoring of visitor use patterns.

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Conference Proceedings ed by A. Arnberger, C. Brandenburg, A. Muhar 2002, pages 187-190

Simulating Visitors' Dispersion in a Nature Reserve based on a Friction Model

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Abstract: A friction model is used for predicting the risk of human penetration of fragile vegetation and bird breeding sites in a nature reserve in central Belgium. The basic components of the study are the terrain classification and the determination of friction values. Different sets of friction values are proposed: based on expert estimation, on walking speed, on energy consumption estimation and on willingness to trespass. The results are compared with spatial data derived from visitor's observations and interviews. The model is to be improved in a later stage by incorporating the effects of visitor's goals, and of attractors and detractors such as vistas, free roaming cattle or physical challenges. The outcome of this study will be used as basis for the evaluation, and eventually of the redesign, of the current management decisions provided in and around the reserve. Also it should help in following-up the effects of the rapidly changing vegetation and terrain conditions on the behaviour of visitors.

INTRODUCTION

The policy concerning nature conservation is rapidly changing in Flanders (northern region of Belgium). New reserves are being established, often in former extensive agricultural areas. More and more it is being realised that nature protection has to be backed by co-existing functions such as extensive recreation: nature conservation needs continuous and increased official and public support.

The "Demerbroeken" (marshes of the river Demer) is a typical example of a wetland area, formerly used for hay cultivation and later for poplar growing, now being reverted into a mosaic of restored wet hayfields, willow groves, extensive grazing fields, and ponds. The site is situated about 45 km east of Brussels. It retains a multifunctional character, since it not only is a nature reserve, but also a site popular for walking and a floodplain. Apart from a hill at one of the site corners, the whole site is flat. In this study a part of the site of 100 ha is being studied in detail.

The managers have great concern for maintaining an equilibrium between opening up the site for the general public and the protection of fragile parts such as quaking fen (floating organic mats) and bird breeding sites. The whole site is surrounded by habitation area and the general accessibility in the terrain is rather high.

Since it is not the intention to implement hard measures such as fencing off the reserve, which would detract from the overall site value, the central question is how to confine visits to the robust parts of the landscape through the layout of tracks and specific inconspicuous management practices such as selective mowing and discrete boarding.

The intensity of visits is too low and the site too complex and too large to develop on short time a map on visitor's distribution based on systematic observations or enquiries. Therefore an alternative approach is proposed, which uses a GIS based friction model that enables to calculate potential visit intensities at any part of the site, from specified site entrances. The method should terminate in a design and management tool, allowing among other to assess the impact of changes in the infrastructure, season effects or management practices on the distribution pattern of visitors.

This study was started up only a few months ago, and no final results, let alone validations and practical applications can be shown. Therefore, this paper will concentrate on the methodological aspects in the first place.

METHODS AND TECHNIQUES

There are essentially four methodological parts: the definition of a baseline terrain classification, the estimation of parameters concerning people's preferences and activities in the terrain, the selection of a movement model and the interpretation and validation of the results.

Baseline site information

Aerial orthophotographs from the systematic aerial recording over Flanders in the period 1997-2000 were used for demarcating the habitats of the study area. The term habitat is used here as a vegetation unit with homogeneous structural characteristics such as dominant species (e.g. reed) or species groups (e.g. grass and sedges) canopy height, density, soil conditions, microtopography

Figure 3. Study area: Demerbroeken (Zichem, Belgium). Habitats are depicted in a greyscale with increasing trespass resistance from pale grey to black. Circles symbolise entrances. This site fragment is about 1 km in W-E transect.

etc. These are the characteristics that are supposed to be the conspicuous determinants of people's behaviour and movement choices in the terrain. The air photo interpretation is followed by and corrected through field survey. In the field survey a careful mapping, supported by GPS, of all tracks and paths was made, as well as of ditches, fences, dams, information boards, benches and other elements that have an impact on movements in the site. The tracks are also classified in terms of width, vegetation cover, roughness of the surface, wetness conditions and lateral vegetation. All these elements are put into GIS format using ArcView and consequently gridded to 1m resolution. Care is given to preservation of object connectivity in the grid format, especially for linear objects such as tracks and fences.

Visitors observations and enquiries

This study aims at making an estimation of the trespassing probabilities in any part of the site. Unlike in city parks of urban forests, the density of visitors in the Demer marshes is rather low and irregularly distributed over the year. Therefore it is impossible to establish a visitors density map based on field observation alone. A more indirect approach is based on an enquiry of groups of people invited to visit the site. At the moment of the submission of this paper, 25 people have been requested to indicate on continuous scales a) their preference judgement concerning preselected sites, b) their preference concerning moving in certain directions, c) their estimation of effort needed to move along certain directions throughout certain types of terrain. In addition to visitors enquiries, the terrain managers themselves were asked to express the different terrain types in terms of walking resistance. These values have been used provisionally as reference.

Friction model

The whole site is being interpreted as a continuous area with varied penetrability. The perimeter of the site is considered as an impenetrable edge but for discrete entrances. An isotropic negative growth model is applied, based on the following formula:

$$N_{i+1} = N_i - U*R_{i/i+1}$$

whereby Ni is a residual amount of "energy" in pixel i, U is a fixed unit "energy" that is lost in each transition from pixel i to pixel i+1 and $R_{i/i+1}$ is a resistance or friction factor that is taken into account in the transition from position i to i+1. The "energy" is given as a "start package" to selected objects, in this case the entrances of the site. This energy principle can be alternatively interpreted: effective energy, number of people, walking apparel quality, etc. The formula is being applied isotropically throughout the landscape until exhaust level. Each pixel of the landscape is being reached through a virtually unlimited set of pathways reaching the pixel from different possible orientations. The energy unit along the horizontal or vertical direction in the grid is fixed at 338 for calculation and memory economy in using integer values. The corresponding energy unit for the longer diagonal moves in the grid is 478. Using these two integers, a rounding error of only 0,004 is allowed in the calculations. The lowest resistance value is 1. The initial energy package set at the entrances of the site can be adjusted so as to correspond to the maximal reachable distance in case of overall resistances of 1. The set of friction values assigned to the different terrain classes should correspond to the effective resistances experienced, compared to the lowest resistance terrain conditions of 1, e.g. a flat asphalt road. The resistance values can be defined in different ways: physical walking energy consumption, traversing time, or willingness to traverse different terrain types. The programme used (CONNEC) is basically similar to cost-friction models in several commercial GIS packages, but has some additional possibilities, such as calculating cumulative accessibility, or calculating "walk-sheds" (areas of unique walking origin). The friction model was applied earlier in a project concerning biological connectivity in fragmented cultural landscapes for several species (Villalba et al., 1998; De Genst et al., 2001).

RESULTS

The establishment of resistance value series

Resistance values, defined according to the key expert, are put in a scale 1-100. 100 corresponds to the resistance of a thick reed vegetation. Fig. 2 compares the resistance values according to the key manager in the area and those obtained by measuring the passthrough time. The expert estimation and the timing were set to equal value. The other timing figures were rescaled accordingly.

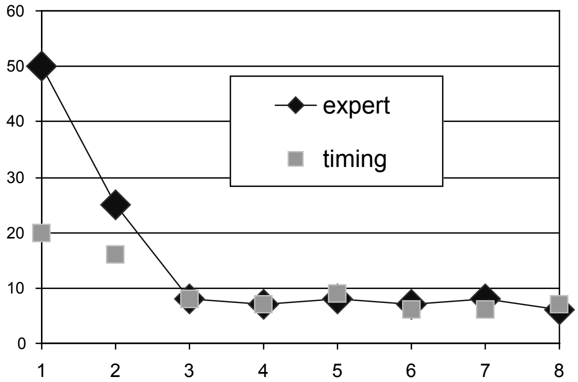
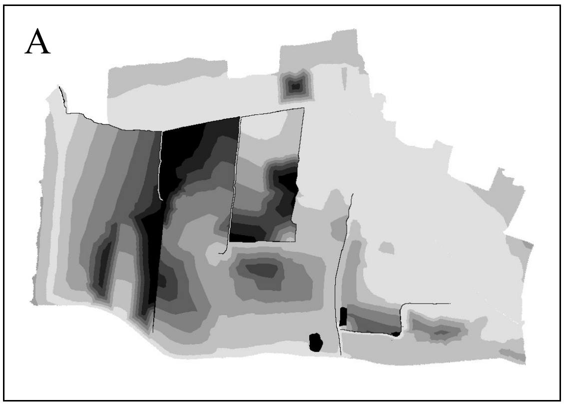


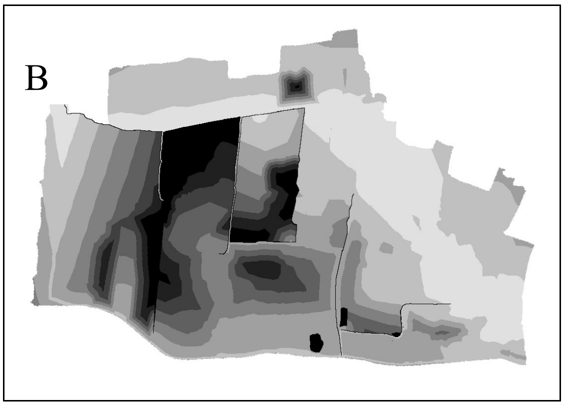
Fig. 2 Resistance scale 0-100. Comparison between expert estimation and measured passthrough speed (timing) for 8 land cover classes: 1= thick reed vegetation, 2 = woodland with thick understorey, 3= coniferous wood, 4=grazed terrain, 5=mowed quaking fen, 6=medium sized grass, 7= irregular track, 8=track though woodland

This comparative analysis and reciprocal recalibration is actually being completed by further field investigation. The provisional graph of fig. 1 suggests a similar trend whereby the expert model can be used as reference. The intuitive expert judgement likely is determined by perception of physical resistance and willingness to trespass rather than just attainable speed. Equal speed in sites of different roughness may hide different energy use levels. Therefore a third source of information is the use of effective human energy measurement in different terrain types, such as provided by Montoye et al. (1996). A fourth source is being investigated by enquiring psychological preferences/resistances for entering different terrain types.

Simulations of terrain access

Fig. 3 gives three simulations of access. The accessibility is the summation of the residual friction value from the dispersion starting at two entrances. (See fig. 1)





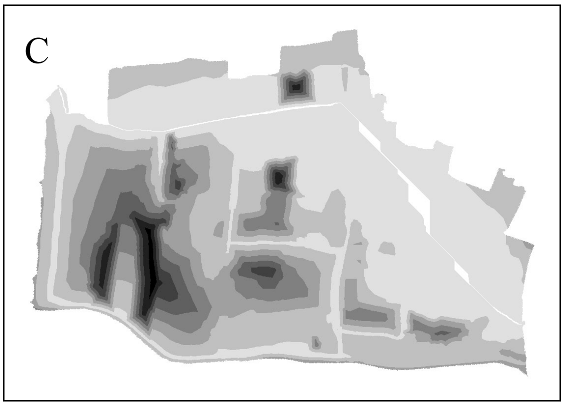


Fig. 3 Access models. A. With normal friction values for area units and standard friction value (6) for paths. B. Same as A but with differentiated path friction values. C. Same as A, but with friction values of ditches reduced to value 20. Grey shades vary from>80% residual growth value (pale grey) to 0% residual value (black).

The figures make clear that the friction model reacts sensibly to alternative scenarios. The differentiation of the pathway resistances according to width, surface roughness, wetness etc. changes considerably the overall accessability picture. Also the role of barriers such as ditches or metallic fences can be estimated very sensitively.

Provisional results of enquiries amongst invited people to the site suggest that this will result in well differentiated friction values for different road and surface types. Also, the impact of surrounding landscape characteristics, mystery effects etc. is likely very pronounced on the exact movement patterns. At the other hand, the statistical dispersion of values because of differences in personal characteristics should be taken strongly into consideration.

DISCUSSION AND OUTLOOKS

The accessability or penetrability model used in this paper has strong potentials for predicting risks of trampling according to the topological situation of fragile habitats. The model is non directional and will consider the whole site as a potential trespass area. Furthermore the model is based on an 'exhaust' principle that to a certain degree mimics human fatigue and preference for the easiest pathways. The model can be used easily for mapping the impacts of changes in the landscape. The model is very sensitive for apparently small changes such as a single footbridge over a stream or the effect of grass mowing, hence opening up more area for trespass. Likewise, the impacts of fencing off, broadening ditches etc. in order to control terrain visit can be easily simulated.

The exhaust principle however ignores possible 'refueling' e.g. by taking into consideration rest periods. The isotropy of the method furthermore does not consider directional factors such as terrain slope, visual attractivity and other goal elements in the landscape. It should be further clarified what exactly such models are capable of simulating: the displacement behaviour of individuals, the average roaming behaviour of groups, the probability of a certain site to be visited etc. Likely this modeling endeavour could be completed by linking several types of models: dispersion models, path finding models (Jöhnsson s.d.), landscape preference models and other.

The resistance or friction values as used in the model can be defined and measured according to different methods. Further comparison of the outcomes of these methods is necessary in order to obtain a useful ranked set of terrain types. An important question is the relation between physical resistances and psychological resistances. It is expected that this research will be able to contribute to this question in a later stage. The seasonal and atmospheric effects are also important factors of variation for the resistance values.

The next research steps will be the comparison of the dispersion calculations with further visitor's behaviour in the site. The low density of visitors however impedes a direct validation. Special emphasis will be given therefore to more indirect validation through enquiries and interviews with groups invited to the site and with local witnesses such as site managers, hunters and frequent visitors.

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Monitoring and Management of Visitor Flows in Recreational and Protected Areas
Conference Proceedings ed by A. Arnberger, C. Brandenburg, A. Muhar 2002, pages 191-198

RBSim 2: Simulating the Complex Interactions between Human Movement and the Outdoor Recreation Environment

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Abstract: This paper describes advancements in recreation management using new technology that couples Geographic Information Systems (GIS) with Intelligent Agents to simulate recreation behaviour in real world settings. RBSim 2 (Recreation Behaviour Simulator) is a computer simulation program that enables recreation managers to explore the consequences of change to any one or more variables so that the goal of accommodating increasing visitor use is achieved while maintaining the quality of visitor experience. RBSim provides both a qualitative understanding of management scenarios by the use of map graphics from a GIS as well as a quantitative understanding of management consequences by generating statistics during the simulation. Managers are able to identify points of over crowding, bottlenecks in circulation systems, and conflicts between different user groups.

RBSim 2 is a tool designed specifically for the purposes of simulating human recreation behaviour in outdoor environments. The software is designed to allow recreation researchers and managers to simulate any recreation environment where visitors are restricted to movement on a network (roads, trails, rivers, etc.). The software architecture is comprised of the following components:

- GIS module to enter travel network, facilities, and elevation data
- Agent module to specify tourist personality types, travel modes, and agent rules
- Typical Trip planner to specify trips as an aggregation of entry/exit nodes, arrival curves, destinations and agents
- Scenario designer to specify combinations of travel networks, and typical trip plans
- Statistical module to specify outputs and summarize simulation results.

This paper describes the RBSim software architecture with specific reference to the trip planning algorithms used by the recreation agents.

RBSIM – RECREATION BEHAVIOUR SIMULATOR

The purpose of the Recreation Behaviour Simulator Version 2 (RBSim 2) is to simulate the consequences of management decisions on visitor flows and encounters within a defined road and trail network within an outdoor recreation setting. RBSim 2 is a computer simulation tool, integrated with a Geographic Information System (GIS) that is designed to be used as a general management evaluation tool for any visitor and recreation facility management problem on linear networks. This capability is achieved by providing a user interface that imports park information required for the simulation from either MapInfo or ESRI ArcView geographic information systems. Once the geographic data is imported into RBSim, the park manager may then build alternative management scenarios (Itami et al. 1999).

Some of the factors the manager can change include the number and kind of vehicles, the number and arrival rates of visitors, and facilities such as the number of parking spaces, road and trail widths and the total capacity of facilities.

Statistical measures of visitor experience are generated by the simulation model to document the performance of any given management scenario. Management scenarios are saved in a database so they can be reviewed and revised. In addition, the results of a simulation are stored in a database for further statistical analysis. The software provides tables and graphs from the simulation data so park managers can identify points of over crowding, bottlenecks in circulation systems, and conflicts between different user groups.

Park managers can use RBSim 2 to compare alternatives by experimenting with different policy levers that can operate within the software. Such levers may activate or deactivate rules which agents in the RBSim environment will follow as they move through the environment of the Park.

RBSim uses concepts from recreation research and artificial intelligence (AI) and combines them in a GIS to produce an integrated system for exploring the complex interactions between humans (recreation groups) and the environment (geographic space) (Gimblett et al. 1996a; Gimblett et al. 1996b, Gimblett and Itami 1997, Gimblett 1998). RBSim joins two computer technologies:

- Geographic Information Systems to represent the environment
- Autonomous human agents to simulate human behaviour within geographic space.

WHAT IS AN AUTONOMOUS AGENT?

RBSim uses autonomous agents to simulate recreator behaviour. An autonomous agent is a computer simulation that is based on concepts from Artificial Life research. Franklin as Graesser (1996) define an autonomous agent as follows:

"An Autonomous agent is a system situated within and a part of an environment that senses that environment and acts on it, over time, in pursuit of its own agenda and so as to affect what it senses (and acts on) in the future."

Agent simulations are built using object oriented programming technology. The agents are autonomous because once they are programmed they can move about their environment, gathering information and using it to make decisions and alter their behaviour according to specific environmental circumstances generated by the simulation. Each individual agent has its own physical mobility,

sensory, and cognitive capabilities. This results in actions that echo the behaviour of real animals (in this case, human) in the environment.

What is compelling about this type of simulation is that it is impossible to predict the behaviour of any single agent in the simulation and by observing the interactions between agents it is possible to draw conclusions that are impossible using any other analytical process.

WHY RBSIM IS IMPORTANT TO RECREATION MANAGERS

RBSim 2 is important because until recently, there have been no tools for recreation managers and researchers to comprehensively investigate different recreation management options. Much of the recreation research is based on interviews or surveys, but this information fails to inform the manager/researcher how different management options might affect the overall experience of the user. For example a new trail may be introduced to alleviate crowding or conflicts between different user groups. How does this change increase or decrease the potential conflicts? How many more users can be accommodated and for how long? What is the impact on other facilities in the same park? Questions like these cannot be answered using conventional user survey tools. These questions all pivot around issues such as time and space as well as more complex issues such as inter-visibility between two locations. By combining human agent simulations with geographic information systems it is possible to study all these issues simultaneously and with relative simplicity.

RBSIM 2 COMPONENT ARCHITECTURE

Figure 1 shows the relationship of the major components of the RBSim 2 object hierarchy. An RBSim 2 simulation model is comprised of the following components:

Road/Trail network

The Road and Trail network is imported either from ArcView Shape files or MapInfo Tab files. On import standard fields required by the simulator are added to the associated attribute tables. Once the network has been edited and attributed it is written to a topologically structured network of Links and nodes.

Links are a series of line segments defined by a series of x,y,z coordinates that describe the alignment of the road or trail between two nodes. Link attributes include Label, Link Type, Link Category, number of lanes, maximum speed, length and slope. Links also may have access restrictions assigned to a scenario, such as open and closure times for different travel modes

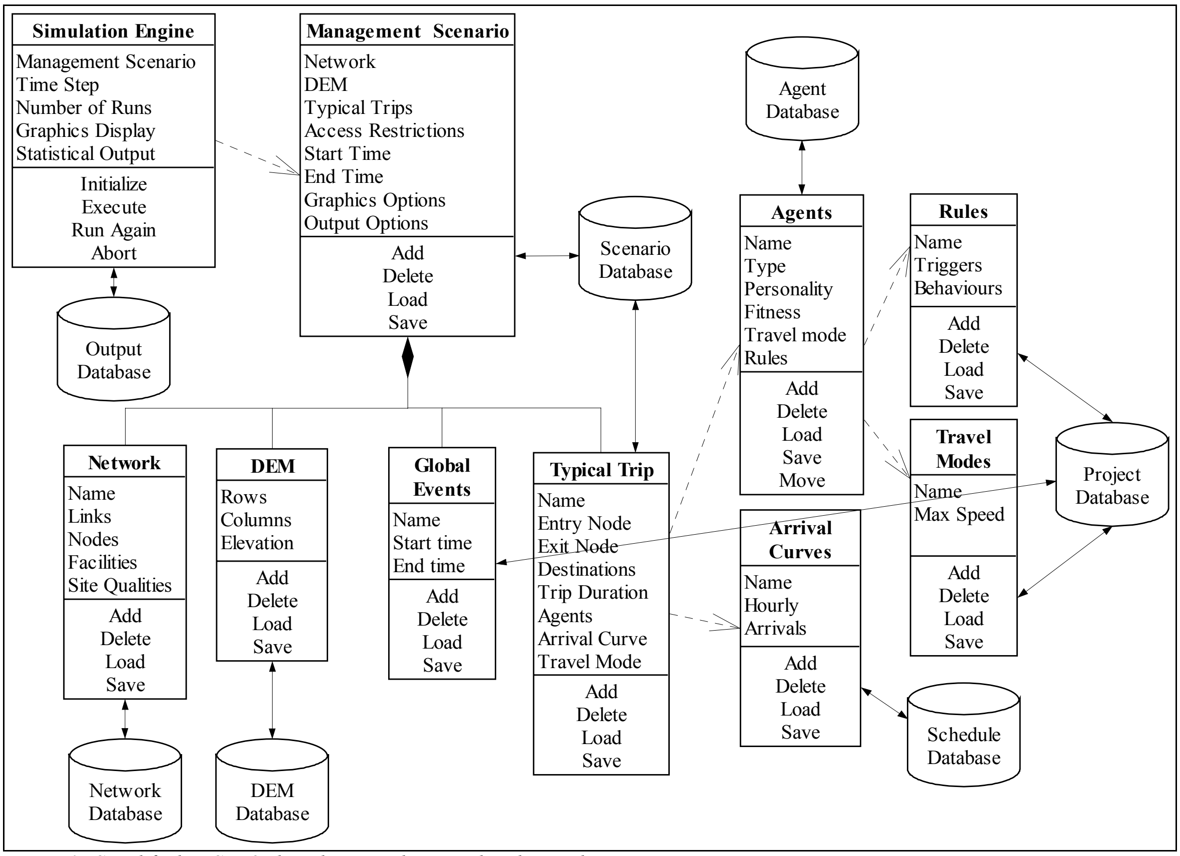

Figure 1. Simplified RBSim 2 class diagram showing class hierarchy.

A node is a point in the network representing a particular physical location at an intersection between links or where one or more facilities are located. Nodes are joined to the network by one or more links.

In addition to X,Y,Z coordinates, nodes have attributes including label, park entry, park exit, locale, facilities, and site qualities. Facilities are user defined destinations such as a visitor centre or picnic area that have a capacity and a typical duration of visit assigned to them. Site qualities, are user defined values such as scenery, history, or environment,education that are attributed to a node. A locale is a collection of one or more *nodes* with associated facilities that have a shared identity and can be grouped based on proximity to each other or common access.

Digital Elevation Model (DEM)

Elevation data is represented in a regular grid of elevations. They are used to assign elevations to the network and in calculating intervisibility between agents. DEM's are imported into RBSim from ESRI binary export files.

Global Events

Global events are user defined events that are raised during a simulation. Events have a start time and an end time and are controlled by the simulation engine. An example might be a rain storm, nightfall, temperature change, or any other event that affects the entire simulation.

Arrival Curves

Arrival Curves indicate the number of visitors arriving per hour over a 24 hour day. Arrival curves may be derived from traffic count data or estimated by managers familiar with the arrival patterns. Arrival Curves are used as part of the description of a typical trip, described later.

Agents

Agents have a number of standard attributes including fitness level, travel mode, travel speed, and preferences. Preferences are a list of values that correspond to site qualities that are attributes of network nodes. Values are weighted using Saaty's (1995) Analytical Hierarchy Process[1]. Preferences are used in the agent's logic for way-finding in locales which is described later in this paper.

Agents also have visual abilities. They can do line of site calculations to other agents at run time to count the number of other agents visible within a user defined radius.

Agent Rules

Agent rules are a set of user defined behaviours that are defined using a stimulus/response or event/action framework. RBSim 2 exposes runtime properties of the network, agent, and global events. Each of these properties will have a state or value

[1] For a more detailed explanation of the use of AHP in agent reasoning see Itami and Gimblett, 2001

which can be defined as a stimulus or event. Boolean logic can be used to combine two or more stimuli to create complex conditions for behaviour.

Behaviour is defined as a directive to search for a location or facility. An example of a complex rule is:

If (TravelMode = 'Car' AND Locale='12 Apostles' AND LocaleEntry = True) THEN Find Carpark

Agent rules are assigned to agents in the management scenario builder. The order rules are executed can change behaviour, so the user can specify the order of execution of rules. For instance, an agent should always park a car before going to a visitor centre.

Typical Trips

A Typical trip is described by an entry node and exit node to the network, an arrival curve, and probability distribution of agent types, a list of destinations (locales), and a trip duration. The concept of a typical trip is based on the premise that visitors have common patterns of use. For example day use visitors arriving during weekdays will have a different arrival pattern, a different duration of stay, and perhaps a different pattern of destinations than a traveller arriving on a weekend or an overnight visitor. Typical trips can be derived from field data or based on the experience and expertise of managers on-site.

Management Scenarios

A management scenario is an aggregation of a network, a DEM, one or more typical trips, a set of ordered agent rules assigned to one or more agents, zero or more global events, a set of access restrictions, and a set of runtime simulation conditions (see Simulation Engine).

Access restrictions (or gates) allow the manager to open and close parts of the road and trail network to different travel modes. Access restrictions are scheduled with a start time and end time. They may be hourly closures or seasonal closures.

Agent rules are assigned to each class of agent defined. Individual rules can be turned on and off for each agent, and the order that rules are executed may be uniquely defined for each agent class.

Simulation Engine

The simulation engine executes the management scenario. For each simulation run, the user defines the start date and time of the simulation, the end date and time of the simulation, and enables or disables the graphics display, statistical outputs, and agent inter-visibility.

Once these simulation conditions are defined, the user then runs the simulation. The simulation engine initialises the simulation in the following steps.

1. The network is loaded and validated
2. Each typical trip is loaded and the arrival schedule is interpolated for the duration of the simulation. All arrivals are then aggregated and sorted by arrival time.
3. Global events are scheduled
4. Network access restrictions are scheduled
5. Locales are sub-setted from the network.
6. For each locale, for each travel mode, a travel time matrix is calculated for all origin-destination pairs.
7. If output statistics are requested, the output databases are initialised.
8. If runtime graphics are requested, the graphic windows are initialised.
9. The simulation run is then commenced. The simulation engine starts the simulation clock and for each time step, reads from the arrival schedule to find all agents entering the simulation for that time step. For each agent, the simulation agent creates an instance of the agent, assigns it a personality preference profile, a set of rules, a fitness level, a travel mode, arrival mode, and a trip duration. The simulation engine then calculates a "Global trip" from the typical trip destination list. The global trip begins at the entry node for the trip and ends at the exit node. The path to intermediate destinations is generated based on least travel time algorithm. The global trip is saved as a trip itinerary and passed to the agent. Each agent then responds to a single method "Move" for each time step of the simulation. Once the agent is created, the simulation engine only issues the move method to each agent. The agent uses its own internal logic and rules to navigate through the network, selecting destinations, and determining duration of stay for each destination.

THE WAYFINDING LOGIC OF AGENTS

All agents follow a plan a global trip plan as described earlier, however these plans provide only a general trip itinerary. Once the agent begins its trip, changing conditions of the network (facilities becoming full), global events (rain storms), agent states (agent fitness, running short on time), can all act together to change the behaviour of the agent according to rules and the internal way-finding logic of the agent.

The way-finding reasoning of an agent is influenced by the following factors:

- Available time (defined by time elapsed subtracted from total trip duration).
- Travel mode as it affects travel time.
- Agent preferences
- List of rules and their order
- Currently executing rules
- Internal state of the agent
- Current location of the agent
- Condition of the network including availability of facilities, access restrictions,

and travel time to destinations on the network

- Previously visited destinations

As the typical trip defines the entry and exit node and a series of locales and durations, the simulation engine then uses travel time algorithms to find the most efficient route between destinations. However once an agent reaches a locale, it must use its internal way-finding logic to find destinations, generate a path that links these destinations, and simultaneously take into account the factors in the above list.

When an agent arrives at a locale, it checks to see if there is a duration set for this locale in the global trip itinerary. If the duration is >0 then the agent checks to see if there is enough time left in its total trip duration by subtracting the time elapsed since the beginning of the trip and the time to travel to the exit node. If the remainder is positive and greater or equal to the duration set for this locale, the agent enters the locale and performs the following initialisation procedures:

1. Loads the subset locale network for the agent's current travel mode.
2. Generates weights for the site qualities for each node in the locale by multiplying the node site quality with the corresponding personality preference value (unique to the agent)
3. Marks any nodes that have already been visited as "visited" and sets their site qualities to zero.
4. Sets its internal state to "entering locale"
5. Loads its rule list.
6. Generates a locale trip plan.
7. Executes its move behaviour for the locale.

The way-finding logic is encapsulated in step 6, generating the locale trip plan. The locale network is a topologically structured network containing the links and nodes, access restrictions, facilities, and site qualities for the locale.

Once the locale network has been initialised, the agent then evaluates all possible combinations of destinations from its current node location. These paths were pre-calculated when the simulation was initialised to enhance performance. The agent then evaluates each path and rejects any path that exceeds the available locale visit duration. The remaining paths are then ranked to maximize the site preferences and contain facilities that are on the agent's current rule list. A gravity model is used to weight the paths so paths with high priority facilities are ranked higher for facilities close to the agent's current location.

Once the preferred path is selected, the agent loads it as its current trip itinerary. The agent then traverses this itinerary as far as it can in the current time step. If the agent encounters a node that contains facilities that are on its current rule list, the agent changes its internal state to "visiting facility" and generates a visit duration for that facility. If the facility at the node has no available capacity (e.g. the parking lot is full), the agent "looks ahead" on its itinerary to see if a facility of the same class is available, if there is, the agent then continues its trip toward that node. If there is no other facility of the same class, the agent will then change its state to "queuing" and waits until the facility becomes available.

At each iteration of the simulation the agent must check its available trip time, its current travel mode, its current rule list, and its current state. Any of these can trigger a change in behaviour. The agent may abandon its current trip and calculate a path back to its car, or to the exit. If the conditions have not changed, then the agent continues to execute its current behaviour.

Though there are a lot more details to this behaviour, the above reflects the overall logic behind the agent's way-finding logic. When implemented, the logic produces behaviour that appears "smart" in that the agents generate logical paths and exhibit behaviour that is human-like.

12 APOSTLES MASTER PLAN
PORT CAMPBELL NATIONAL PARK
VICTORIA, AUSTRALIA

Port Campbell National Park is managed by Parks Victoria, Australia. The park is typified by spectacular coastal scenery with limestone cliffs and sea stacks against the backdrop of the forceful waves of the Southern Ocean. The park's popularity is enhanced by its proximity to Melbourne and the large number of tour buses that visit the site daily. These factors contribute to the heavy visitor use, and the inevitable crowding and decline of visitor satisfaction and environmental quality. RBSim 2 was used to examine the impact of changes in park infrastructure and increasing visitor rates over a 10 year period on the Twelve Apostles site. This site has recently been upgraded with a new parking lot and visitors centre. All parking south of the Great Ocean Road has been removed and visitors must now park in an improved parking lot north of the Great Ocean Road (see figure 2).

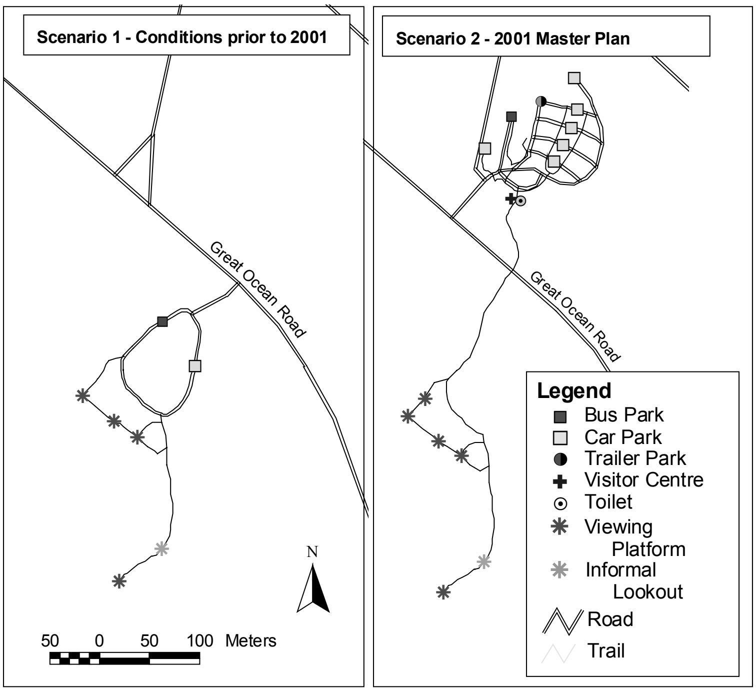

Figure 2: Network layout and facilities for Scenario 1 and Scenario 2. Limited parking to the south side of Great Ocean Road in Scenario 1 encourages illegal parking, visual impacts, and crowding. Scenario 2 shows all vehicular traffic has been moved north of the Great Ocean Road with an enlarged parking area, a new Visitor Centre, new public toilets and a pedestrian walkway that goes under the Great Ocean Road to the viewing platforms facing the 12 Apostles.

Some 701,000 people visited the site in 2001/2 and by 2006/7 this is expected to be 864,000. The new visitor centre which includes new toilet facilities and an interpretive centre provides a gateway to the site via a pedestrian tunnel that leads visitors under the Great Ocean Road along a path to the viewing platforms along the cliff edge of the spectacular views of the 12 Apostles. Traffic counts before and after the construction of the new facilities were taken to provide baseline and calibration data for the RBSim model. Simulation results are examined to answer a set of five management questions of key interest to the rangers of Port Campbell National Park.

Table 1 shows the before (scenario 1) and after (scenario 2) layouts of the 12 Apostles site.

Facility	*Scenario 1*	*Scenario 2*
Viewing Platform	***345 People***	***345 People***
Informal Lookout	***5 People***	***30 People***
Bus Park	***6 Buses***	***12 Buses***
Car Park	***30 Cars***	***245 Cars***
Visitor Centre	***None***	***100 People***
Toilet	***None***	***29 People***
Trailer Park	***None***	***12 Cars***

Table 1: Comparison of facilities at the 12 Apostles locale before (scenario 1) and after (scenario 2) the implementation of the new master plan.

Table 2 shows the arrival rates for cars over a 24 hour period for three time periods. The projections for 2006 and 2011 are based on a projected 3.55% growth rate per annum.

These figures were used for both scenarios. Rbsim 2 generates a standard set of statistical outputs these include:

Time	2001	2006	2011
5:00	2	2	3
6:00	19	23	27
7:00	6	7	8
8:00	20	24	28
9:00	54	64	76
10:00	114	136	161
11:00	153	182	216
Noon	203	241	286
13:00	230	273	325
14:00	213	253	301
15:00	235	279	332
16:00	193	229	272
17:00	90	107	127
18:00	37	44	52
19:00	10	12	14
20:00	2	2	3
21:00	7	8	10
22:00	1	1	1
Totals	3590	3893	4253

Table 2: Arrival rate for cars entering the 12 Apostles site for three time periods. These rates were used for both Scenario 1 and scenario 2.

- Car park and bus park capacity
- Trip completion rates.
- Visual Encounters. This is a measure of crowding at a particular attraction[1].
- Queuing time at parking facilities
- Length of stay

Each of the measures were analysed according to the original management questions. Space limitations do not allow discussion of the statistical methods used to analyse the results, however these are fully reported in Itami, Zanon and Chladek (2001).[2] Only results for Scenario 2 are reported here.

How well will the new facilities at 12 Apostles cope with growing visitor loads?

Results show bus parking will be inadequate during the busiest time of the day between 2:00 and 4:00 pm by the year 2006. This shortage is exacerbated by the year 2011 as bus parking is inadequate for the whole period from 3:00 pm to 5:00 pm

By 2006 the car park is full from 1:00 pm to 4:00 pm by 2011 the car park is full from 12:00 pm to 5:00 pm.

How is length of stay affected by the new configuration of the 12 Apostles site?

The longer walk from the new parking facilities to the viewing platforms extends the average length of stay an average of 6 to 7 minutes. Predictions by RBSim in this regard are confirmed by measurements on-site.

How crowded will the site get in the future?

As the number of visitors increase, there is increasing pressure on viewing platforms and lookouts. Crowding increases because of the increased duration of stay and the increased capacity of car parks.

How will visitor satisfaction be affected by the new facilities and growing visitor numbers?

It is expected that visitor satisfaction will decrease with an increase in visitors. This is caused by increased queuing times at parking lots, an increase in the length of stay, the number of visual encounters, especially at viewing platforms, and the number of visits that fail because of lack of parking at peak periods. This can partially be resolved by increasing the capacity of viewing platforms, but the long-term solution will require redistributing the visitors to other sites, especially at peak periods.

Management Recommendations

- Bus parking will need to be managed between 3:00 pm to 5:00 pm within 5 years (eg. use informal spaces near the visitor centre).
- Limit car arrivals after 1:00 pm in 10 years or build an extension to the car park.
- Viewing platforms will have to be increased in capacity in the 5 to 10 year time horizon if the overflow car park is used or if the car park is extended further.

CONCLUSIONS

RBSim 2 is a general agent-based model for simulating the behaviour of visitors in recreation environments where movement is constrained by linear networks. The open architecture allows recreation managers to build simulation models for any park and recreation area. Because RBSim 2 is designed as a management tool, managers can examine a broad range of management options and compare and contrast different strategies. By interacting with the simulation model, managers can evaluate the effectiveness of alternative facilities management plans to determine the performance on visitor flows and visitor satisfaction under different visitor loads.

RBSim is under continuous development to generalise it for a broader range of recreation environments. This development is linked to behaviour research (see paper by Gimblett et al. in this conference) in the U.S. and Australia. We are now in the process of developing simulations for a broad range of environments and recreation management problems.

The component architecture described in this paper allows us to build additional agents as new components and integrate them with RBSim using "plug and play" technology. In this regard, we are in the process of designing "shuttle bus" agents and "animal" agents such as grizzly bears. There is considerable interest in integrating the behavioural modelling of RBSim2 with traditional GIS ecosystem models to develop temporal environmental impact models.

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A Concept for Coupling Empirical Data and Microscopic Simulation of Pedestrian Flows

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Abstract: In this paper we present a concept for coupling empirical data and a microscopic simulation of pedestrian motion. Since there is no automatic detection method available for this task up to now the main focus is on developing such a system.
A review of the different detection methods is presented and the requirements are given an automatic system has to fulfil. Additionally, a possible realisation of such a detector is described. Experiences with such a system for vehicular traffic are reviewed.

INTRODUCTION

The simulation of pedestrian motion has reached a high interest in many fields of human live. There are two major directions of pedestrian flow simulation: One is the investigation of basic phenomena encountered in human motion like the formation of trails with opposite walking directions [14, and references therein] or the formation of temporary roundabout traffic [13]. The other field is the application of these simulations to optimise pedestrian flows in complex geometries for various intentions.

Our simulation was originally developed for the simulation of evacuation processes onboard passenger ships [7]. But due to its high flexibility it can also be used to simulate pedestrian flows within football stadiums or shopping malls.

Since our model provides a high simulation speed it is possible to perform calculations faster than real time for a large number of pedestrians. Combining this high calculation speed with an automatic detection system for pedestrian flows will enable medium term predictions for the distribution of people from detected initial conditions.

The outline of this papers is as follows: In the next section we present the basic elements of our model. The following section gives an overview over the available empirical data and problems that occur during the collection. Next, an overview over the currently available systems for the detection of pedestrians is given. A short discussion of the usability of these methods for our concept follows. From this we develop the requirements for an automatic detection system which is described in the next section. The last section gives an idea for a coupled detector/simulation system and its probable use.

MODEL DESCRIPTION

For the simulation of pedestrian flows a Cellular Automaton (CA) model is used [7]. Contrary to macroscopic models which pay no attention to individual behaviour of pedestrians our microscopic model simulates individuals.

The floor plan is divided into quadratic cells with a size of 0.4m by 0.4m. Each of these cells can be occupied by at most one pedestrian. The people are allowed to move from one cell to each neighbouring unoccupied cell. That means the coordination number is 8.

Walls, furniture and other obstacles are represented as inaccessible cells (see figure 1). The orientation of the pedestrians towards a certain target is done by a potential field. Walking in the direction of the gradient is the shortest way to a given target that is the source of the potential. The values for the potential field are subject to a metric that generalises the "Manhattan metric". The distance to the target is coded in the grey shade of the cells. The lighter the grey the shorter the distance.

The update of the pedestrians is done in a random order. The order is set at the beginning of each time step. Moved pedestrians are deleted from the order. Because of that each pedestrian is moved only once in a time step.

Individual characteristics of the pedestrians are given by a set of parameters. These parameters are assigned according to a normal distribution between given limits. The parameter sets include the walking speed which is given in cells per time step, a swaying probability to describe a variation from the shortest path, a dawdle probability to describe the speed reduction due to orientation, a patience to give the ability to search for a new way when the currently chosen way is jammed, and a maximum vision range.

To reach higher walking speeds than one cell per time step (e.g., 0.4m/s) each time step is divided into sub time steps (see figure 2). In each sub time step a pedestrian can move from one cell to a neighbouring cell. By filling in as much sub time steps as the required maximum velocity is we can simulate higher walking speeds. In this context, lengths are measured in cells and speeds in cells per time step.

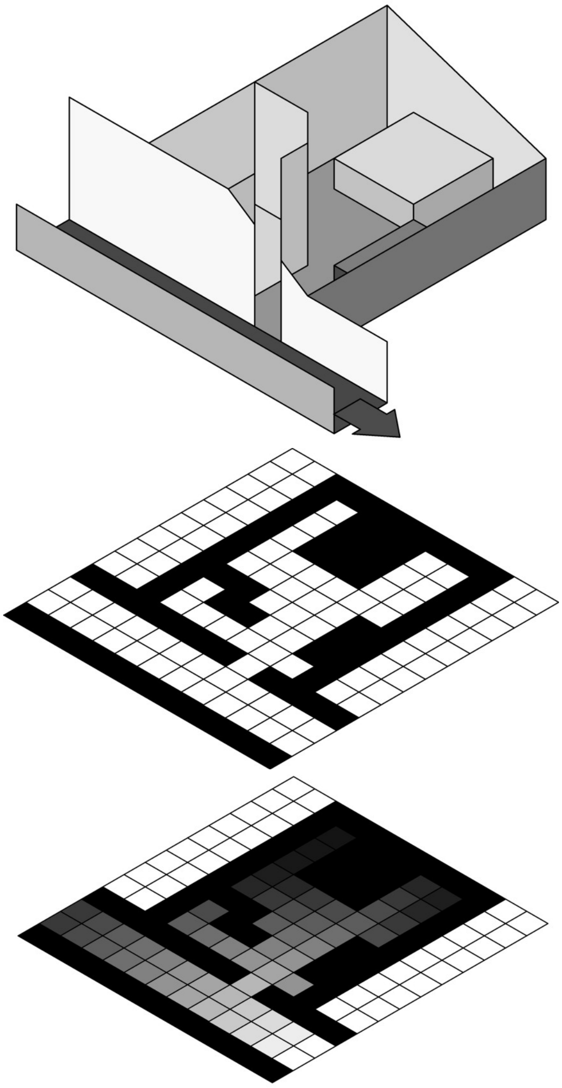

Figure 1: Discretisation of the floor plan. Inaccessible areas are marked as black cells. Accessible cells are white. The grey cells represent the potential field which leads to the exit.

The interactions between the individuals are repulsive. If a cell is occupied by a pedestrian no other pedestrian can use this cell in the particular time step. In this way accidents are prevented.

The outcome of the simulation is the total evacuation time. This is the time until the last person has left the facility. Since decisions of pedestrians are made by drawing random numbers a single simulation run can produce an arbitrary result. So we repeat each simulation a couple of times with different random numbers to make a statistical statement about the evacuation time (Monte Carlo simulation). Additionally, for each person the starting point and the exit coordinates are recorded together with some statistical information (e.g. which speed for how many time steps). In the upcoming version a density and occupancy plot will be available. These plots provide information on which cells are most frequently used during the evacuation.

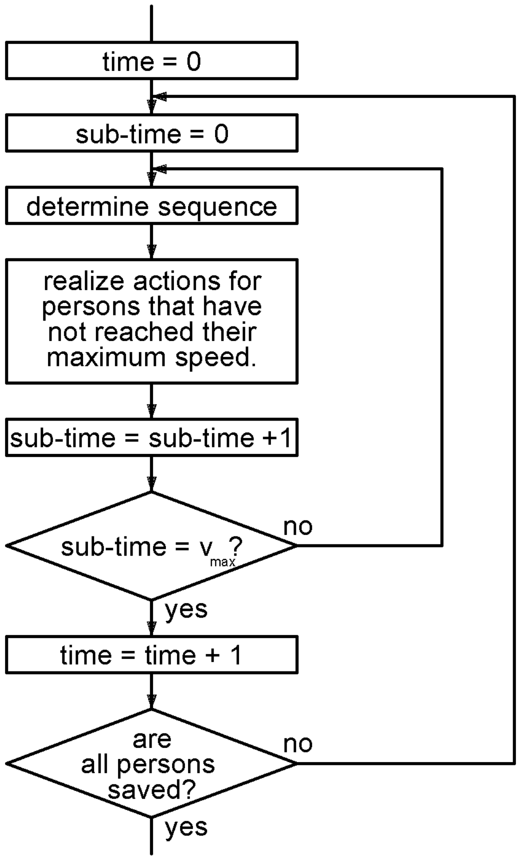

Figure 2: Algorithm of the microscopic simulation. The update sequence of the persons is random. The number of sub time steps equals the maximum walking speed.

EMPIRICAL DATA

For our simulation we use a small set of parameters. Nevertheless it is highly recommended to adjust these parameters for our simulation as well as for other simulations dealing with pedestrian motion. This is done either by extracting them from the literature [3], from observations, or by trial and error [10].

In the end there is always the need for observations since the outcome of the simulation is an evacuation time which has to be compared with full scale tests (unless the results are trustworthy).

To compare the simulation with full scale tests we have observed some evacuation drills in schools and on ships and we have undertaken some own experiments.

These observed drills, especially in the schools, showed some critical points of the simulation we did not pay much attention to before. For example, while the real exercise in a primary school [6] was done in about 85 seconds the simulation predicted about 160 seconds. This gap occurred because we did not consider the special circumstances that our observation produced: The exercise was done in a primary school with pupils of the age of 6 to 10 years (first to fourth grade). Our observation equipment (cameras, staff) produced a high grade of nervousness so that the pupils tried to make their job very good what means that they moved very fast. In the first simulation runs we did not consider this fact and worked with pupils which were too slow. By fitting the walking speeds to recorded values the simulated time dropped down to about 100 s.

By comparing the simulation to another evacuation exercise in a secondary school a second necessary point occurred. It showed up that neglecting furniture in the class rooms leads to a difference in evacuation time. Our first idea was that the class rooms basically serve as a reservoir for the pupils and when the alarm is given they just move out. It occurred that the furniture (tables) in the class rooms lead to a guidance of the pupils within the class room. This resulted in a better outflow through the door and not to the jam which appeared without tables. This increased the outflow and led to a simulated evacuation time which better fit to the measured time.

Phenomena like the influence of furniture are qualitative. They can be analysed by simply watching the recorded video films. But if we want to extract data like walking speeds from such drills we have to examine the films frame by frame. This is a very time consuming work.

From this fact the idea arose to use an automatic detection system. Looking at what is currently available for human detection we found nothing sufficient and we formulated some essential requirements. From these requirements we derived an idea for such a detector.

If such a detector would be available there is a wide field of applications for the detector itself as well as for a coupled detector/simulation system.

CURRENT DETECTION METHODS

In this section we give an overview of the detection methods which are currently available for human beings. Most of these detectors can only detect the presence of people but no individual data like walking speed and direction.

Detectors can be differentiated by several criteria. One differentiation can be done by the categories *active* or *passive* detectors. This differentiation is based on the measurement principles the detectors use. Active detectors are working on a sender/receiver basis. A sender emits some kind of radiation (in most cases electromagnetic radiation). Either the reflected signal is detected or it is detected that the signal is blocked by an obstacle (e.g., for light barriers). By measuring the travel time of the radiation the distance to the target can be computed. Microwave detectors, active infrared detectors, ultrasonic detectors, and laser scanners belong to this category.

Passive detectors do not emit any radiation but detect the environmental radiation field and react on changes therein. Typical passive detectors are passive infrared detectors and video cameras.

A second approach for the differentiation of sensors is the type of application they were developed for. In this case the detectors can be divided in the categories *static* and *dynamic* sensors. Dynamic sensors are only able to detected moving objects while static sensors can only detect fixed objects.

In the following a short description of the different sensors is given. For a more detailed view on the different detectors, see [2].

Active Infrared Sensors

Active infrared sensors emit infrared light with a wavelength close to the visible spectrum and detect the reflected part or the transmitted one. They are capable of detecting non moving objects. A special case of these sensors is the infrared light barrier. The light barrier is triggered when a beam of infrared light is interrupted. The need for an interrupted light beam enforces a special mounting position for light barriers which is not always possible.

Passive Infrared Sensors

Passive infrared sensors are frequently used as motion detector for automatic illumination, alarm plants, or automatic doors. They consist of a pyro-electric element which produces an electric current when infrared radiation acts on the element.

They react on rapid changes in the environmental infrared radiation field. Because of that they are only able to detect moving objects. The detected wave length is above 10 μm.

Microwave Detectors

By emitting and receiving electromagnetic waves with a wavelength of 1 to 10 cm microwave detectors belong to the group of active detectors. Sending and receiving is done with a single antenna. By measuring the travel time of the wave the distance to a target can be computed and by using the Doppler-Effect the velocity of a target can be measured.

A measure beam is emitted by the antenna and the mixed signal of all reflections is received. Because of that only the strongest signal is analysed.

By using the Doppler-Effect, microwave detectors are capable of detecting the velocity and moving direction of a target. This enables microwave detectors to measure only pedestrians who are walking in a certain direction. But it also produces problems when a detected person who fits detection criteria is superimposed by a signal of a person who does not match the criteria. Then there will be no person detected.

Ultrasonic Sensors

Some animals orientate by using ultrasonic (e.g., bats). The detection is done by emission of silent sonic impulses and receiving of echo.

While this technique is sufficient for animals it is not reliable for person detection. The strength of the reflected ultrasonic impulses depends on the clothing of the persons. A weak reflection leads to non-detection of persons. Additionally, for a strong reflection the impulse has to impinge vertically as the reflection has to.

An advantage of ultrasonic detectors is the ability to detect unmoving objects for infinite time periods.

Mat Detectors

Some materials change their behaviour under pressure. This effect is used in mat detectors. Mat detectors are placed instead of sidewalk slabs or beneath them.

There are two different systems of pressure sensitive mats available. One system consists of a piezo-electric coaxial cable which is embedded in rubber mats. When the cable is exposed to pressure like from a person standing on the mat an electric voltage is produced.

The other system measures and analyses the change in the optical properties of glass fibres.

In this configuration mat detectors are only useable to detect the presence of persons. To count persons the mats have to be divided in smaller elements and then arrays of these elements have to be installed.

Laser Scanners, Radar Scanners

The measuring principle of scanners is the computing of travel time of various electromagnetic radiation. Either infrared light (for Laser scanners) or microwaves (for Radar scanners) is used. The narrow bundled radiation is emitted by a moving emitter and reflected by the target. By computing the travel time or the phasing, the distance to the target can be detected.

Originally, scanners had been developed for the differentiation and counting of different road users. They are also used for the detection of persons in secured areas. Since the scanners are mounted overhead a use for the collection of pedestrian data is in principle possible but has not yet been tested.

Video Analysis

Currently, video analysis is used for data collection of cars. The video images are analysed by a grey scale analysis in pre-defined windows. For cars this technique works sufficiently good but does not satisfy the needs for pedestrians. The main problem is the definition of windows which fit to pedestrians anywhere in the plane.

A new system from the University of Minnesota [1] is able to track pedestrians in real time. This system works for single pedestrians with a frame rate of 30 frames per second but the frame rate drops down with an increasing number of pedestrians. The number given is 25 frames per second for 6 pedestrians. This drop down depends on the available computer power. Since the computational possibilities increase very fast it will be only a question of time since a larger number of pedestrians can be tracked in real time.

Thinking of a long term observation using video analysis the question of data security has to be addressed. Taking videos of persons is often not allowed unless they do not give their explicit permission.

DISCUSSION OF THE DETECTORS

Since most of the above mentioned systems have been developed for the detection of pedestrians waiting at crossings they are not able to extract any motion data of the pedestrians. Furthermore, some of the systems are not able to detect how many pedestrians are there. For example, infrared detectors give a signal independent of the total number of pedestrians. If there is at least one pedestrian they trigger the crossing light.

This limitation is not hindering if the detectors are used for presence detection at crossings. But it makes them unusable for collecting data like walking speed and direction.

Another disadvantage is the ”loss” of pedestrians due to occlusion. This is the main problem of the optical systems like video analysis or radar scanners since they are usually not mounted overhead. But it is essential that pedestrians do not simply disappear or suddenly appear for the collection of data.

The great advantage of a video analysing system is variable size of the observed area. By simply changing the zoom of the camera a higher resolution can be reached.

IDEA FOR A NEW DETECTION METHOD

From the above mentioned points we can derive requirements for a detection system which can be coupled to our or any other microscopic simulation. The main requirement is the robustness against occlusion. The system must be able to detect the presence, walking speed, and walking direction independently from the level of occlusion to give a full set of data to the simulation. Since this can only be reached by mounting cameras or scanners overhead (what is not always possible) this is the main problem.

Another possibility to prevent occlusion is the detection from beneath. This idea is based on the inductive loops which are used for traffic detection [8]. Inductive loops are common in collecting data from moving cars. The metal parts of the cars trigger an inductive loop and this signal is analysed by a computer.

Since humans are (at least in the beginning) not metallic the use of inductive loops is impossible. The idea for the detection system is the use of footprints of the walking pedestrians on the above mentioned pressure sensitive mats (figure 3).

In the current configuration the mats are only able to give a signal when something exerts a pressure on the mat. A spatial resolution is not given. But by dividing a mat in small quadratic elements of 10cm by 10cm it would be possible to detect where a footprint is made. By measuring the distance of the footprint from the edges of the array it is possible to predict where a person enters the array. From the shape and orientation of the footprint a prediction for the walking direction can be made (see figure 3).

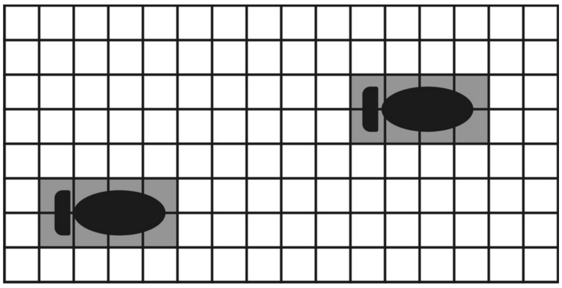

Figure 3: A possible situation on a spanned mat detector. The footprints (black) trigger the underlying elements (grey). Because of the closeness to the left edge of the array the next footprint is estimated near the right edge.

The analysis of the position and orientation of the first footprint starts the system to wait for the second footprint in walking direction. From the temporal and spatial distance between the footprints the walking speed and direction can be computed. By counting the footprints the number of pedestrians can be obtained to get the density on the detector.

It will have to be shown that this approach is feasible. However, up to now we do not know of any facts that make this generally impossible.

Details

To explain the above mentioned mat array approach in more detail we now give an explanation of the assumptions made.

To find a good balance between costs and benefits we estimate that a size of 10cm by 10cm for the elements is sufficient. A better spatial resolution would be given with smaller elements but the increase in elements (half the size means four times the number) will possibly slow down the data extraction.

From this starting point we can derive the other requirements like detection speed. The estimated mean velocity of the detected persons is about 1.3m/s and the step length is about 0.6m/s (see [3]). This means that the time delay between the first and the second footprint is about 0.5s. When we require a measured accuracy of 0.1m/s for the velocity and (due to the cell size) take a variation of 0.1m for the step length, the upper limit for the deviation in the time measurement is 0.08s.

The total length of a mat array must not be less than 2m. This is because of the required direction detection. To decide where the first footprint is made we need the first footprint to be made near one edge of the array. With a length of 2m the first footprint is in any case made closer to one edge than to the other.

The width of the mat can vary depending on how many persons should be able to walk side by side. The lower limit for the width is the width of one person, e.g., about 0.5m.

Every single element is then connected to a computer which is triggered by the first footprint. The orientation of the activated elements determine in which direction the next footprint is estimated and the time measurement starts. When the second footprint activates the underlying elements the time measurement is stopped. From the distance between the activated elements the step length is calculated and together with the measured time the velocity can be computed.

This has, of course, not to be done online, but the data can be recorded and stored and analysed later on.

COUPLING TO THE SIMULATION

The collected data are fed into the simulation as the initial entrance rate and velocity in the simulated area. This area can be all kind of route network. From that source the simulated pedestrians spread over the network and walk through it according to the algorithm mentioned above. At some points within the network additional detectors can be attached to adapt the simulated amount, velocity, and direction of persons to reality. This makes a complete surveillance of the area unnecessary while the simulation fills the gaps where no surveillance can be done. Additionally is it possible to get data on the occupation of unmonitored areas. A similar system is applied successfully to city [16] and highway traffic [17].

Furthermore, a prediction of jammed areas would be possible because of the high simulation speed. This enables for the specific positioning of staff to resolve such congestions. Especially in the case of protected areas it is necessary to prevent such congestions as people are impatient. If they have to wait at a waypoint (e.g., a bottleneck on a way) they will soon try to shortcut trough the woods. To prevent this, a staff member can be positioned there to hinder the pedestrians in taking a shortcut and to speed up the other pedestrians in the bottleneck. This increases the effectiveness of the staff.

This coupling of empirical data and micro simulations is done with great success for highway networks in Germany ([4,5] and references therein).

CONCLUSION AND OUTLOOK

The presented concept for a coupled system of detectors and a microscopic simulation offers a wide range of possible applications. Not only in the field of data collection an automatic detection system would provide great benefits but also in the field of simulation and prediction of pedestrian flows. This enables the optimisation of route networks as well as the optimal positioning of staff members. Through a combined system of a microscopic simulation and a couple of detectors a complete surveillance of large areas becomes unnecessary.

The next steps will be the transfer of the theoretical data of the detector into a working system. After a detailed analysis of the capabilities the coupling to the simulation can be done.

Even though at the present state this is only a concept, there are three strong arguments for pursuing this approach:

- It has been done successfully for vehicular traffic.
- The basic technologies are available.
- There is a plethora of potential applications.

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Monitoring and Management of Visitor Flows in Recreational and Protected Areas
Conference Proceedings ed by A. Arnberger, C. Brandeburg, A. Muhar 2002, pages 205-210

Using Simulation Modeling to Facilitate Proactive Monitoring and Adaptive Management of Social Carrying Capacity in Arches National Park, Utah, USA

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Abstract: Recent research and management experience has led to several frameworks for defining and managing carrying capacity of national parks and protected areas. The process outlined in contemporary carrying capacity frameworks embodies the principles of adaptive management. That is, management decisions are guided and adapted within these frameworks by monitoring indicator variables to ensure that standards of quality are maintained. The objective of this study was to develop a computer simulation model to estimate the relationships between total park use and the condition of indicator variables. In this way, simulation modeling might facilitate proactive monitoring and adaptive management of social carrying capacity of parks and protected areas.

INTRODUCTION

Public visits to parks and protected areas continue to increase and may threaten the integrity of natural and cultural resources and the quality of the visitor experience. For example, annual visits to the U.S. national park system are approaching 300 million, and this level of use may disturb fragile soils, vegetation and wildlife, and may cause unacceptable crowding and visitor conflicts. Starting as early as the 1960's, outdoor recreation research has adapted and developed the concept of carrying capacity to address these issues related to visitor use (Manning, 1999). In the context of outdoor recreation, social carrying capacity refers to the amount of visitor use that can ultimately be accommodated in parks and outdoor recreation areas without diminishing the quality of the visitor experience beyond an acceptable level.

This study addresses the application of computer simulation modeling to defining and managing social carrying capacity in Arches National Park, Utah. Previous research has led to establishment of selected indicators and standards of quality for major attractions within the park (National Park Service, 1995; Manning et al., 1995; Manning et al., 1996a; Manning et al., 1996b). For example, to avoid unacceptable levels of crowding, the number of people-at-one-time (PAOT) at Delicate Arch should not exceed 30 more than 10 percent of the time. But how many visitors can be allowed to hike to Delicate Arch before this standard of quality is violated? Moreover, how many visitors can be allowed in the park before standards of quality are violated at this and other attraction sites? A computer simulation model of visitor use was developed to help answer these and other carrying-capacity related questions.

CARRYING CAPACITY AND ADAPTIVE MANAGEMENT

A number of frameworks have been developed to provide managers with a basis for making decisions about the carrying capacity of parks and protected areas, including Limits of Acceptable Change (LAC) (Stankey et al., 1985), Visitor Impact Management (VIM) (Graefe et al., 1990), and Visitor Experience and Resource Protection (VERP) (National Park Service, 1997). Common to all of these frameworks is formulation of management objectives concerning the degree of resource protection and the type of recreation experience desired. Management objectives are made operational through a set of indicators and standards of quality (Manning, 1999). Indicators of quality are defined as measurable, manageable variables that reflect the essence or meaning of management objectives. Standards of quality are defined as the minimum acceptable condition of indicator variables. Indicator variables are monitored over time, and management actions are applied as needed to ensure that standards of quality are maintained.

The process outlined in contemporary carrying capacity frameworks embodies the principles of adaptive management. Adaptive management has been characterized as a form of experimentation and learning in which a team of managers, planners, and experts formulate hypotheses concerning the relationship between management actions and corresponding outcomes (Lee, 1993). A management "experiment" is carried out by taking management actions, monitoring the outcomes of the actions, and comparing the monitoring data to hypothesized outcomes. Managers adapt to differences among expected and actual outcomes of management actions by reformulating their hypotheses and implementing new management actions. Management outcomes are monitored to test revised hypotheses, and additional learning about the system under management takes place. This process continues in an incremental cycle of experimentation and learning. For example, consider a park or related area where crowding-related indicators of quality (e.g., the number of people seen at one time at popular attraction sites) have been monitored and are not within standards of quality. Managers of the area may hypothesize that these indicators of quality can be brought within standards of quality by limiting the number of people who enter the park or by implementing a permit system that controls the temporal and/or spatial distribution of visitors to the area. In order to test these hypotheses, visitor use limits or a permit system are implemented for the park. Monitoring is conducted to test the hypothesis that crowding-related indicators of quality are within standards of quality given the new management action. Through this process the manager learns about the effectiveness of management actions and adapts future management decisions accordingly.

While carrying capacity frameworks such as LAC, VIM, and VERP have been successfully applied in a number of park and recreation areas, a potential weakness of this approach to carrying capacity in particular, and adaptive management in general, is their arguably reactive nature. That is, they rely on a monitoring program to determine when standards of quality are violated, or are in danger of being violated. A more proactive approach to managing carrying capacity would be to estimate the level of visitor use that will cause standards of quality to be violated, and to ensure that such levels of visitor use are not allowed. Computer simulation modeling has the potential to facilitate a more proactive approach to defining and managing social carrying capacity. Specifically, simulation modeling provides managers with a tool to experiment with and predict the outcomes of a range of management actions that might otherwise be too costly to consider and/or may lead to potentially undesirable consequences. In this way, outdoor recreation managers can capitalize on the strengths of adaptive management, decision-making guided by experimentation and learning, while avoiding potential constraints associated with such an approach.

OVERVIEW OF SIMULATION MODELING AND APPLICATIONS TO OUTDOOR RECREATION

Simulation modeling is the imitation of the operation of a real-world process or system over time. It involves the generation of an artificial history of a system, and the observation of that artificial history to draw inferences concerning the operating characteristics of the real system. Simulation modeling enables the study of, and experimentation with, the internal interactions of a complex system. The approach is especially suited to those tasks that are too complex for direct observation, manipulation, or even analytical mathematical analysis (Banks & Carson, 1984; Law & Kelton, 1991; Pidd, 1992).

The most appropriate approach for simulating outdoor recreation is dynamic, stochastic, and discrete-event, since most recreation systems share these traits. Models that represent systems as they change over time are *dynamic* models, differing from static models that represent a system at a particular point in time. Complex and highly variable systems are often modeled using *stochastic* simulation. A stochastic simulation model contains probabilistic components and takes into account the random variation of systems over time. *Discrete-event* simulation models are dynamic models that imitate systems where the variables change instantaneously at separated points in time. This contrasts with continuous systems where variables change continuously over time. A mountain stream is usually modeled as a continuous system, where variables such as stream flow change continuously over time. An example of a discrete-event system is a campground: variables, such as the number of campers, change only when there are campers arriving or departing.

From the mid-1970's to the early-1980's, researchers explored computer simulation modeling as a tool to assist recreation managers and researchers (Manning & Potter, 1984; McCool et al., 1977; Potter & Manning, 1984; Schechter & Lucas, 1978; Smith & Headly, 1975; Smith & Krutilla, 1976). The main goal of the Wilderness Travel Simulation Model, as it came to be known, was to estimate the number of encounters that occurred between recreation groups in a park or wilderness area. The model required input variables such as typical travel routes and times, arrival patterns, and total use levels. Outputs included the number of encounters between visitor groups of various types and the date and location of encounters. Initial tests established the validity of the model, but the model soon fell into disuse. Computers were relatively inaccessible at the time, and the evaluative component of carrying capacity research had not yet produced defensible numerical standards of quality.

Recent changes in computing power complemented advances in evaluative research to provide the context and impetus for the present study to revisit computer simulation for recreation research and management. Simulation-capable computers have become "smaller, cheaper, more powerful and easier to use by non-specialists" (Pidd, 1992). Exponential growth in the power of personal computers has facilitated the use of graphic user interface and visual interactive modeling technologies to make the simulation process accessible (Pidd, 1992). These advances have led to wide proliferation of simulation in the fields of business management and manufacturing.

In recent years there has been renewed interest in applying simulation modeling to outdoor recreation management, resulting in the development of two related approaches. Research at Grand Canyon National Park (Daniel & Gimblett, 2000) and Broken Arrow Canyon near Sedona, Arizona (Gimblett, Daniel, & Meitner, 2000; Gimblett, Richards, & Itami, 2001) combined simulation modeling with artificial intelligence technologies and geographic information systems (GIS) to address social carrying capacity-related issues at the study areas. Studies at Acadia National Park (Wang & Manning, 1999), Yosemite National Park (Manning et al., 1998b, Manning et al., 1999), Yellowstone National Park (Borrie et al., 1999), and Alcatraz Island (Manning et al., 1998a) used a simulation approach similar to the Wilderness Travel Simulation Model. These studies involved building models of specific sites or specific activities to determine social carrying capacities within these National Park areas. This paper presents an application of the latter approach to simulation modeling at Arches National Park. Specifically, a computer simulation model of visitor use of Arches National Park was developed to estimate the maximum use level that can be accommodated at Delicate Arch and within the park more generally without violating standards of quality for a crowding-related indicator of quality (PAOT at Delicate Arch). The results provide numerical estimates of social carrying capacity of Delicate Arch and Arches National Park.

METHODS

Data Collection

A variety of methods were employed to gather the baseline data used to build the simulation model of visitor travel in Arches National Park, including vehicle counts with traffic counters, on-site visitor surveys, field visits, and map analysis. In addition, parking lot counts were conducted to validate model outputs. The following paragraphs describe the data collection methods in more detail.

A traffic counter placed at the entrance to Arches National Park was used to record the number of vehicles entering the park and the time each vehicle entered. These traffic data were collected during a seven-day period from August 19 - August 25, 1997. Total daily vehicle entries for these seven days averaged to 1,346 vehicles.

Data concerning visitor characteristics and their travel patterns within Arches National Park were collected through a series of on-site surveys administered to park visitors during the summers of 1997 and 1998. During the summer of 1997, vehicle travel route questionnaires were administered to 426 visitor groups as they were exiting the park. One visitor from each group was asked to report their group's size, the total amount of time they had spent traveling on the park roads, and where and how long they paused during the visit. Finally, with the aid of the interviewer, they were asked to retrace the route of their trip on a map of the park. The vehicle travel route questionnaires were administered on 6 days during the period from August 14 – August, 30, starting at 7:00 a.m. and ending at dusk. Safety concerns pre-empted stopping cars and surveying visitors after dark.

A second questionnaire was administered during the summer of 1997 to a total of 180 visitor groups returning from their hikes to Delicate Arch. One visitor from each group was asked to report the group's size, the total amount of time they had spent on the trail to Delicate Arch and at the Arch, and where and how long they paused during the hike. The Delicate Arch hiking questionnaires were administered on 3 days during the period from August 15 – August, 24, starting at 7:00 a.m. and ending at 10:00 p.m..

During the summer of 1998, 160 questionnaires were administered to tour bus drivers on 42 days between July 9 and October 22. Bus drivers were asked to provide the same type of information that was collected in the vehicle travel route survey the previous summer. Tour bus travel route data were collected during the daylight hours from 7:00 a.m. to dusk.

Hiking questionnaires were administered during the summer of 1998 at The Windows and Devil's Garden sections of the park. Similar to the hiking questionnaire administered at Delicate Arch during the previous summer, visitor groups at The Windows and Devil's Garden areas were asked to report information about their group size, the route they hiked, and the places and amount of time they paused during the hike. A total of 245 questionnaires were completed by visitors returning from their hikes around The Windows on 5 days during the period from July 18 - August 3, and 320 questionnaires were administered to hikers returning from their hikes in the Devil's Garden section of the park on 5 days during the period from July 5 - August 6. Surveys in both locations started at 7:00 a.m. and ended at 10:00 p.m..

Additional data needed to construct the model were gathered through analysis of park maps. Specifically, the lengths of road and trail sections between intersections were calculated from maps provided by the park.

Data needed to validate the output of the simulation model were gathered through a series of vehicle counts conducted at selected parking lots in the park. The number of vehicles in the Wolf Ranch (Delicate Arch), The Windows, and Devil's Garden parking lots were counted 11 times a day between 6:00 a.m. and 10:00 p.m. on four days during the period from August 19 – 25, 1997. The total number of vehicles entering the park was recorded with traffic counters on each of the days that parking lot counts were conducted. The parking lot count data were compared to parking lot values output by the simulation model run at total use levels equivalent to the number of vehicles entering the park on the days validation data were collected.

Model Algorithm and Programming

The Arches National Park travel simulation model was built using the object-oriented dynamic simulation package, Extend (1996). The structure of the model was built with hierarchical blocks that represent specific parts of the park's road and trail systems. The simulation model is comprised of three main types of hierarchical blocks, including entrance/exit blocks, intersection blocks, and road and trail section blocks.

Entrance/exit blocks were built to generate simulated visitor parties. Visitor parties are generated by the simulation model based on an exponential distribution varying around mean values calculated from the park entrance counts recorded by the traffic counter. The exponential distribution has been demonstrated to accurately simulate arrival rates at park areas with random arrival patterns (Wang & Manning, 1999). Within the entrance/exit block, newly generated visitor parties are assigned values for a set of attributes designed to direct their travel through the simulated park visit. First, visitor parties are randomly assigned travel modes (automobile or bus) and group size, both according to probability distributions derived from the visitor surveys. Next, travel speeds are assigned to visitor parties according to a lognormal distribution. The mean travel speed and standard deviation of the distribution were calculated from the travel times reported by survey respondents and the lengths of their travel routes. The lognormal distribution has been demonstrated to accurately simulate different travel speeds in parks (Wang & Manning, 1999). Lastly, the visitor parties are randomly assigned a route identification number that directs groups through their simulated park visit. Travel route identification numbers are assigned to visitor parties according to frequency distributions of actual routes reported in the visitor surveys.

Intersection blocks were designed to direct simulated visitor parties in the right direction when they arrive at road and trail intersections. Lookup tables unique for each intersection direct visitor parties to the next park feature (e.g., road section, trail section, parking lot, attraction site) selected from the set of alternatives at the intersection. The direction of travel selected for a visitor party at each intersection is based on the value of the group's route identification number and the number of previous times, if any, the group has been through the intersection.

Road section blocks were built to simulate travel along park roads. Simulated visitor parties are delayed within each road section they enter for a length of time determined by their assigned travel speeds and the length of the road section. Similar to road section blocks, parking lot and attraction site blocks were designed to hold simulated visitor parties for periods of time based on data collected from the visitor surveys. Parking lots were also designed to output the number of visitor parties parked at each parking lot throughout the simulated day. Attraction site blocks were designed to output PAOT at selected attraction sites throughout the simulated day.

Model runs

A series of model runs were conducted to achieve three purposes; 1) to estimate the maximum number of visitors that can be allowed to hike to Delicate Arch between the hours of 5:00 a.m. and 4:00 p.m. without violating the standard of quality for PAOT at Delicate Arch (i.e., to estimate a social carrying capacity of Delicate Arch); 2) to estimate the maximum number of vehicles that can be allowed to enter Arches National Park between the hours of 5:00 a.m. and 4:00 p.m. without violating the standard of quality for PAOT at Delicate Arch (i.e., to estimate a social carrying capacity of Arches National Park); and 3) to validate the simulation model by comparing actual parking lot counts with parking lot data generated by the simulation model. Each run simulated park use from 5:00 a.m. to 4:00 p.m. As noted earlier, safety concerns (i.e., stopping vehicles after dark) prevented vehicle and tour bus travel route surveys from being administered after dark. Therefore, the model does not simulate visitor use during the evening hours.

For the first objective, estimating a social carrying capacity of Delicate Arch, the model was run at a range of total use levels representing the number of visitors hiking to the Arch. Twelve runs were made for each use level to capture stochastic variation. The average percent of time that PAOT at Delicate Arch exceeded 30 (i.e., the maximum acceptable level of PAOT at Delicate Arch) was recorded for each total use level modeled. This process was repeated to estimate a social carrying capacity of Arches National Park, except that the total number of vehicles entering the park was modeled.

To achieve the third objective, validating the simulation model output, a series of 48 model runs were conducted. Model runs were conducted for each of the total park use levels recorded during the four days that parking lot counts were recorded. The model runs were repeated twelve times for each of the four simulated days to capture stochastic variation. The number of vehicles in selected parking lots was tracked through each simulated day. For each of the total use levels modeled, the average number of vehicles in the selected parking lots was calculated at time intervals that matched the actual parking lot count times and compared to observed data.

RESULTS

Social Carrying Capacity of Delicate Arch and Arches National Park

Numerical estimates of social carrying capacity of Delicate Arch and Arches National Park are reported in Table 1. The figure in the first column of Table 1 indicates that the estimated social carrying capacity of Delicate Arch is 315 hikers. That is, the model estimates that a maximum of 315 people can be allowed to hike to Delicate Arch between the hours of 5:00 a.m. and 4:00 p.m. without violating the standard of quality for PAOT at Delicate Arch. The social carrying capacity of Arches National Park is estimated to be 750 vehicles. In other words, the model results suggest that a maximum of 750 vehicles can be allowed to enter the park between the hours of 5:00 a.m. and 4:00 p.m. without having PAOT at Delicate Arch exceed 30 more than 10 percent of the time.

Delicate Arch	Arches National Park
315 hikers (5:00 a.m. - 4:00 p.m.)	**750 vehicles (5:00 a.m. - 4:00 p.m.)**

Table 1. Numerical Estimates of Social Carrying Capacity

	T statistic
Windows parking lot counts	**-3.00***
Delicate Arch parking lot counts	**1.46**
Devil's Garden parking lot counts	**-0.28**
Park-wide parking lot counts	**-0.40**

Table 2. Parking Lot Validation Statistics

Model Validation

Table 2 presents validation results based on comparisons between actual parking lot counts and model outputs. The four days of counts were combined and a set of four t-tests were performed to test for statistically significant differences among observed data and model outputs at each of the three parking lots and park-wide. There was a statistical difference found among observed data and model outputs only at the Windows parking lot.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Study findings suggest that it is feasible to develop a park wide model of visitor use encompassing both vehicle and pedestrian travel. Moreover, such a model can be used to develop relationships between use (e.g., the number of vehicles entering the park each day and the number of visitors hiking to Delicate Arch each day) and the condition of indicator variables (e.g., PAOT at Delicate Arch). Such a model can be used to provide numerical estimates of social carrying capacity of an attraction within a park or protected area. Further, as this study demonstrates, a travel simulation model can be used to estimate a park-wide social carrying capacity.

While monitoring is incorporated as an important element of contemporary carrying capacity frameworks, constraints on human and financial resources often limit the ability of park and protected area staff to conduct comprehensive monitoring of crowding-related indicators of quality. Further, due to the dispersed nature of visitor use of parks and protected areas it is often difficult to conduct monitoring through conventional means such as field observations. The application of computer simulation modeling to defining and managing social carrying capacity of parks and protected areas facilitates a proactive approach to monitoring. Specifically, rather than monitoring the field conditions of indicator variables as they change in response to expanding visitor use, simulation modeling can estimate the condition of indicator variables under a range of visitor use levels. While simulation modeling does not eliminate the need for on the ground monitoring of indicator variables, it has the potential to reduce the costs, time, and related challenges associated with monitoring crowding-related conditions of parks and protected areas. In this way, simulation modeling makes it more feasible for park and protected area staff to engage in the process of experimentation and learning that is characteristic of adaptive management.

Findings from this study suggest that managers at Arches National Park can use the simulation model to inform decisions about how to manage social carrying capacity. Among the options available for managing social carrying capacity at the park is the alternative to regulate the amount of visitor use at specific attraction sites within the park. As mentioned previously in this paper, the simulation model provides managers with numerical estimates of social carrying capacity at Delicate Arch. Managers could use this information to guide decisions concerning the appropriate number of visitors to allow to hike to Delicate Arch. However, in some cases, regulating where visitors are allowed to travel within a park or protected area may limit visitors' choices to an undesirable extent and may be difficult for managers to implement. An alternative approach would be to regulate the amount of visitor use at the park-wide level. That is, it may be preferable to visitors and easier for managers if the number of people allowed to enter the park is regulated, rather than limiting where visitors may go once they are in the park. Decisions about how to regulate the total number of visitors entering Arches National Park can be informed by the numerical estimates of park-wide carrying capacity generated by the simulation model in this study.

Visitor use limits should be considered a last resort for managing social carrying capacity in national parks and related areas. Other forms of management, such as public transportation, permit systems, and site design may provide adequate solutions to social carrying capacity issues without having to limit use. Further research should explore the use of simulation models to estimate the effectiveness of alternative visitor management practices. For example, to what degree does redistribution of spatial and temporal visitor use patterns through a permit system affect PAOT at attraction sites and/or the number of encounters among hiking groups? To what extent are crowding-related conditions of national parks and related areas affected by the use and design of public transportation systems? Additional research should assess the capacity of simulation modeling to address these and related questions.

As noted earlier in this paper, statistical tests used to validate the simulation model indicated a significant difference between actual and model vehicle counts for the Windows parking lot. However, statistical tests supported the validity of model output based on parking lot counts at Delicate Arch, Devil's Garden, and all three parking lots combined. While these results are encouraging, further efforts to validate the model are warranted. Specifically, additional parking lot counts, as well as PAOT counts at selected park locations, would provide the basis for further comparisons with simulation model output and strengthen conclusions about the validity of the model output.

ACKNOWLEDGMENTS

The authors would like to acknowledge the following people for their assistance with various aspects of the research: David Lime, University of Minnesota, Wayne Freimund, University of Montana, and Karen McKinlay-Jones, Arches National Park.

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Monitoring and Management of Visitor Flows in Recreational and Protected Areas
Conference Proceedings ed by A. Arnberger, C. Brandeburg, A. Muhar 2002, pages 211-217

A Spatial Model of Overnight Visitor Behavior in a Wilderness Area in Eastern Sierra Nevada

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Abstract: This paper documents an attempt to simulate spatially the behavior of a group of sampled overnight visitors in a dispersed recreation setting – the Humphrey's Basin region of the John Muir Wilderness in the eastern Sierra Nevada Mountains. This study utilizes spatial data depicting the behavior of backcountry visitors in Humphrey's Basin to formulate a model based on cost surface techniques in a geographic information system (GIS) to develop a measure of visitor effort expenditure as a way of describing factors influencing spatial distribution of camping behavior. This hiking effort index model (HEI) measures the accumulative cost hikers expended to traverse varying distances between campsite locations in the study area. The cost grid input for the HEI model consisted of a) a slope factor derived from digital elevation models (DEM), b) the measured hiking times of backpackers at various slopes, and c) the relative cost of traveling either on or off trail. The model measures relative travel cost in units of hiking minutes. The model was tested using a subsample of the actual spatial data of visitor behavior not used in the running of the HEI model. Results indicate that the HEI model does accurately simulate the spatial distribution of visitors. This study thus suggests that human behavior in a dispersed recreation setting can be successfully modeled as well as pointing to ways of further improving simulation techniques
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INTRODUCTION

Social scientists recognize that human spatial patterns are more than just background to or expressions of social action. They understand that spatial patterns are instrumental to the formation and reproduction of human behavior (Penn and Dalton, 1994). Yet, little research exists that describes how people distribute themselves within recreation systems (Wang and Manning, 1999). This means that significant aspects of the character of encounters, conflicts, experience opportunities and benefits in recreation are not well understood (Gimblett et al., 2001).

Much of the research about recreation in wildernesses and other protected areas during the last forty years has concentrated on adapting the concept of carrying capacity to recreation use (Stokowski, 2000). The carrying capacity work, and its theoretical complement, normative theory, have produced useful findings (Shelby et al., 1996; Cole and Hammitt, 2000). Yet, researchers have debated the applicability of the carrying capacity concept to human recreation issues for years (Wagar, 1974; Manning and Lime, 2000).

One critical deficiency of human dimensions research is the lack of data that captures actual patterns of human use of natural resources (Ewert, 1996). Managers in heavily used wilderness areas have been found to rely for the most part on personal opinion in their decision-making (Cole, et al., 1997). Basic information on human use in protected areas is patchy (Manning, 2000). The low frequency of monitoring of human use belies its importance to wilderness management (McClaran and Cole, 1993). Recreation use is still inadequately measured and described (Watson, et al. 2000). Without better data better models of human use patterns can't be produced (Machlis and McKendry, 1996). The data that needs collecting should be of the type, and only of the type, that is actually needed by managers and other decision makers (Williams, 1998).

A stated objective of new recreation models is to empower land managers to make better-informed decisions while reducing the negative consequences of policy decisions. Models have been defined as simplified copies of complex entities or systems, copies that allow otherwise impossible or impractical study of the most important aspects of those systems (Gilbert and Troitzch, 1999). In the case of a recreation model of a wilderness area, an effective spatial/temporal model of a backcountry area could enable managers to comprehensively map human use and preview the implementation of policies and their consequences (Gimblett et al. 2000). In contrast to human use pattern models that are derived from spatial/temporal data, policy decisions based solely on experience and intuition and tested through trial and error tend to be costly, time-consuming and harmful to visitor relations (Shechter and Lucas, 1978).

A spatial model is particularly appropriate in a recreation context because how visitors perceive impacts and the quality of their experience is predicated to a significant degree upon where exactly encounters and conflicts occur. A significant problem in simulating human use patterns is the complexity of human behavior. An outstanding feature of models such as the wilderness use simulation model (WUSM) was their capacity to handle complexity. Therefore, the objectives of this study were to simulate the character of human behavior by isolating some of the contributing factors into that behavior.

STUDY AREA

This study was conducted in the Humphrey's Basin area of the John Muir Wilderness. Humphrey's Basin is an alpine lakes basin located in the Inyo and Sierra National Forests in California. It is located about 32 km. west of the town of Bishop, which is approximately 480 km. east-southeast of San Francisco and 440 km. north of Los Angeles. For the purposes of this study, Humphrey's Basin is defined by Lake Italy to the north, the Pacific Crest Trail to the west, the Kings Canyon National Park boundary along the Glacier Divide to the south, and by North Lake to the east. This defined area is 145,763 acres or 590 sq. km. Practically speaking though, the actual boundary of the study area was defined by the map provided for participants upon which they recorded their information. Any visitor behavior that occurred within the confines of the map provided as part of the data collection was deemed to have taken place within the study area itself.

Humphrey's Basin is ideally suited for studying complex recreation behavior. Being a large wilderness area it offers varied settings in which visitors can travel on- and off-trail, and can choose destinations from innumerable suitable locations. Although permits are required by the Forest Service for overnight use in the John Muir Wilderness, backpackers are free to camp wherever they please, as long as they camp the stipulated distance away from water sources. The basin is accessible to and used by dayhikers, overnight backpackers, packstock trips (trips using pack animals -- horses and mules) and guided mountaineering trips.

UNIVERSITY OF ARIZONA STUDY

The data used to build the HEI model was collected as part of a larger study conducted cooperatively by the Forest Service and the University of Arizona. The Forest Service contracted with the university for two seasons of data collection on backpacker, packstock outfitter and mountain guide use in nine study areas during one season and in three of the same areas the following season. Humphrey's Basin was one of those areas studied both years. The Forest Service has used data drawn from the study in the completion of a general management plan for the John Muir and Ansel Adams wilderness areas. Their use of the data is not related to this study in any way.

Data from the Arizona/Forest Service study were collected during two seasons, 1999 and 2000, of permitted overnight backcountry use in the nine study areas. Dayhikers were not asked to participate. Data was collected for a total of eight months spread over the two seasons. In both study seasons, data collection forms were first distributed on or just before the fourth of July and were continuously available until the end of the backcountry season. The end of the season varies yearly, depending on the arrival of snow. In 1999 and 2000, season's end occurred sometime in late October.

Data was collected through the use of a type of trip diary or, as they were referred to for the purpose of this study, trip reports. The traditional recreation data collection mechanisms, interviews and surveys, were not used for this study. Those methodologies don't capture situational effects well, while visitors may have no conscious strategy in their spatial behavior and might not be able to articulate it even if they did (Stewart, 1998; Gilbert and Troitzch, 1999).

Some research indicates that observing a sample of trails and trailheads on sample days produces optimal data on visitor behavior. This method wasn't feasible in this study, given the cost that would be involved and the size of the study areas. Using self-administered methods, as in the case of mandatory permit systems, generally has been found to produce adequate results (Lucas and Kovalicky, 1981).

Each trip report consisted of three sections. The first solicited general information about visitors and their trips. This information included what trailhead each party left from. Section two was a series of questions regarding visitor satisfaction with different features of the wilderness experience. The section's data had no bearing on the development of the spatial models that concern this discussion.

The final section of the trip report asked wilderness visitors to record where they went on their trip, whom they encountered there, and how long they spent at each campsite. Each separate study area contained a different map. Like the satisfaction information, the encounter information isn't relevant to this model. The data that does concern this model was where visitors camped and for how long. Visitors denoted the location of each camping incident by marking a dot on a map included in the trip reports. Alongside each dot visitors wrote on the map the night or nights they spent at that campsite. Only camping occurrences that took place in Humphrey's Basin were counted and analyzed for this model. Accordingly, information from visitors who began their trips outside of the basin but spent part of their stay within the area was included in this study.

Trip reports were distributed to visitors through a number of outlets. Trip report stations that allowed the reports to be self-administered by visitors were set up at feeder trailheads that provide access to Humphrey's Basin. In 2000, the Forest Service sent trip reports to all visitors who received their permit by mail. This wasn't possible in 1999. The trip reports came with a self-addressed postage-paid envelope. Visitors were instructed to take a trip report with them during their visit, complete it as they went along, and then seal the finished report in the envelope and drop it in the mail. Reports were mailed to the University of Arizona in Tucson, AZ.

The data collection methods used in this study acted as a limitation to the precision of the eventual modeling results. The backcountry visitors who participated in this study were not selected in a strictly random manner. Not all visitors had an equal chance of receiving a trip report and there was some degree of bias in what portion of the population of visitors returned completed trip reports. An overwhelming majority of returned trip reports came from people who took them at trailheads. Only an insignificant portion came from those administered through the other distribution methods. Therefore the sample used in this study can't be said to be strictly representative of visitors to Humphrey's Basin. Also, visitor use studies have concluded that visitors often misreport where they go in the backcountry. Ideally, observers would record visitor behavior (Cole et al. 1997).

MEASURING DISTANCE BY A COST SURFACE

Once the data was collected from the wilderness study area, the next step was to find the principle on which to build the model. Rossmo argues that the most fundamental analytic device in geography is the nearness principle, also known as the least-effort principle. Rossmo defines the least-effort principle as: given his choice, a person will select a route that requires the least expenditure of effort. This suggests that all other factors being equal, hikers will always chose the closest destination (Rossmo, 2000). Tests of animal behavior demonstrates that animals do use least-cost pathways (Ganskopp and Johnson, 1999). But how does one define closest? Does it involve more than just distance? Rossmo argues that the perception of distance is influenced by the relative attractiveness of destinations, the number and types of barriers along the route, the traveler's familiarity with the route, the actual physical distance, and the attractiveness of the route.

The nature of the data collected in the Sierra excluded consideration of all but two of the influences Rossmo cites. The data from Humphrey's Basin meant a spatial model would have to be constructed from the distance traveled by hikers and the barriers they faced on their trips. DeMers states that the way to show the functional distance covered by travelers is to calculate an impedance value for their trip. This impedance value is the accumulative cost incurred as distance is crossed (Demers, 1997). Accumulative cost assigns a distance value to a route that counts some associated measurement besides feet or meters. For example, the accumulative cost of the flow of water runoff might measure impedance by the degree of slope of the terrain and the density of vegetation screens along the route. Thus, for hikers in the Sierra, the accumulative cost of hiking would be the total expenditure of effort, however that is measured, they expend to negotiate the landscape.

Raster-based GIS calculate the accumulative cost of a route in the form of a cost surface. To produce a cost surface, which is represented by a tessellated grid, one selects a starting point, or source cell, which has an accumulated cost of zero. As the GIS window moves across the cells adjoining the source cell, the GIS adds the cost of traversing each cell to the total already counted. For example, crossing a cell adjacent to the source that has an associated cost of 1 would leave the journey with an accumulated cost of 1. If the next cell crossed has an associated cost of 2, the accumulated cost to that point of the route would be 3, and so on until the terminus is reached. So, a cost surface is the representation of the value associated with the difficulty of traveling to each point on the surface from the starting point. Accordingly, locations on the cost surface that are remote from the source cell will have much greater values than cells proximate to the starting point.

ASSIGNMENT OF ROUTE COST

The topography of Humphrey's Basin was represented by a digital elevation model (DEM). This DEM was constructed by reformatting eight DEMs into grids using the ArcInfo GIS and then combining them. The eight 1:24,000-scale (7.5 minute) digital elevation models (DEMs) used to represent the study area were obtained from the US Geological Survey. The DEMs used in this study were of Florence Lake, Mt. Darwin, Mt. Henry, Mt. Hilgard, Mt. Thompson, Mt. Tom, Tungsten Hills and Ward Mountain. These DEMs were combined by the *mosiac* command in ArcInfo. GIS allow reprocessing of DEMs into maps representing various features latent in topography. One determinant of cost in the HEI model would be the degree of slope of the cells hikers traversed in the cost surface. ArcInfo was used to reclassify the combined DEM into a grid representing slope values for the area.

The degree of slope had to be translated into some unit of measurement to depict the relative cost of each cell. Time was chosen as the measurement unit. Wagtendonk and Benedict conducted a study of travel time variation among backpackers on trails of different slope in Yosemite National Park (Wagtendonk and Benedict, 1980). They timed backpacking parties as they hiked a mile on a trail of gentle rise (.75%), a trail of moderate rise (5.0%), and a trail of severe rise (12.5%). They considered trails of this slope to be the only pertinent routes in Yosemite. They did extrapolate these measurements later to obtain travel times for trails of steeper slopes. A c*on* state- ment in ArcInfo was used to reclassify the slope grid using the travel times in the Yosemite study and thus obtain a cost grid of hiking times for each cell in the study area. Cells having a gentle slope were assigned a value of .019, those with a moderate slope were assigned a value of .023, and those cells with steep slopes were assigned a value of .025. These values were reached by taking the averaged slope class values that represented number of minutes needed to hike a mile. These values were then converted for travel times needed to cross a one-meter cell.

Hiking cross-country is almost always more difficult than doing so on established trails. To account for this increased difficulty for hiking cross-country, each cell in the study not associated with a hiking trail in Humphrey's Basin was assigned double the impedance value. This doubling of difficulty values was chosen to reflect the increase in difficulty that hiking off-trail involves without inordinately skewing the influence of this factor on the model's results as a whole. Therefore the range of values in the cost grid to be used in the production of the cost surface were from .019 minutes for cells on a gentle slope and trail to .051 minutes for cells on a severe slope without a trail.

RUNNING THE HEI MODEL

The cost spent in time hiking was then calculated for each applicable segment of travel between campsites used during backcountry visits in Humphrey's Basin. This derivation of hiking effort times, which does not correspond to the actual time elapsed between campsites, but rather the cost of travel as expressed in hiking times, was done in two sections: first nights and last nights. The first night section comprised segments where the travel was between the Piute Pass trailhead and a first night's camping. A grid was made with just the Piute Pass trailhead. This source grid and the cost grid were the inputs to the c*ostdistance* function in ArcInfo. Only first nights of trips that originated at the Piute Pass trailhead were used. There were 229 reported first nights of this type in the database. Of these, 10% were not used in the model. These 23 would be used to test the model later. The 10% figure was chosen because it provided the best compromise between the conflicting needs to have a large enough sample to run the model and still have a sufficiently large reserve sample set aside to test the model with.

Section two, last nights, used all final nights of any trip that terminated at the Piute Pass trailhead. The source grid was again the Piute Pass grid. Any camping incident was used as long as it was the last night of a trip and it ended at this trailhead. Also, the concluding night's campsites of trips beginning outside the study area were included in this section as long as the final night occurred within Humphrey's Basin and the trip ended at the Piute Pass trailhead. There were 233 total nights in this section. Setting aside 10% for model verification, left 210 for running the model.

TESTING THE HEI MODEL

To test the accuracy of the hiking effort index model, a cost surface with the Piute Pass trailhead as the source point was produced. This surface was then reclassified into zones corresponding to the 20%, 40%, 60%, 80% and 100% percentiles of the First Night and Last Night sections. The procedure for testing was to overlay the 10% sample of camping incidents set aside from the two sections on the zones created from the model. If the model has any validity the 10% subset, randomly chosen through the SPSS statistics software, would fall within the zones in the same percentages as occurred in the larger set. For instance, for first nights, 20% of campsites had a HEI figure of 88.8 or less. Therefore one would expect 20% of the 10% subsample or 4.6 incidents to fall within that first zone. Likewise, 40% of the 23 or 9 should fall within the zone delimited by zone two, which had a zone boundary denoted by the HEI number of 124.4.

RETURN RATES FOR TRIP REPORTS

521 trip reports were returned from the Humphrey's Basin study area, 324 from 1999 and 197 from 2000. There are several ways to judge the success of this return. One way is to compare the number of returned reports with the number of reports actually put into the hands of overnight visitors. Because of the logistical difficulties of administering this study, such a comparison can only be broadly estimated. Given the numerous distribution points – pack stations, mountaineering centers, ranger stations, visitor centers, etc. – and the length of the study periods, no census of the actual number of trip reports given to visitors has been conducted. A general estimate is that between 6,000-7,000 were handed out for all areas in 1999. 1455 trip reports were returned from all areas that same year. No figures are available for Humphrey's Basin alone. For 2000, around 2,000 reports were probably handed out in the three areas. Of those 397 total were mailed back. So, 1999 had a return rate (using 6,500 as the number given out) of 22.3%. 2000 had a rate of 19.8%. This is a rough measure of the percentage of permitted parties who knew of the study and participated.

Another way of judging the participation rate is to compare the number of returned reports with the number of permits issued. This analysis can be done on the study areas separately. 1007 permits were issued for Humphrey's Basin trailheads in 1999. That is a return rate of 32.2%. This was the second highest rate return rate of the nine study areas. 644 permits were issued for use in the Mono Creek study area, which is located directly to the north of Humphrey's Basin. 139 trip reports were returned from there, a 44.7% rate. The lowest return rate, 16.1%, was in the Rush Creek area. 323 permits were issued for there and 52 trip reports returned. The percentage of reports returned against permits issued for all nine areas was 25.1%, 1371 against 5467 (one study area had no figures for permits issued). No figures were available for permits issued for 2000. This analysis begs the question of whether in this kind of study returns rates are of the same significance as they are in studies of visitor satisfaction. In those traditional recreation research studies consensus on the quality of experience is sought after. This study seeks to uncover use patterns, and for that there is no precedence established for how much data is needed to accurately establish those patterns.

RESULTS OF THE HEI MODEL

The presentation of the model results is done for all results, first nights, and last nights, as defined above. The table of the frequency statistics of the hiking time segments lists the results of the HEI analysis (table 1). The mean figure of 209.2 for all segments represents the cost in minutes of hiking effort that sampled backpackers expended on the average segment for all trips included in this survey. Histograms for all results and each of the two sections of analysis graphically present the distribution of hiking times (figure 1).

Segments	All	First	Last
n	460	228	232
Mean	209.20	178.57	239.31
Median	199.01	138.79	233.56
s	107.61	100.61	105.96
Minimum	4.74	4.74	22.24
Maximum	662.54	457.92	662.54
Range	657.79	453.18	640.30
20th percentile	116.49	88.80	135.18
40th percentile	179.82	124.44	202.46
60th percentile	231.22	188.19	265.10
80th percentile	295.85	278.96	302.50

Table 1: Results of HEI model, in minutes of hiking effort.

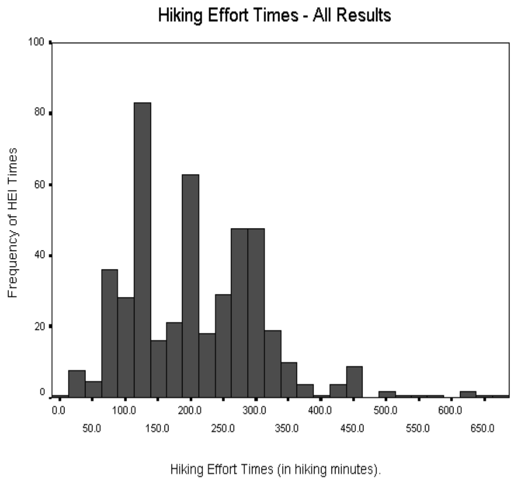

Figure 1: Histogram of hiking effort times for all segments run in the HEI model, n = 460.

TEST RESULTS OF HTI MODEL

The models of first and last nights both performed well. All 23 values of the test sample for both models fell within the study zones. As a whole, the first night model slightly underestimated the values, while the last night section slightly overestimated the values. For the 20th percentile, first nights were 35% under the expected value. Last nights were 35% over. First nights were within 2.2% of the expected value at the 40th percentile. Last nights were 23.3% over there. At the 60th percentile, first night values came within 1.4%. Last nights improved to being only 8% over the value. First nights stalled at the 80th percentile, and fell to being 24% under. Last nights held steady at 7.4%, this time being under. On average, the first nights section was 12.5% under the expected value. The mean of the discrepancy figure for last nights was 14.7%. The average accuracy for both sections was therefore 13.6% within the expected value. Chi-square tests on both sets of results confirm the accuracy of the model. With 4 degrees of freedom, the 95% chi-square statistic is 9.488. If the first and last nights sections were accurate one would expect to get chi-square results below 9.488. The first nights chi-square result was 1.609. The last nights result was 2.314.

DISCUSSION

The results of the hiking time analysis were not normally distributed. Both the first nights and last nights sections evidence multi-modal distributions. Both sections are positively skewed as well. Due to the presence of an obviously anomalous outlier, the range of all the results was inflated. This outlier, the maximum value of all results, was from the first nights section and represented a result so large that it was almost definitely the product of an error. Removing that value from the database reduces the range of results by 160 minutes of hiking time. Still there was great variance in the times recorded.

Removing the outlying values from the high end and some from the very low end in each section produces much more tightly grouped results. Once this is done it's clear that most segments took between 75 and 325 minutes of hiking time. The most frequently recorded times were 125 minutes and 200 minutes. The last nights had a larger corrected range than did the first nights. Both the last nights and the first nights had strong multi-modal distributions. Though there was a range of values in the percentiles listed in the table of results, that range wasn't that great. This supports the findings that there was a strong tendency of the results to cohere around the mean values. Not surprisingly the values for each of the percentiles grew larger as nights got later in the represented trips.

Despite the presumed diversity in personality types, levels of experience, goals and expectations of visitors to the study area, the hiking effort index results reveal some significant trends about hiking behavior taking place there. As the frequency statistics show, an average hiking segment in Humphrey's Basin took about 3 ½ hours of hiking time. The bias of the results to the positive side indicates that there are some hikers who, for at least part of their visit, hike for a much longer time than the average. This was to be expected. Still, contrary to expectations, these extreme hikers represented a relatively small percentage of the entire population of backcountry visitors. First night hikes, those from the trailhead to the first campsite, on average were the shorter of the two sections. Last nights were on average more than an hour of hiking effort longer. One can infer that visitors covered less ground early in their trips, increased distances as they went along, and did their longest hikes to return to the trailhead from their last campsite.

The spatial significance of the distributions of hiking times in all sections was marked. Most important is that these distributions show that campers preferred some areas to others, and that that preference had a very definite spatial aspect. The peaks in the histograms of hiking times correspond to those areas in Humphrey's Basin where visitors camped most often. For the results from all incidents, the most popular areas were those that correspond spatially to the hiking times of first, 125 minutes, and second, 200 minutes. The third most popular locations are those that correspond spatially to the hiking times grouped from 250 minutes to 300 minutes.

Another revealing occurrence is that the contrast of these popular times from the times next to them is so great. The 120-minute section in the histogram of all results had a frequency of 84. The sections on either side of it had frequencies of only 16 and 28. That means the 120-minute time, and destination, were much, much more frequented than those right next to it.

Thus, visitors repeatedly chose to camp at destinations that corresponded to very specific and narrow hiking times, and chose to pass over areas that were just around it. Thus the model demonstrated a very fine level of resolution to the spatial aspects of visitor behavior in the study area.

CONCLUSION

The results of this study strongly suggest that accurate spatial modeling of human behavior in dispersed recreation settings is possible. Limitations of the data collection methodology notwithstanding, the HEI model accurately simulated where backcountry visitors would camp. Additionally, the model characterized the differences in hiking behavior between the different portions of visitor trips. These attributes of the HEI model could assist recreation managers in understanding the spatial and temporal aspects of use in their protected areas. All human hiking behavior is a combination of "push and pull" influences, i.e. effort and attraction. This model concentrated on the "push" factors. Further study should entail modeling the complementary facets of the relative influence of landscape attractions – the "pull" of prime camping locations, scenic vistas and peaks for climbers – on visitor distribution.

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Cyclical Visitor-Behavior Patterns of Urban Forest Recreation Environments and their Determinants – A Statistical View

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Abstract: Urban forest recreation environments have their particular rhythms, not only natural periodicities, but also periodicites of their human members (vistors, rangers,...). A human forest ecosystem as a basic unit of analysis can be defined as an interaction between the population, the organization of forest and the technology in response to the environment. In order to manage such forest ecosystems information about the recreation demand of visitors is needed, particularly about the rhythms of the visitor flow. A scientific project in Stuttgart, a town in South-Germay, provides for an example. The central objective of this paper is to detect periodicities in a time series of frequencies of certain groups of visitors, observed by a fix video camera over one year (March 1999-March 2000) (n=1421 measurements). A not widespreaded statistical method, the spectral analysis, will be applied on the data. Certain periodicities can be found, especially a day-cycle, week-cycles and year-cycles for the various groups of visitors. Impacts of weather (sunny, cloudy, rainy) and weekday (weekend or not) have significant influence on the visitor flow. A simulation illustrates the shape of the cycles, which are detected.

INTRODUCTION

Urban forests as human ecosystems have their particular rhythms, and member of Homo sapiens – vistors, residents, rangers – are part of them. To manage this forests without a sense of these rhythms is unrelastic, myopic and not sensible. The concept of „human ecology“ proposed by Hawley (1950, 1986) can serve as theoretical framework for both urban forest management and urban forest research. The human ecosystem as a basic unit of analysis is defined „by the interaction of *population*, *social organization*, and *technology* in response to *environment*“ (Machlis, 1989, p.158). This interaction can be recognised as a mutual adaption of this four components in a biological sense

In Germany there is a lack of detailed knowledge not specially of the biological ecosystem or of the social organization but of the visitor behavior and of its rhythms. Therefore the focus of this paper lies on the research of visitor behavior and its periodicities in a forest recreation environment. A forest science project in the forest of Stuttgart provides for the database. The research issues of this statistical-method orientated paper are:

1. Are there any periodicities in the visitor flow over one year?
2. Differ various groups of visitors as walker, jogger, cyclist in their periodicities?
3. Are there any impacts of weather or week-day on the frequencies of visitor?
4. Is it possible to simulate the visitor flow over one year?

THEORY

The concepts of forest recreation environment in Germany differ widely form the concepts in the USA. In the USA this theme is discussed under the heading of park and wilderness management. That means ecosystems f.ex. forests are diveded in one part, the park, which is easy accessible for visitors and in another part, the wilderness, which is not accessible for visitors, because there is a lack of clear path, roads... and in the whole a lack of safety. Due to the ecological micro structures of German forest ecosystems there is no park culture in Germany. The forest have to fullfill simultaneously multiple demands: recreational needs, nature protection and natural ressources (wood...).

Although the views of forest recreation environment in USA and Germany don`t accord, the theoretical concepts of park management, f.ex. suggested by Agee & Johnson (1988) can be used by German forest scientists and environment psychologists for research and design of forest recreation environments, particularly the theory of human ecology. The roots of human ecology lie primarily in general ecology, sociology, and anthropology. It is faced with the relation between physical environment and behavior. The two key assumptions of human ecology for Machlis (1989, p.161) are: „Assumption 1. Homo sapiens is both biological and cultural. A significant portion of human social behavior is biologically determined... Assumption 2. Homo sapiens is ecologically interdependent with the natural world." Support for the first assumption comes strongly from the discipline of socialbiology (Wilson, 1975). Johnson & Agge (1988, p.6) stress on four elements of biological and social systems:

(1) „Ecological systems are continually changing.
(2) There may be substantial spatial heterogeneity in impacts from particular action.
(3) Systems may exhibit several levels of stable behavior.
(4) There is an organized connection between parts, but everything is not connected to everything else".

The temporal and spatial properties of both parts the biological part and the human part seem to be essential for the consideration of forest (human) ecological systems. Marlies (1989) asks the question, what we need to understand an ecological recreation area in order to mange it wisely. Beside the knowledge about the physical environment, information of the various groups of human populations, that use the park and their visit flows is needed.

This brings us to the viewpoint of this paper: to look on the temporal properties of visitor flows in recreation areas. Form a statistical perspective you have a time series of observed behavior frequencies of different kinds of visitors f.ex. walker (Möbus & Nagel, 1983; Schmitz, 1989). You can analyze time series in the time domain or as here suggested in the frequency-domain, which is up till now not widespreaded in the social sciences and particularly in the environmental psychology (Larsen, 1987; Mc Burnett, 1997). In its most general form, spectral analysis involves decomposing a time series into several periodic functions. It is somewhat like a regression analysis in that the objective is to account for variance in the data by fitting a model, whereby the model is nonlinear. Brigola (1997) and Butz (2000) offer introductions in fourier-transformation, an other word for spectral analysis. The harmony in music or the moon cycle can be helpful to understand the basic ideas of spectral analysis.

Suppose a periodic oscillatory wave as the tone „a" of a violin, which can be made visible by an oscillator. This observed wave as a kind of time series y_t will be understood as a combination of certain pure waves (sinus tone in music). Such a wave can be characterized primarily by a **periode P** or a **wave length**, that is the time, in which a cycle once recurs. The moon cycle has a period about P=26 days. 1/P is the **frequency f**, the proportion of the cycle, which is realized in one time unit. For example 1/26 of the moon cycle is realized in 1 day. The **amplitude A** describe the height of the wave. If you take the unit-circle with the circumference of 2π , than you can get the **circle frequency** $\omega=2\pi f$. You can move the whole wave on the time axis. This was called **phase** θ. The cosinus- and sinus-functions have periodic properties. Therefore this function will be used for the following function (1) with k different harmonic waves:

$$(1) \qquad y_t = \sum_{j=1}^{k} A_j \cos(\omega_j t + \theta_j) + e_t$$

where e_t is a stationary random series and t is the time. Using the trigonometric identity $\cos(\omega+\theta) = \cos(\omega t)\cos(\theta) - \sin(\omega t)\sin(\theta)$. Equation 1 can be written as

$$(2) \qquad y_t = \sum_{j=1}^{k} a_j \cos(\omega_j t) + b_j \sin(\omega_j t) + e_t$$

where $a_j=A_j \cos\theta_j$ and $b_j=-A_j \sin\theta_j$.
The function f in equation (2) is periodic in t in the sense, that

$$(3) \qquad f(t+P) = f(t), \qquad (-\infty < t < \infty)$$

To estimate the parameters, the Fourier coefficients a_j und b_j, the Least-Squares method can be applied. The sum of quadratic errors e_t is thereby to be minimized.

As mentioned before the variance of the time series can be decomposed into the variances for each fourier-frequency f_k. This is called **periodogram**:

The sum of $I(f_k)$ over all f_k is the total variance of the time series σ^2_y. As in regression you can express each periodic function with its variance components as proportion to the total variance. In regression analysis this proportion is called coefficient of determination. The function I_k can also be used for **white-noise-testing** (Fisher's Kappa). If the time series consists only out of white noise, than the normalized y-coordinates of the periodogram $I(f_k)/2\,\sigma^2_y$ has a χ^2-distribution with 2 degress of freedom (Schlittgen, 2001, p.88). If there is some periodicity in the data, one period of the periodogram must show a big value. Therefore the maximum of $I(f_k)/2\,\sigma^2_y$ will be used as empirical test-value Z. The probability of H_0 „White noise" is:

$$(4) \qquad I(f_k) = n \cdot (a_k^2 + b_k^2)/2$$

$$(5) \qquad P(Z > z) = 1 - (1 - e^{-z})^{(N-1)/2}$$

whereby z is the observed maximum of the periodogram and N is the number of timepoints. For a periodogram-interpretation the following issues must be taken into account:

(1) Alising: Only periods P till 2*time units can be observed. To detect a two-week-cycle for instance one measurement per week on two weeks is at least necessary. If there is a cycle with lower frequency it cannot be detected, but it appears hidden as long wave. Therefore it is

important to choose a adaequate decomposition of the observed time series.

(2) Leakage: If the time series is short, there is not only a great peak in the periodogram in the main frequency, but also in the nearby frequencies. This effect decreases with increasing n.

(3) Missing-Values: To detect periodicities in a time series it is necessary to have a series without missing values.

For the last problem Schlittgen (2001, p.183f) offers several solutions. One is to replace the missing values with the average over all data. Another method takes into consideration the specific autocorrelation structure of the values nearby the missing value. At first the p-order autoregressive process AR(p) is estimated. At second the predicted values which replace the missing values are estimated by minimizing the following sums of squares of errors e_t (SS) with known autoregressive parameters α:

$$(6) \quad SS = \sum_{t=p}^{N} e_t^2 = \sum_{t=p}^{N} (y_t - \hat{a}_1 y_{t-1} - \ldots - \hat{a}_p y_{t-p})^2$$

If the partial derivatives of (6) $\delta SS/\delta y_t$ for each missing value is set to zero the predicted values are the solution of a linear equation system.

Up till now only one series is observed. If you consider simultaneously more than one time series, the multivariate spectral analysis offers you many possibilities for the analysis (Priestley, 1996, p.660). One of them is the **coherence-diagramm**, which shows for each frequency, how much the two time series are correlated. The coherence-coefficient varies between 0 and 1.

To test the influence of weather and weekday on the visitor flow a regression analysis will be used, which take into account the specific autocorrelation structure of the data, f. ex. a regression with an AR(2)-process of the random component e_t (Mutz, 1998, Becker et al. 1998) and x_j as the predictors:

$$(7) \quad y_t = \sum_{j=1}^{m} \beta_j x_{jt} + \varepsilon_t$$

$$u_t - \alpha_1 u_{t-1} - \alpha_2 u_{t-2} = \varepsilon_t$$

After the presentation of the mathematical-statistical background we return to central question of this paper. Within the scope of one year several cycles (day, week, month, year) are expected to recur. The cycles of different visitor groups don't differ very much, only such between jogger and walker. The joggers start earlier in the morning or later in the evening with their forest-visits than the walker. In will be supposed, that at weekend and at sunny days the frequencies of visitors rize at maximum.

METHODS

The data are taken from a forest-science project of Janowsky (2002). The central objective of this project was to work out a forest-paths-concept for the forest of Stuttgart, a town in South-Germany, which fullfill not only the economic, but also the leisure demands for this forest. In one part of this study the visitor flow over 1 year should be observed. The data are collected by an observation-study which took place one year each day from 6 a.m. to 10 p.m. (March 1999 - March 2000), whereby the monitoring was done by a motion-sensitive fixed video camera. The data for the statistical analysis are generated by counting the behavioral events on the videotapes, aggregated for 8 time-units of 2 hours per day. Not only the total visitors are counted, but also different groups of visitors: walker, jogger, cyclist and others (cars...). The last one are not included in the statistical analysis due to its low frequencies. Additionally the weather is categorized in three groups: sunny, cloudy and rainy. For the regression analysis the categories are transformed by effect coding into dummy-variables (Cohen & Cohen, 1983). For a detailed discussion of the design and sampling see Janowsky (2001).

Because of breakdowns of the video camera only n=191 days out of 366 days can be analyzed. In order to apply the spectral analysis, the above mentioned method was used to replace the missing values with estimated values. Additionally a cubic polynomial week-trend was assumed. To estimate these values very precisely, for each month a model was fitted. The *proc autoreg*-procedure of the statistic software-program SAS was used with a slightly different algorithm as described above. Figure 1 and Figure 2 show the time series without and with replacement.

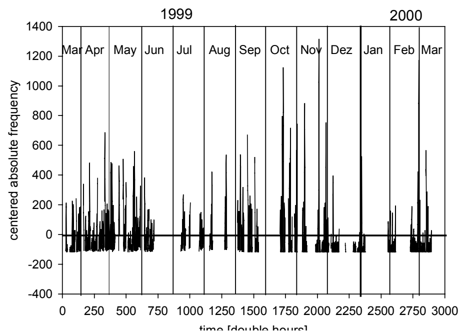


Figure 1.: Raw time series without missing value replacement

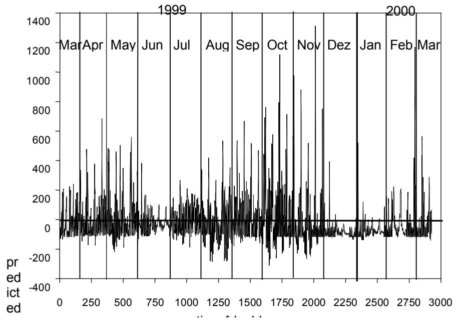


Figure 2.: Time series with missing value replacement

The total structure of the time series can be maintained by the replacement. In June 1999 or in Januar 2000 there is lack of data. Therefore the estimations are rather poor. But without substitutions spectral analysis generates misleading results. At the end 2928 double hours from 53 weeks with 5-7 days and 8 double hours per day build up the database for the spectral analysis, which is outperformed by the *proc spectra*-procedure of SAS.

RESULTS

First, descriptive statistics are calculated to describe the distribution of the frequencies. Table 1 shows the essential statistics of the distribution of frequencies over one year, seperated for the visitor groups, and total.

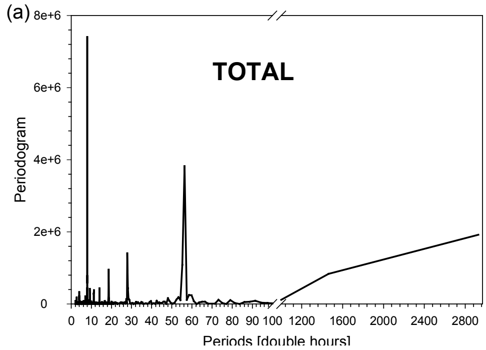
	M	STD	MIN	MAX	CV
walker	84.0	143.9	0	1372	171.3
jogger	27.4	34.7	0	399	126.6
cyclist	4.3	7.4	0	51	172.5
total	115.6	165.5	0	1428	143.1

Table 1.: Descriptive statistics of the raw frequencies over the whole year March 1999-March 2000 (n=1421 double hours).

As expected the walkers has the main proportion to total with a mean value of 84 per double hour and day. Than it follows the group of the joggers with a mean frequency of 27.4 and the cyclists with 4.3. The distribution is strongly asymmetric with few very high values f.ex. a maximum of 1428 visitor in double hour. To avoid biased estimates in spectral analysis these few outliers (>99% of the distribution) are replaced by the mean value. Additionally the time series was centered before the spectral analysis takes place.

Second, it was tested whether the time series is white-noise (random fluctuation). Fisher's Kappa was calculated for each visitor category (total, walker, jogger, cyclist): $T_{total}=251.88$ $p<0.01$, $T_{walker}=158.87$ $p<0.01$, $T_{jogger}=96.12$ $p<0.01$, $T_{cyclist}=300.35$ $p<0.01$. All four time series show significant periodicities. But it must be taken into account that the high sample size makes it difficult, to maintain the statistical hypothesis H_0. Other white-noise-tests as Bartlett`s Kolmogorov-Smirnov Statistic however show similiar results.

Third, the periodogram will be estimated for each visitor group and for total. Figure 3a,b show the periodograms for total and for the group of the walker. Instead of the fourier-frequency f=1/P the period P is used.



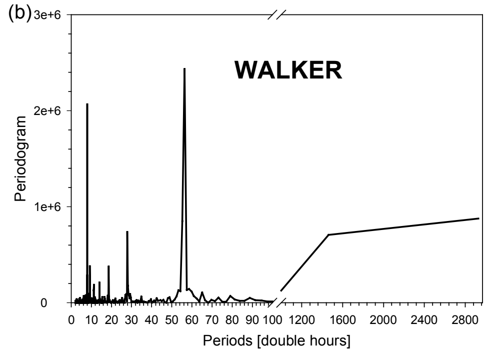


Figure 3.: (a) periodogram for the total time series (b) periodogram for the time series of the walker

The similiarity of the periodogram of figure 3a and 3b is obvious. The peaks in figure 3a indicate important cycles: at period 8 a day-cycle, at period 18.65 a 1/3week cycle, at period 27.5 a 1/2week cycle and at period 56 a week cycle (=7 days * 8 hours per day). Additionally a 1/2year-cycle at period 1464 and a year-cycle at period 2928 recur. 17.2% of the total variance of the total time series is accounted by the day cycle, 8.9% by the week cycle, 4.5% by the year cycle and 1.9% by the 1/2year-cycle. Similiar results can be found for the walker.

Therefore the day- and week-periodicity are more important than the year-cycles. Significant month-rhythms are not observed. The time structure of the visitor flow is mainly influenced by the group of the walkers. Nearby the big peaks you can find many small peaks, which probably indicate a leakage effect. Due to the high importance of the day cycles, the time series needs at this time area more differentiation. Random fluctuation in the data can be another cause for this phenomena.

In figure 4a,b you can find the periodogram of the groups of the joggers and the cyclists.

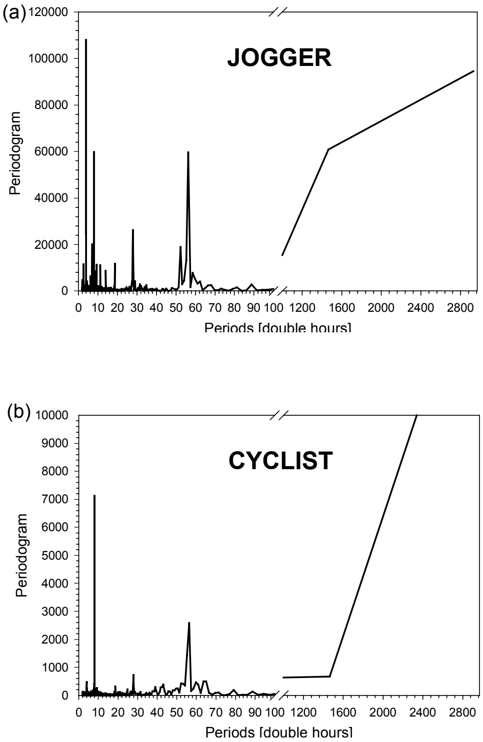


Figure 4.: (a) periodogram for the time series of the group of the jogger (b) periodogram for the time series of the cyclist

If you compare figure 3a/3b with figure 4a/4b the similiarity between this figures is apparent. The peaks in figure 4 at period 8, 18.65, 28 and at period 56 indicate a day-, 1/3week-, 1/2week- and week-cycle. A 1/2year- and year-periodicity is also found, particularly for the jogger. But there are also differences. Concerning the joggers it can be found at period 4 a 1/2day-cycle, which has the greatest explained variance-portion. It follows the 1/2year and the year-cycle in explaining the total variance of the time series at second best. While for the joggers the day-/year-periodicities play a central role, the year-cycle is essential for the cyclists. This frequency explains about 20.5% of the total variance in the time series of the cyclists. Riding a bike or jogging depends heavily on the season (warm/cold). Jogging is a sport, which takes place almost early in the morning or later in the evening, which explains the half-day-cycle.

Fourth, coherence-diagrams can illustrate, how much the time series of a special visitor group is connected to the time series of another group for certain frequencies. In Figure 5a, 5b, 5c the coherence-diagrams for the correlations between each of the time series of the three visitor groups are shown. Instead of the periods the circle frequency 2πf was used. Walker and jogger, walker and cyclist show high correlations (>.60) rather in the higher frequency domain with circle frequencies smaller than 1.0 or periods beginning at 6 (3/4day) ending at 2928 (year).

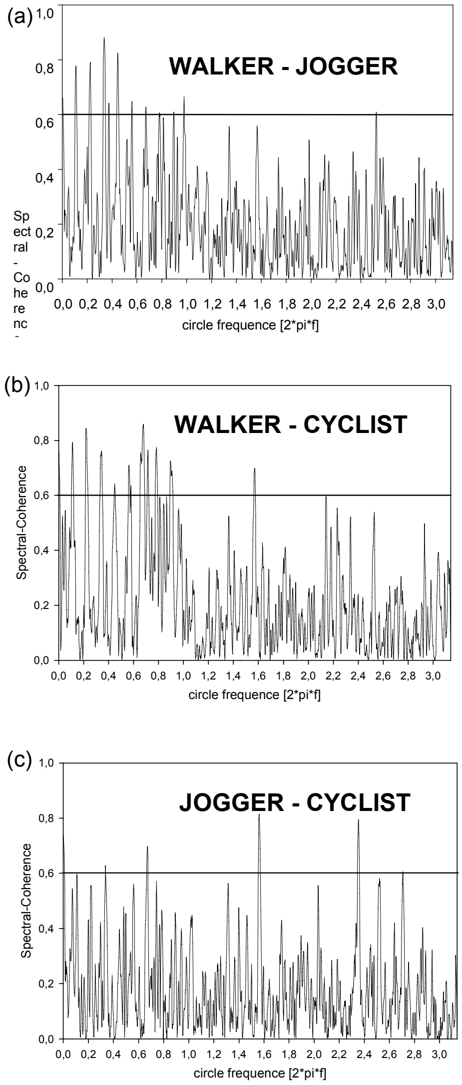


Figure 5.: spectral coherence diagram for the time series of (a) walker-jogger (b) of walker-cyclist (c) jogger-cyclist, seperated for each circle frequency. (vertical line=correlation of .60).

In the coherence diagram *jogger-cyclist* (figure 5c) the correlation for the circle frequency under 1.0 are not so high as in the in the latter one, but there are single peaks at circle frequency at 1.57 and at 2.6, which indicate a high correlation of the 1/2day-cycle and 1/3day-cycle of the two time series. While for joggers and cyclists intraday cycles are strongly joined together, for walkers and cyclists, walkers and joggers week-cycles are strongly related. In spite of differences between the three visitor flows this result claims some support for the strong relation of the three time series, particularly concerning the week- and year-cycles.

Fifth, a regression with an AR(3)-process was calculated to prove, whether weekday and weather has an impact on the total visitor flow. This analysis is only outperformed for the month of april, because for this month over 80% of the data have non-missing values in all variables. 74.3% of the frequency-variance can be accounted by the model. As expected a significant effect of the weather was found. Sunny weather simultaneously increases the frequency about 39 persons, rainy weather decreases the frequency about the same number of persons. Cloudy weather has no effect. But also when the weather is nice at one time, two hours later, but not four hours later, the frequency of visitors increases. For the weekend the flow of visitors increases too. If the weather is nice and it is weekend, then four –not two– hours later the flow of visitors is strongly raised. This results are only valid for the month of april.

Sixth, a simulation is done to illustrate the shape of the cycles which are detected. Figure 6 shows the predicted mean-centered time series from a 1-day-, 1/3week-, 1/2week-, 1/2year-, year-cycle using the estimated fourier coefficients a_j and b_j and equation (2).

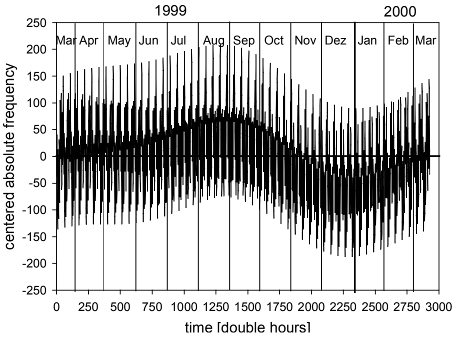


Figure 6.: Simulated time series over 1 year

In figure 6 you can well recognize the day-periodicity and the year-cycle, beginning in march, increasing till august and decreasing heavily in november and december.

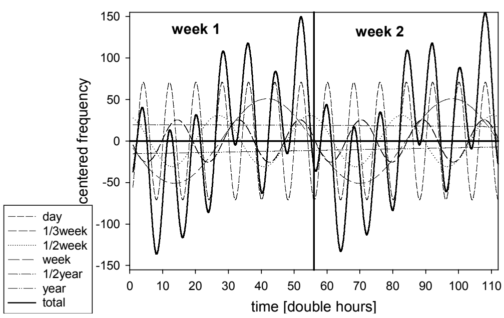


Figure 7.: Simulated time series for two weeks in march 1999

Figure 7 decomposes the simulated time series of figure 6 into its components or basic waves for two weeks in March 1999. The strong influence of the day periodicity on the total periodicity can be demonstrated. This day-cycle is overlayed by certain week cycles, which bring about the chacteristic shape of the total frequencies in one week.

CONCLUSIONS

Urban forests as human ecosystems have their particular rhythms, and member of Homo sapiens – vistors, residents, rangers – are part of them. To manage this forests without a sense of these rhythms is unrealistic. Therefore special methods of data gathering and data analysis must be choosen to find such periodicities. The data are taken from a forest-science project of Janowsky (2002). The central objective of this project was to work out a forest-paths-net-concept for the forest of Stuttgart, a town in South-Germany, which fullfill not only the economic, but also the leisure demands. One area of questions emphasizes the visitor flows at a important position in this forest.

The study should *at first* prove, whether there are any periodicities in the visitor flow over one year. Certain periodicties can be found. Particularly a day-cycle, but also week and year-cycles play an important role in explaining the whole time series. Month periodicities are not detected. The coherence diagramms claim some support, that this result can be generalized over all visitor groups (walker, jogger, cyclists).

Secondly, the study should give an answer to the question, whether the weekday (weekend or not) or the weather at certain hours have a strong impact on the visitor flow. Such influences can be found, especially lagged influences of weather.

Thirdly, the estimated fourier coefficient allows us to simulate the time series of the total visitor flow. The peaks of high visitor frequencies in summer (july, august, september) and rather low frequencies in winter (november, december) were obvious.

This paper should introduce in a statistical method, not very widespreaded in the social sciences and the forest science using an empirical example. The problems of this methos as alising, leakage, missing value are discussed. New perspectives as the multivariate version of spectral analysis was outlined. This method allows to connect under an ecosystem or human ecology perspective natural periodicities of forests with the periodicities of humans, particularly their utilization behavior f.ex. walking, jogging...

The next generation of statistical analysis of periodicities has just started in the psychology and social sciences under the title of „chaos theory“. But the proponents of this movement recommend in a first step the application of spectral analysis (Robertson & Coombs, 1995; Kiel & Elliott, 1997; Alisch, 2001). A detailed discussion of this new, very sophisticated, but not yet established methods would go beyond the scope of this paper.

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Monitoring and Management of Visitor Flows in Recreational and Protected Areas
Conference Proceedings ed by A. Arnberger, C. Brandenburg, A. Muhar 2002, pages 225-232

Modelling the Dependency between Visitor Numbers and Meteorological Variables via Regression Trees

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Abstract: We propose using regression trees as a flexible and intuitive tool for modelling the relationship between weather conditions and day to day changes of the visitor load in outdoor recreation areas. Regression trees offer a number of advantages when compared e.g. to linear models, specifically by outlining different seasonal and meteorological scenarios. When applied to video monitoring data from the Lobau, an Austrian nature conservation area, good regression tree models for the total number of visitors and the counts for some visitor categories (bikers, hikers, swimmers) were found, while other categories could not be adequately represented (dog walkers, joggers). The regression trees indicate a strong relationship between weather and total visitor numbers, as well as weather and the number of bikes and swimmers, respectively. The relationship to weather was found to be only slight for hikers and dog walkers, and completely absent for joggers.

In general, the use of derived meteorological quantities in form of thermic comfort indices for characterizing weather conditions results in better models than the use of directly observable meteorological quantities.

INTRODUCTION

It has been shown (Brandenburg, 2001, Brandenburg and Ploner, 2002) that the number of visitors to the Lobau can be predicted with good results by using a combination of meteorological variables and derived thermic comfort indices which are used to describe human perception of weather conditions. These predictions were based on linear regression models for the logarithmised visitor numbers.

Regression trees are an attractive alternative for prediction because they handle nonlinearity and interactions between variables implicitly. Additionally, they offer a hierarchy of importance of the predictors involved, a classification of the data based on both predictors and the predicted variable, and an intuitive graphical representation of the model.

In this article, we hope to address three basic questions:

1. the basic suitability of regression trees in modelling visitor loads,
2. the possible improvement of model quality when including meteorological information,
3. the relative merits of directly observable meteorological variables like temperature as opposed to derived comfort indices.

MATERIAL & METHODS

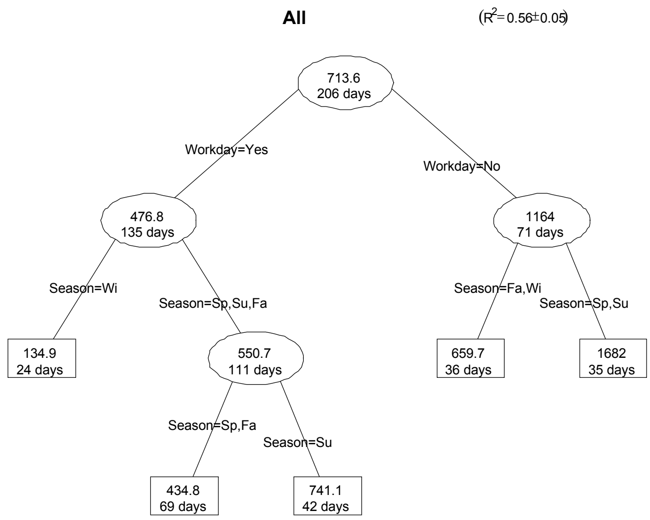
Data Collection

Visitor numbers were gathered using video material collected between August 1998 and September 1999. Cameras were located at five main entrance points to the Lobau. Visitors were counted and assigned to one of several user groups (hikers, dog walkers, joggers etc.). Due to practical problems with camera maintenance, specifically during the initial phase of the project, complete data from all five video stations was available for 206 days (out of 426) only. While we were able to interpolate missing visitors numbers quite well by using the results of the non-compromised stations, we have followed the decision of Brandenburg, 2001, to use only the 206 complete days for modelling. In order to take into account obvious fluctuations in visitor numbers, these days are classified as either 'workdays' (working days) or ''holidays' (i.e. either weekend or a public holiday).

Meteorological data were obtained from a nearby weather station. The technical details of the data collection are described in Brandenburg and Ploner, 2002.

We have modelled both total visitor numbers per day and the counts for five user categories:

Figure 1.Regression tree for the total visitor number per day, using only seasonal information.



- Bikers and hikers make up the main part of visitors to the Lobau.
- Dog walkers and joggers are comparatively smaller user groups, but with potentially high impact on the local wildlife.
- Swimmers also represent a smaller visitor group, though through the typically longer duration of their stay, they tend to have high ecological impact.

Numerous meteorological variables have been considered for their relevance in recreation behaviour (Brandenburg and Ploner, 2002). For use as independent variables in the regression trees, we have found it sufficient to work with ambient air temperature, relative humidity, wind velocity, precipitation, vapor pressure, and solar radiation, each observed at 2 pm.

The meteorological elements listed above were use to calculate a number of *comfort indices.* These indices are combinations meteorological variables that are designed to measure the subjective perception of weather on a one-dimensional scale corresponding to the everyday use of 'good' and 'bad' weather as opposites on a fairly continuos scale. For our current work, we have considered four parameters:

- Equivalent Temperature (Auer et al., 1990),
- Effective Temperature (Auer et al., 1990),
- Chill Factor (Becker, 1972),
- Physiologic Equivalent Temperature (Matzarakis et al., 2000).

Definitions and some background information on these indices is given in Brandenburg, 2001.

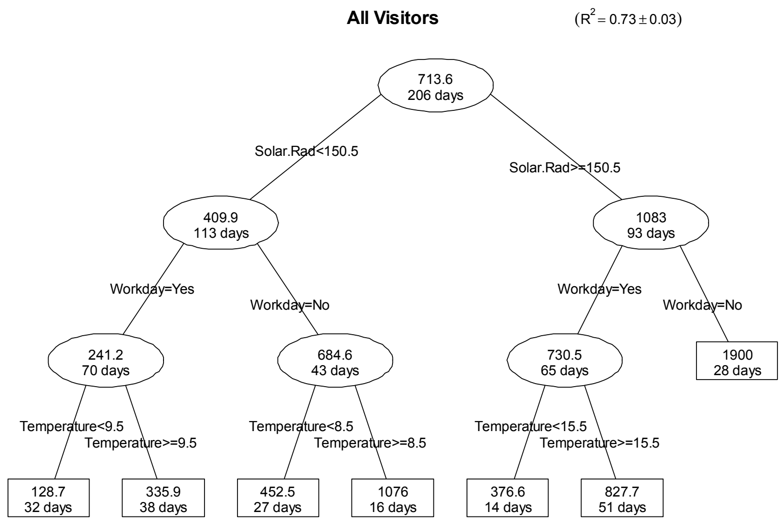
Working with regression trees, we have found the Equivalent Temperature (T_{eq}) to be the most useful comfort index: it gave persistently better results than the others, and was the only one that offered high quality models for visitor numbers on its own, without including either one of the other comfort indices or some meteorological variable.

Classification and Regression Trees (CART)

Regression trees describe the relationship between a response variable and a set of independent variables by recursively partitioning the data set at hand. The methods and terminology described in the following are due to Breiman et al., 1984.

Starting with the full set of observations, the current set is divided in two so as to make the two new subsets as homogenous as possible in regard to the response variable. This process is repeated until all subsets appear to be sufficiently homogenous. The resulting partition of the data set can be described by a binary tree, where each terminal node represents a subset of the observations, and each interior node represents one of the splitting rules. The value predicted by the model for each of the terminal nodes is then an appropriate summary function of the response variable within that node, usually the mean. Figure 1 shows the graphical representation of such a tree for the daily total number of visitors to the Lobau: internal nodes are shown as ovals, terminal nodes as rectangles, and

Figure 2. Regression tree for the total visitor number per day, using seasonal information and meteorological data.



the corresponding splitting criterion as edges; each node contains the average visitor load for the corresponding subset (first line), and the number of days in the subset (second line). Starting from the topmost (or *root*) node, which stands for the complete set of observations, we see that the set contains 206 days with 713.6 visitors on average. In the first step, these observations are split up according to whether they were made on a workday (left branch) or on a holiday (right branch). The corresponding nodes show that there are 135 workdays and 71 holidays, with average visitor loads of 476.8 and 1164 respectively. The left node is then split up again, this time according to the season the observation occurred in: winter workdays go to the right, all others to the left. The right node, with 24 observations averaging 134.9 visitors, is a rectangular terminal node that is not split up any further, unlike the 111 days in the left node. In this way, the 206 daily visitor counts are split up into five subsets (terminal nodes) according to workday and season, with visitor loads ranging from 134.9 on winter workdays to 1682 on spring and summer holidays.

In our approach, splitting rules involve only one independent variable at a time: a simple threshold value for intervalscaled or ordinal variables, and a partition of the observed values for a nominal variable. Starting from the root, all possible splits for all variables within a node are considered, and the one which produces the greatest homogeneity is chosen; the process is then repeated for both subnodes, until all nodes within the tree are sufficiently homogenous. While this stepwise procedure does not guarantee that the resulting tree is optimal overall, it assures that important splits happen before less important ones ('further up' the tree).

Regression trees that are grown only with regard to the homogeneity of the terminal nodes are well known to overfit the data badly, resulting in needless and irreproducible complexity of the model. This is avoided by balancing the size of the tree against its cross-validated predictive power: the initially grown maximally homogenous tree is cut back progressively by removing terminal branches, resulting in a sequence of trees of decreasing complexity and increasing cost (in terms of loss of predictive power). Among these trees, the most parsimonious one is chosen. This process is known as *cost-complexity pruning*.

It has the added advantage that the tree model comes together with a crossvalidated estimate of the model quality. This estimate is calculated by splitting up the data set randomly in ten subsets and refitting the tree ten times, while leaving out each one of the subsets in turn. The trees grown on ninety percent of the data are then used to predict the average for the left-out ten percent. The combined mean squared predictions errors of the crossvalidation runs, divided by the sample variance, is called *relative error* (*RE*) by Breiman et al. (1984, chapter 8.3). In this article, we use the equivalent *coefficient of determination*, which we write in a slight abuse of notation as

$$R^2 = 1 - RE\ .$$

As Breiman et al. (op.cit.) note, R^2 as defined above is not really the same as in linear regression, specifically it is neither the square of a correlation coefficient nor can it be properly interpreted as the amount of variance explained. Still, it is a measure of model quality, with values close to one implying good predictive power, and with values close to zero implying a poor model. We feel that this is not only more familiar for most researchers, it also makes comparisons with linear models as described e.g. in Brandenburg and Ploner, 2002, much easier for the reader than the relative error.

The R software package we used in our analysis (Ihaka and Gentleman, 1996) relies on the approach described in Clark and Pregibon, 1993, the specific model that we employed (Poisson deviance for counting data) on the implementation described in Therneau and Atkinson, 1997.

Modelling Strategy

We have used regression trees to model visitor numbers in several different user categories under three different assumptions:

1. that apart from the visitor numbers, only seasonal data is available, i.e. in which season a visitor count was observed, and whether on a workday or holiday,
2. that in addition to the seasonal information, we have meteorological variables like ambient air temperature, humidity,etc.,
3. that we have T_{eq} values in addition to the seasonal information.

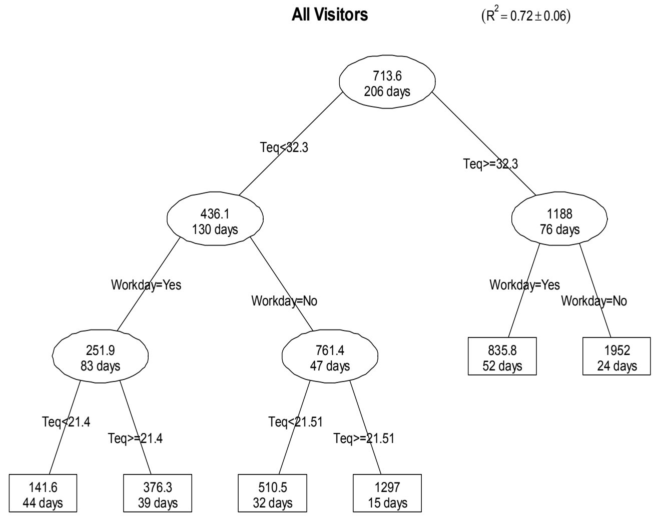
The first class of models serves as a baseline result, telling us how well we can expect to do in predicting visitor loads *without* using meteorological information at all. A comparison of these results with the second and third class hopefully shows the possible improvement in model quality and predictive power when incorporating weather information, and a comparison of the models in the second and third class highlights the respective advantages of directly observed and derived meteorological variables.

RESULTS

Total Number of Visitors

Figure 1 shows the regression tree using only seasonal information. The first split is according to whether a day is a workday or not, and the following splits are according to season: for workdays, spring and fall are grouped together, whereas for holidays, fall and winter, and summer

Figure3. Regression tree for the total visitor number per day, using seasonal informatio and Equivalent Temeprature (T_{eq}).



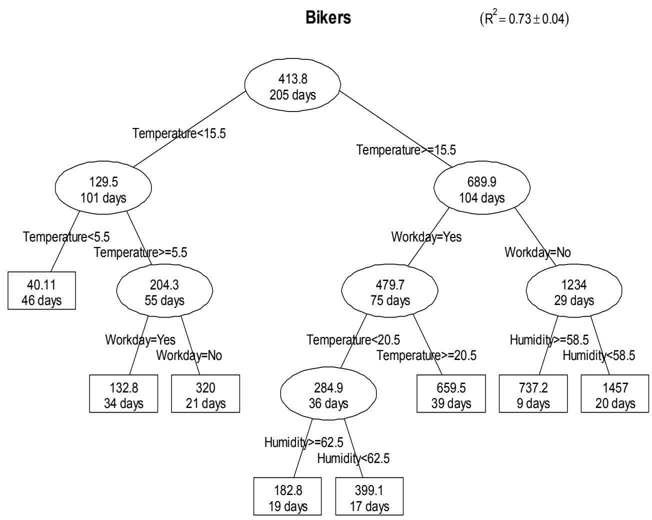
and spring end up in the same terminal nodes. Hardly surprising, the lowest average visitor load is recorded on winter workdays (leftmost terminal node), and the highest on spring and summer holidays (rightmost terminal node). Also, a summer workday has a higher average visitor load (741.1) than a holiday during the colder season (659.7). The overall model quality is quite good for such a simple model (R^2=0.56).

Figure 2 shows the regression tree that incorporates meteorological observations. Here, the main split is according to solar radiation; the next split for both nodes with high and with low solar radiation is into workdays and holidays, and the final splits are by ambient air temperature. The model partitions the observation days into seven subsets, with average visitor loads ranging from 128.7 on workdays with low solar radiation and temperatures below 9.5°C, to 1900 on holidays with high solar radiation. The model quality is quite good (R^2=0.73) and clearly higher than for the seasonal model in Figure 1. For the total number of visitors at least, using meteorological variables clearly improves the model. The resulting model is also remarkably balanced, in the sense that the second-level splits are on workday, and the third level of splits on temperature, so that the final subsets are defined by the same variables in the same order.

Figure 3 finally shows the regression tree for daily visitor counts using only seasonal information and Equivalent Temperature (T_{eq}) to characterise the different scenarios. The quality of the model is quite as good as that in Figure 2 (R^2=0.72 instead of R^2=0.73), though with a slightly higher standard error (s.e.=0.06 instead of s.e.=0.03). The root node is first split into days with T_{eq} below and above 32.3. This is quite close to the distinction between "comfortable' (35.1 to 49) and 'cool' (below 35.1) given for the T_{eq} in Auer et al., 1990, so we adapt these names here for the right and left branches of the tree, respectively. Both comfortable and cool days are then split up according to the workday, and the cool days are then split up again on T_{eq}, into workdays above and below 21.4, and holidays above and below 21.51, respectively. The splitting values for cool workdays and cool holidays are very similar, so we interpret this as a split between days that are properly 'cold' and days that are merely 'cool', where the limit is at a T_{eq} value of approximately 21.5. The final partition can therefore be read as cold workdays, cool workdays, cold holidays, cool holidays, comfortable workdays and comfortable holidays, with corresponding estimated visitor loads (terminal nodes in Figure 3 from left to right). This is a quite satisfying interpretation, and if we look back to Figure 2, we see that the categories derived using the solar radiation and the temperature can be interpreted in much the same way, though the model contains an additional split of the set of days that we have denoted as comfortable holidays above.

It should also be noted that the models in Figure 2 and 3 do not use the season to partition the observation days. Apparently, the information in both the meteorological variables and the T_{eq} make the rather artificial distinction between traditional seasons redundant in explaining visitor loads for the Lobau.

Figure 4. Regression tree for the number of bikers per day, using seasonal information and meteorological data.



Bikers

The regression tree for the number of bikers per day (not shown), based on seasonal information only, is of comparable quality to the one for the total visitor number (R^2=0.57, see also Table 1), though it is slightly more complex (six terminal nodes instead of only five in Figure 1). Figure 4 shows that again, the inclusion of meteorological information clearly improves the quality of the model (R^2=0.73). The main split here is between days with temperatures above and below 15.5°C: the right branch comprises cool days, while the left branch might properly be designated as 'coolish and above'. The cool days are then split again into outright cold days (below 5.5°C), and moderately cold to cool (between 5.5°C and 15.5°C). Note that even on the 46 cold days, we can expect an average of 40.11 bikers per day! The moderately cold to cool days are split up again into workdays and holidays, with about 2.5 times the average number of bikers on holidays than on workdays. Going back to the root node, the 'coolish and above' days are also split up into workdays and holidays. The holiday branch is then divided one more time, into days with high and low humidity (above and below 58.8%), where humid days see about half of the number of bikers than less humid days. The workdays on the other hand are again divided into coolish and 'comfortable or better' days, according to air temperature (above and below 20.5°C); on the coolish side, we have again the distinction between humid and less humid days (above and below 62.5°C), again with about half the number of bikers for the humid days. Compared to Figure 2, the tree is somewhat larger, and clearly less balanced in the relative importance of the independent variables. This might suggest a more complex relationship between weather and the number of bikers, though it should be noted that the construction of the regression tree in Figure 4 also requires only three independent variables, none of them what might be considered the most obvious meteorological parameter, i.e. precipitation. A possible explanation for this suspicious absence is offered in the Discussion.

Figure 5 shows the regression tree for the number of bikers, using only seasonal information and the T_{eq}. The model shows a clear improvement to the model in Figure 4, indeed it is the best of all our models (R^2=0.81). As in Figure 3, the first split occurs according to the T_{eq}; the splitting value is virtually the same (32.06 instead of 32.3), so again, we consider this as a split between cool and comfortable days. The cool days on the left branch are then split up into cold days (T_{eq} below 21.4) and moderately cold to cool days (T_{eq} between 21.4 and 32.06). The latter are then again divided into workdays and holidays. The comfortable days are immediately split up into workdays and holidays, and only the workdays are further subdivided on the T_{eq}, with splitting value 46.08. In the classification given by Auer et al., 1990, this is at the upper end of the comfort zone (35.1 to 49), already close to the category 'slightly humid' (49.1 to 56). In our case, workday bikers seem to prefer the more humid condition, so maybe here it stands rather for the difference between a 'nice' and a 'very nice' day.

As for the total number of visitors, both the meteorological variables and the T_{eq} make the season redundant.

Hikers

Figure 6 shows the regression tree for the average daily number of hikers, based on seasonal information only. The main split is between workdays and holidays, with workdays further divided into cold season (fall and winter) and warm season (spring and summer), whereas the distinction for holidays is between spring and the other seasons. While the quality is quite good for this simple kind of model (R^2=0.61), adding either meteorological variables or a comfort index (not shown) does not substantially improve the quality of the models (Table 1); these models also differ only slightly from the one in Figure 6, by splitting workdays according to solar radiation and T_{eq}, respectively, instead of seasons, with only minor changes in predicted average visitor loads. Specifically, the distinction between spring and the other seasons remains for holidays, so that the right subbranch is identical to the one in Figure 6.

This implies that for the number of hikers, weather is more relevant on workdays than on holidays, even though its consideration does not

Figure 5. Regression tree for the number of bikers per day, using seasonal information and Equivalent Temperature (T_{eq}).

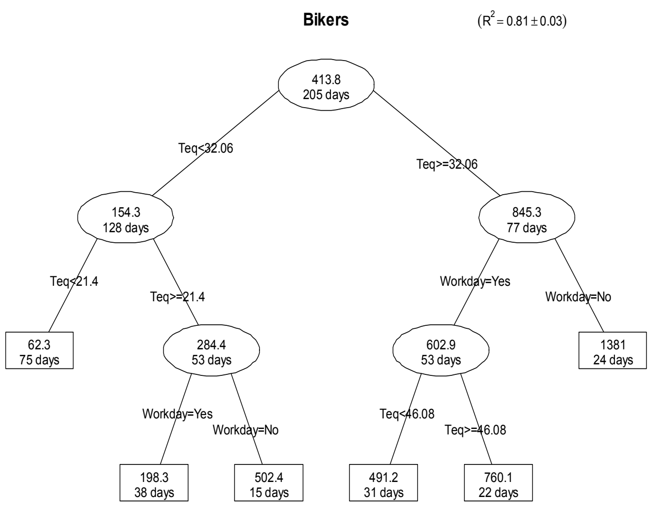
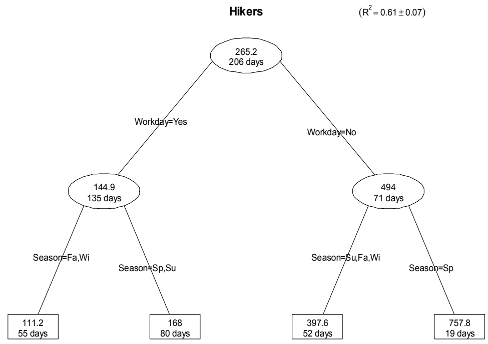


Figure 6. Regression tree for the number of hikers per day, using only seasonal information.



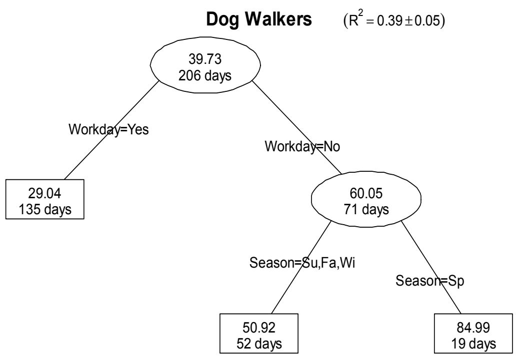
improve model quality substantially. This agrees with the fact that the largest numbers of visitors were observed on the first weekends during spring with tolerable weather conditions (Brandenburg and Ploner, 2002). This seems to indicate that there is a greater willingness for a weekend or holiday walk in the Lobau, regardless of weather.

Dog Walkers

The regression tree for dog walkers shown in Figure 7 is a simplified version of the model for hikers shown in Figure 6: days are split into workdays and holidays, and only holidays are further split into spring holidays and all others. Including either meteorological data or comfort indices did not change this model at all: apparently, the number of dog walkers is quite independent of meteorological conditions. Given the need to walk a dog daily, this is not too surprising, though it might be seen to imply that the majority of dog owners come from the residential areas within walking distance to the Lobau, as it appears improbable that dog owners would travel far under bad weather conditions.

The overall model quality is not good (R^2=0.39), so that apparently, there are factors neither seasonal

Figure 7. Regression tree for the number of dog walkers per day, using only seasonal information.



nor meteorological that cause the variation in the number of dog walkers.

Joggers

The only model we were able to fit to describe the average daily number of joggers distinguishes between workdays and holidays, and is execrably bad (R^2=0.17). The model does not change when meteorological variables or comfort indices are added, so we find ourselves quite unable to make predictions about the average number of joggers.

Swimmers

The seasonal model for the number of swimmers (Figure 8) is quite what we would expect: swimmers only in summer, more on holidays than on workdays. Given the extremely simple structure, the quality of the model is quite good (R^2=0.64).

Adding meteorological variables results in the slightly more complex model shown in Figure 9: no swimmers below 20.5°C ambient air temperature, a few hardened cases between 20.5°C and 24.5°C. Serious recreational swimming starts at 24.5°C, with an average of 20.08 swimmers on workdays and of 70.58 on holidays. While this model also sounds quite plausible, it is even slightly worse than the simple seasonal model (R^2=0.59).

Adding the T_{eq} to the seasonal data, we get the model in Figure 10: no swimmers below a T_{eq} value 42.94, a lot above 42.94 on holidays, a few on workdays with T_{eq} values between 42.94 and 50.4, and an average amount on workdays above 50.4. The model quality is very good (R^2=0.79). Note that the splitting value 50.4 is already in the 'slightly humid' zone (49.1 to 56) given in Auer et al., 1990, whereas the other splitting value 42.94 is safely within the 'comfortable' zone (35.1 to 49).

	Seasonal	***Weather***	T_{eq}
Total	0.56±0.05	0.73±0.03	0.72±0.06
Bikers	0.57±0.05	0.73±0.04	0.81±0.03
Hikers	0.61±0.07	0.65±0.07	0.64±0.07
Dog Walkers	0.39±0.05	-	-
Joggers	0.17±0.08	-	-
Swimmers	0.64±0.07	0.59±0.01	0.79±0.05

Table 1. Crossvalidated measures of determination R^2 (with standard errors) for three different classes of regression tree models: using only seasonal information, i.e. season and day of the week (Seasonal), using seasonal information and meteorological variables (Weather), and using seasonal information and the Equivalent Temperature (T_{eq}). For dog walkers and joggers, these models are identical.

Figure 8. Regression tree for the number of swimmersper day, using only seasonal information.

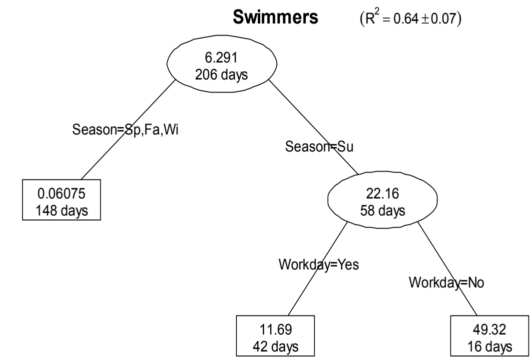


Figure 9. Regression tree for the number of swimmers per day, using seasonal information and meteorological data.

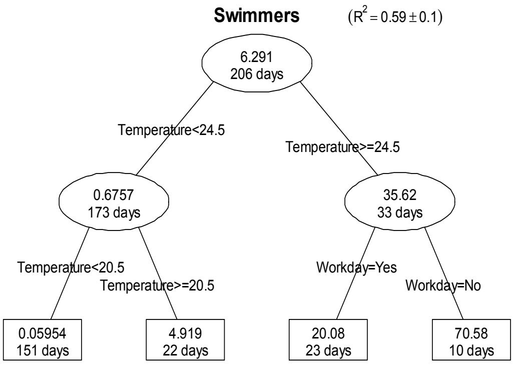
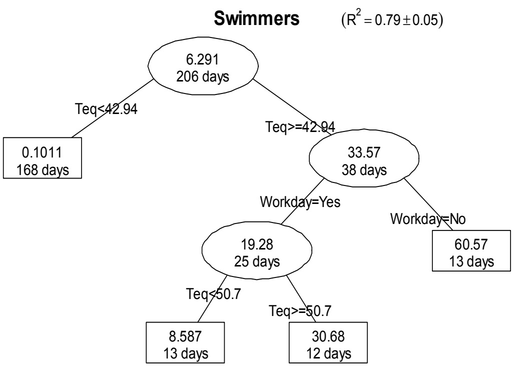


Figure 10. Regression tree for the number of swimmers per day, using seasonal information and Equivalent Temperature (T_{eq}).



DISCUSSION

Suitability

The regression trees for visitor counts exhibited mostly excellent (total count, bikers, swimmers) to acceptable (hikers) model fit, only the trees for dog walkers and joggers were of poor and very poor quality, respectively. The models partition the set of all observations into two to eight different subsets that are defined by seasonal and meteorological conditions. We feel that the interpretations we have given based on the graphical representations of the trees are persuasive, at least for the categories where we could achieve good model fit (total count, bikers, swimmers, hikers). For those categories where we failed to do so (dog walkers, joggers), we suspect that this is due to measurement error: these are comparatively small groups, so that the samples of the video material that were analysed (15 minutes out of every hour, see Brandenburg and Ploner, 2002) did capture the number of joggers accurately enough. Admittedly this is not the case for swimmers, which are not much more numerous, but this might be explained by the fact that the distribution of visitors over the day has only one pronounced peak for swimmers (slightly before noon), but two (one in the evening and one in the morning) for joggers and dog walkers, so that in fact the visitors in the last two categories are spread out more thinly over time.

Comparing these results with the linear models fitted to the logarithmised visitor numbers in Brandenburg and Ploner, 2002, we find that the overall pattern of model quality is the same for most user categories: excellent quality for the total number and the bikers, slightly worse quality for the hikers, only moderate quality for the dog walkers, and very bad quality for the joggers. The R^2 for these linear models is always higher than for the corresponding regression trees, though we do not feel that this represents a serious shortcoming: first, R^2 for the linear models is a proper proportion of variance explained, which, as pointed out above, it is *not* for the regression trees, so these values are not strictly comparable; additionally, the linear models were fitted to the logarithmised visitor counts, so while any predictions made on the log-scale can easily be transformed back to the original scale by taking the exponential function, this is not true of the error of the model. On top of this, we achieved excellent model fit for the swimmers, for who the linear model was even worse than for the joggers, so that we score much better using regression trees in at least one user category.

Using Weather Information

The best tree models are those that incorporate meteorological data as a crucial part (total number, bikers, swimmers); models that retain the season as a variable in the presence of meteorological information exhibit lower model quality (hikers), while those that ignore it are bad to very bad (dog walkers, joggers). In summary, if modelling is worthwhile, it relies on meteorological data and conversely, only through the inclusion of these data are we able to achieve satisfactory model quality.

Meteorological Variables vs. Comfort Indices (T_{eq})

Models based on the T_{eq} are never worse than those using physical meteorological variables, and distinctly better for bikers and swimmers. In case of the hikers, where the comfort index does about as well as the meteorological measurements, we found that the former was more helpful in characterising the partition suggested by the regression trees.

CONCLUSIONS

- Regression trees offer models for visitor numbers that are easily understood and can be displayed attractively. They suggest typical combinations of circumstances for different user groups which influence the decision to visit the recreation area.
- The predictive power of the tree models is comparable to the linear models given in Brandenburg, 2001, without the need to use logarithmised visitor numbers as the dependent variable.
- Using meteorological variables for the tree models improves their predictive quality and makes them more interesting as a short-term predictive management tool, at least for large user groups.
- Using comfort indices, and specifically the Equivalent Temperature, yields models that are more powerful, simpler, and more intuitive than using a combination of physical variables. It is not clear though, whether the comfort indices themselves can be predicted with a sufficient degree of precision to make their use practical.

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GIS-based modeling of car-borne visits to Danish Forests

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Abstract: Vector-based GIS is used as a basic for building a predictive model of car-borne recreational activities in Danish nature areas. Special attention is paid to the forests. The model takes its point of departure from frequencies of forest visits considering type of starting point (dwelling, summer house etc.), travel cost (into four time-bands) and three different nature types (forest, beach, and the remainder landscape). By means of linear regression statistics the model results are correlated with registered activities (number of cars in an extensive selection of parking lots in the nature). Further the effect of various local amenities – distance to the coasts, terrain form etc. – are evaluated. The work is part of the authors Ph.D.-thesis (Skov-Petersen, 2002).

INTRODUCTION AND MOTIVATION

There is a rising request for information about the recreational usage of and pressure on the nature surrounding us. The reasons are numerous including, e.g. more focus on non-market products of forests, a turn in planning and management of the nature to take public participation more into account, and a higher pressure due to the population increase, the sprawl of urban areas, and rising tourism. From the producers side – the forest managers and operators – there is rising concern that wood-production only is not enough to motivate a continued political support, as land is getting scarcer or requested for other activities. As a response to - or a consequent of - this rising emphasis on the multipurpose function of the nature in general and forests in specific, planning and management of the nature needs tools. Further, planning, at least in the developed part of the world, is opening up. This also influences planning of natural recreational resources. Public participation and involvement of NGO's and planning authorities at different levels of planning is getting an integral part of management and planning of nature where it in earlier times was more a concern of few central institutions or land owners. In the process of planning and designing the future forests data and information are needed. This goes as well as a political decision support (Kock, 1975, p 7) and for planning (De Vries and Goossen, 2001).

The Danish forest area has to be almost doubled from approximately 12 % of the national territory to approximately 22 %. In the forest act of 1996 (Miljø- og Energiministeriet, 1996) it is stated that the afforestation must facilitate multipurpose use. Among the main motivations are mentioned protection of ground water reservoirs and facilitation of recreational opportunities to the public. It is the intention of the present paper to demonstrate means for evaluation of recreational potentials of existing as well as planned forests and other nature areas. A full description of the project will be found in Skov-Petersen (2002).

OVERVIEW OF THE METHOD

The present investigation is activity orientated. It is seeking to estimate the potential number of visitors to any Danish nature area (with most focus on forests). The empirical data used include both questionnaires (approximately 2500 responses) and registration of actual activities – in terms of parked car - at approximately 2200 locations in the landscape. Both data-sets were kindly made available to the project by Frank Søndergaard Jensen of the Danish Forest and Landscape Research Institute. Partly as a consequent of the available data only car-borne activities are taken into account. Therefore the estimated modelled number of visits to areas close to highly inhabited areas, where the proportion of non-car-borne activities are significantly higher than in the more scarcely populated areas must be interpreted and used accordingly.

The study has a strong emphasis on the structural component. The main emphasis is on the influence of distance between users and resources – in terms of the travel needed between the point of departure and the destination. It is less focused on the choice process e.g. in relation to socio-economic characteristics of the users. Neither is the attention to compile any kind of economic valuation of non-market products of the nature.

The methodological foundation is heavily GIS-orientated and is therefore limited to model approaches and data that can be implemented in a GIS-context. Travel distances are calculated be means of a digital road network. Each node of the network is attributed information about nature resources (beach, forest, and remainder landscape), and the number of users (population, summerhouses, camping lots, hotels and youth hostels). Transport time is sliced up into 4 bands (0-10, 10-20, 20-45, and 45-120 min.). Classes of resources, users, and transport time are in accordance with those used in the questionnaire survey which provide frequencies of travels made to unique combinations of classes (time vs. user-type vs. nature type). The modelled visit-frequency to each node of the network is compared to the actual number of cars registered by means of linear regression statistics. Further, the effect of local amenities (terrain form, closeness to the sea, etc.) is evaluated.

Eventually, the resulting model is used to evaluate a number of afforestation areas appointed by the Forest and Nature Agency. Additionally, using a 1000x1000 grid an assessment – covering the entire Danish territory - of the recreational effect of afforestation is performed.

MEASURING AND MODELLING RECREATIONAL BENEFIT

When it comes to the unit of model results, there seems to be two mainstreams: One that seek to *capitalise recreational benefits in monetary terms* and one that assess the *recreational activities in terms of behaviour*. The main reason that monetary units are strived for, is that it enables comparison of benefits of accessible natural resources with alternatives, possible costs, loss of production, etc. (See for instance Wilhjelmudvalget, 2001, Powe et al., 1997, or Handley and Ruffell, 1993). The monetary valuation of non-market aspects (including recreational use) ranges according to Handley and Ruffell (1993) from various assessments of the value of a day in the forest, values (both user and non-user) of welfare gains due to afforestation, and estimates of carbon fixing benefits. Additionally, Powe et al. (1997) provides an example of valuation of forest resources based on changes in market-prizes of real estate, as a function of proximity to woodland. Loomis (1994) addresses the effect of recreational activities on local/regional economics as an alternative monetary assessment of recreational values of the natural resources. Contrasting monetary valuation *behavioural or activity-based measures* of recreational values of the nature includes measures of the publics *preferences* for different types of nature, *choices* between alternatives, and finally how these preferences and choices are reflected in the *actual activities* taking.

Another main fault-line in the methods for assessing recreational values is the mode of measuring and accordingly, the following mode of analysis and interpreting. The most direct, in terms of address of user, the approach *of stated preference, behaviour, or Willingness To Pay (WTP)*. Individual people are asked about e.g. their actual behaviour (‘When did you last time visit the forest’, preference (‘Do you like this picture or that?’), or WTP (‘How much would you pay for…?’). Alternatively the recreational values can be obtained by registration of the actual activities taking place in the nature or locations related to it. R*evealed preference, activity, or WTP* as this type of study is referred to, can be carried out e.g. by counting the number of parked cars on parking lots, the number of hikes in an area, or by registration of changes in value of real estate as a function of provision of green resources. Some writers refer to the same two types of valuation as *direct vs. indirect registration* (Smith, 1989 and Wilhjelmudvalget 2001).

When assessing human interaction with its recreational surroundings the three basic components are attributes to the *origin*, *destination* and *the system enabling transport* between the two (see for instance Vickerman, 1974a). Origins can for instance be characterised by demography, socio-economy, land use etc. Destinations by the nature type, landscape form, availability of local facilities, entrance fees, etc. The most basic form of transport costs or impedance’s is the Euclidean distances between origins and destinations. This approximation involves two assumptions: a) homogeneity in the spatial distribution of the transport network and b) that possible travelling speed is even all over the network. As the advances in development of GIS has facilitated efficient and accurate calculation of distances and transport times in digital road networks the use of Euclidean distances has become less abundant. The pros and cons of Euclidean vs. network-distance calculation has been discussed in numerous articles including Brainard et al. (1999), de Vries and Goossen (2001), and Bhat and Bergstrom (1997). The effect of increasing distances - e.g. close things means more than more distant ones - or most frequently formulated in terms of 'distance-decay'. The simplest form is the sharp threshold or isocrone functions - anything within a given search radius is included with full effect, whereas all outside the radius are excluded. An example of a more gradual decay function is the 'gravity model' where - in its simplest form - effect is divided by the square of the distance. Distance decay functions, with special reference to recreational resources and behaviour are discussed by Skov-Petersen (2001). In cases where the model includes areas where no roads are available at present – either because a future, potential situation is addressed (Geertmann and Ritseman van Eck, 1995) or because the digital network used doesn’t include small roads and tracks in between main roads Euclidean distances can be used as a supplement to network analysis (Brainard, et al. 1999). Skov-Petersen (1998) provides an example of local Euclidean distances used in a raster-GIS environment for assessment of barrier effect of larger traffic constructions.

A special problem in modelling recreational choices is handling the influence of *alternative choices,* i.e. the effect of the amount of recreational resources available at a point of origin. It can be assumed that the number of visits from an origin to a destination is a function of the magnitude of the demand (e.g. the total number of forest visits), inversely related to the sum of the available resource (e.g. the total number of ha forest available within the time-constraints considered) (Smidt, 1989, Luzar and Hotvedt, 1992, Loomis, 1995). The same issue is sometimes referred to as *intervening opportunities* (Thompson, 1979).

ASSESSMENT OF THE METHODS USED FOR THE PRESENT STUDY

Of the above referred studies the present study resembles especially Brainard, et al. (1999) and de Vries and Goossen (2001). Both predecessors are using GIS as central platform for implementation, and both are highlighting the problems and possibilities in using a digital road network for assessment of travel costs. Further, both studies are aiming at development of a method that could facilitate estimation of recreational values in any nature area within a given region. As de Vries and Goossen (2001) this study is considering a dual data-set including a *stated preference assessment* 'feeding' a travel cost model and a *revealed behaviour study* of activities, registered directly on site in the nature. The motivation is the same; to validate the model in terms of correlation between modelled and registered activities and to enable evaluation of the effect of local facilities and amenities in the nature on recreational activities. Brainard, et al. (1999) argues that an economic valuation is needed to enable transfer of (economic) benefit between sites, whereas the present study wishes to evaluate the effect of landscape amenities on recreational activity. Brainard, et al. (1999) consider different types of origins – dwellings and summer houses – similar to the present study which additionally includes departures from camping sites, youth hostels, hotels, and holiday departures from private homes. Since Brainard, et al. (1999) are using information about the individual respondents origin as well as destination, they have the opportunity of evaluating effect of socio-economic characteristics of the zone of origin on choices and behaviour in terms of forest visits. The evaluation of socio-economic characteristics was given less priority in the present study. A general difference though, is the inclination of Brainard, et al. (1999) to value the nature in monetary terms, contrasting the present study's search to model activities in terms of visits. The obvious spatial components in the phenomena of recreational benefit and behaviour seems not to give raise to much attention to the geographical aspects of the [economic] studies involved (Brainard, et al. 1999).

The basic motivation – to facilitate the planning process with knowledge regarding recreational aspect of the nature in terms of recreational activities – is shared between de Vries and Goossen (2001) and the present study as are a number of basic assumptions and approaches. Despite of this the two studies seems to deviate on three points: de Vries and Goossen (2001) addresses a) both car- and bicycle-born activities (the present study only includes cars), b) a gravity model is used (the present uses time bands), and c) a rather detailed conception of the quality of different nature types is included (the present study considers only beach, forest and the remaining landscape). Further, de Vries and Goossen (2001) have a high degree of details on differences in social groups living in different points of departure but, as a contrast to the present study, only departures of the dwelling population are considered. De Vries and Goossen (2001) makes no attempt to evaluate their model results in terms of real world registrations of actual levels of activity, which is included in the present study.

To summarise the present study is characterised by:

- The introduction of both revealed and stated preference information in the same model
- Even though calculation of travel cost is considered central, it is kept in terms of transport time - not in monetary terms.
- Points of departure are disaggregated into residential houses, summer houses, hotels, camping lots, and youth hostels not only on population being only an indicator of departure from residents.
- Travel cost is treated as probabilities of activity in time bands (not as a monotonous distance-decay)
- Division of the number of users at an origin by the total area resource within the considered time-band as a means for treatment of intervening opportunities or surrogate destinations
- Finally an address is made of the way the size of destination regions is influencing the correlation between model results, local amenities, and actual, registered visitors.

OVERVIEW OF THE METHOD AND DATA BACKGROUND

The following section describes the data-background, the pre-processing of data. Later the steps of the accessibility modelling process are described. The pre-process includes a) extraction of data from interview survey, b) digitising 'car-registration points', c) filtering the road-network, d) calculation of transport-time for each road-segment, e) calculation of population-data, and f) aggregation of user- and resource information to the nodes of the road-network.

Five types of data are used for the analysis:

- A *national* set of information about the stated preferences and behaviour of the general population
- The number of cars registered at a number of parking lots in the landscape during 1995
- L*ocal* data-sets about resources (forests, beaches and remaining untilled landscape.
- A *local* data-set of the number of potential users (population, summer houses, capacity of hotels, youth hostels and camping lots).
- Information about the *transport-network* (describe data background and attributes, filtering, spatial aggregation).

National data refers to non-spatial information being general for the entire area under investigation - the country of Denmark. Local data is geographically disaggregated information, information that differs from one location to another. The distinction between local and global information is made to highlight the difference in nature of the two data-types. The national information serves as 'constants' that can be used for calibration of local information, which can be used for the modelling of spatial interaction.

The modelling processing included a) calculation of the yearly number of trips generated by each combination of time, means of transport, nature-type and type of point of departure (from the questionnaire survey), b) calculation of the amount of resource available at each origin, c) calculation of the number of trips generated at each origin, d) calculation of the number of trips made to each destination, and finally e) comparing calculated number of trips and the number of cars actually counted in the nature.

CORRELATION OF NUMBER OF COUNTED CARS AND ESTIMATED TRIPS

Registration of cars took place 22 times during 12 month in 1995-96. The registration was made at parking lots or along stretches of road known or expected to be used during recreational visits in the nature. The nature areas was enrolled voluntarily by the administrators and registration locations was configured to cover entire nature areas, i.e. it was expected that all cars coming to an area during the time span of a single round of registration would be included. To relate the registration-point to the landscape surrounding them, buffer zones had to be introduced. In some cases – depending on the buffer-size and the spatial distribution of the registration-points – the buffer zones would embrace more than one registration points. This way a single buffer-zone containing a number of registration-points and a series of landscape attributes becomes the minimum unit of investigation

A key point is the selection of a feasible size of the buffer-zones. The buffers should be big enough to even out local variation, both in terms of different attributes to the individual parking lots that might influence the number of visitors and in terms of the data background used for estimation of trips and local attraction parameters (see below). On the other hand they should be small enough still to support estimation of recreational use at a local scale. If only correlation's can be established for large regions it would disable the evaluation of natural areas smaller than the regions. Further, using too big buffers would in cases include natural areas not included in the car-registration campaign. Whichever buffer-size is selected it must also be considered in the context of the behavioural phenomena investigated. The buffer should represent the landscape in a vicinity of the registration point relevant to the activity considered. If a too small buffer is selected, the activity will stray outside it – or is it a too big buffer it will include areas of no relevance to the recreational activity. To unwrap the influence of buffers size a number of different sizes – 125, 250, 500, 1000, and 2000 m - were tested.

The problems associated with aggregation of data into area units – with special reference to the inferential effects of changing aggregation units - are generally referred to as the Modifiable Area Unit Problem or its abbreviation MAUP (Oppenshaw, 1980). Very different correlation's between the same set of variables can be obtained by using different aggregation units. The phenomena can be separated into *a scale effect and an aggregation effect*. The scale effect includes in general that the larger the aggregation units, the larger the correlation between the variables investigated. The aggregation effect occur when a constant number of aggregation areas are moved, reshaped, and resized over an area of investigation. According to Oppenshaw (1980) the optimal or most correct correlation coefficients can in principle be obtained by introduction of all possible configurations of aggregation areas and the examine the frequency distribution of the resulting coefficients. The present approach of using multiple buffers gives the opportunity to investigate the stability of estimates over changing scales in aggregation units. In this way the effect of MAUP – specially the scale effect – can be assessed and envisaged.

At the destinations the natural resources are only considered as belonging to one of he three broad classes; beach, forest, and the remaining untilled landscape. It can be seen as a background pressure of potential visits. Obviously, despite of this background pressure, number of visits varies very much even between sites situated very close to each other. Therefore a number of parameters representing local attraction of the nature were introduced as additional descriptive and/or explanatory variables. These variables include ruggedness of the landscape, closeness to the coast, closeness to lakes, and closeness to locations marked as especially scenic or picturesque.

STATISTICS

A central question if the model performs any better as a predictor of the recreational activity in the nature than the classical models entirely driven by population potential (See for instance. Skov-Petersen, 2001). To assess this expectation of explanatory effect correlations coefficients of the number of cars and the predicted values was calculated. As can be seen in 0 the two classical models (model 2 (exponential distance decay function) and 3 (isocrone distance decay (15 min.))) do not provide any marked explanation of the recreational activities in the areas encounter. Further there is no effect of increase in the buffer size. For the full model (model 1) the picture is more positive there is a marked increase in the correlation coefficients as a function of increasing buffer size.

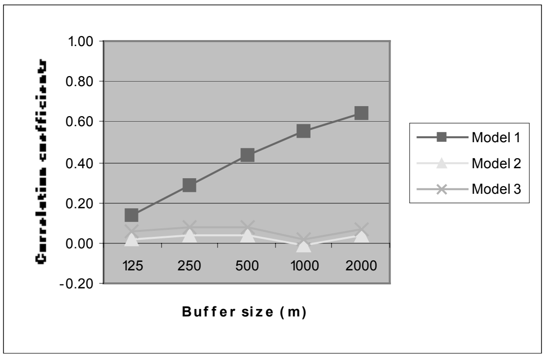

Figure 1: Pearson correlation coefficients of the three models vs. counted number of cars as a function of rising buffer size. Figures are based on the logarithm of counts and model results.

From 0 it can be seen that the number of trips modelled by *accessibility, distance to the coast*, and *slope index* all provides significant estimates of the regression coefficients. All three appears to be robust – in terms of the sign of the estimate vs. increasing buffer size. Accessibility and slope are both positively correlated – i.e. the higher prediction of the accessibility-model and the more slope the landscape, the higher is the recreational activity. Distance to the coast is negatively correlated – the further to the coast the lower the activity. The correlation with the distance to the coast might be an influenced by the high number of registered activities at parking lots facilitating the beaches.

Buffer size (m)	Accessibility (Model 1)	Distance (m) to coast	Slope index
125	0,420720 (0.0001)	-0,000014 (0.0012)	0,435067 (0.0001)
250	0,466505 (0.0001)	-0,000027 (0.0001)	0,289057 (0.0001)
500	0,519789 (0.0001)	-0,000037 (0.0001)	0,276821 (0.0001)
1000	0,603275 (0.0001)	-0,000033 (0.0001)	0,305682 (0.0001)
2000	0,571046 (0.0001)	-0,000037 (0.0001)	0,172477 (0.0962)

Figure 2: Estimates of regression coefficients for parameters selected by stepwise linear regression vs. buffer size. Level of significance mentioned in brackets. Estimates of significance lower than 0.1500 are excluded.

USING THE MODEL FOR ASSESSMENT OF RECREATIONAL EFFECT OF AFFORESTATION

The following two sections provides two implementations of the estimated regression coefficient's of the accessibility model (based on population, summer houses, hotels etc. and existing recreational resources) and local amenities (distance to the coast and terrain form) as independent variables and the expected number of car-borne visits to existing and potential afforestation areas as dependent variable.

When interpreting the data it is important to bear in mind that the estimates represents car-borne activities only. Generally car/motorcycle born activities takes up 46.3 % of the entire national recreational activities but the proportion of other, softer forms of traffic increases when the transport distances decreases (Jensen, 1998, pp 46). E.g. at less than one kilometre approximately only 10 % of the participants are using the car. This means that the closer the fringes of the inhabited areas the less significant is the car-borne activities when compared to other means of transport. With special reference to the present model this is in particular true when the case is rims of small towns. No-one in these cases can travel long distances to go to an area close to the rim. In the cases of larger cities the population of the centre of the city are potentially 'long-distance users' of the recreational areas at the rim. Accordingly, care must be taken not the neglect the potential effect of non-car-borne activities, especially in the case of close-range travel distances.

EVALUATION OF STATE AFFORESTATION AREAS

The Danish Nature and Forest Agency has appointed a number of areas of special action in terms of afforestation. A digital map of 95 of these areas were made available to the project. As an example for the results for the County of Funen are found in figure 3 (index map found in figure 4).

Index number	Project name	Area (ha)	Lower confidence interval (95 %)	Predicted number of yearly visits by car	Upper confidence interval (95 %)
19	Højstrup	283	2165	2763	3526
20	Kerteminde	388	1307	1760	2369
21	Middelfart	1088	2697	3547	4664
22	Årslev	146	713	868	1055
23	Ejby	148	458	592	765
24	Gelsted	26	95	138	197
25	Kirkendrup	498	3031	3883	4973
26	Ringe Skov	456	647	824	1048
27	Søgård	173	838	1059	1338
28	Assens	1247	966	1420	2086

Figure 3: Assessment of the number of car-borne visitors to afforestation areas of the county of Funen. Location of the areas are shown on 0.

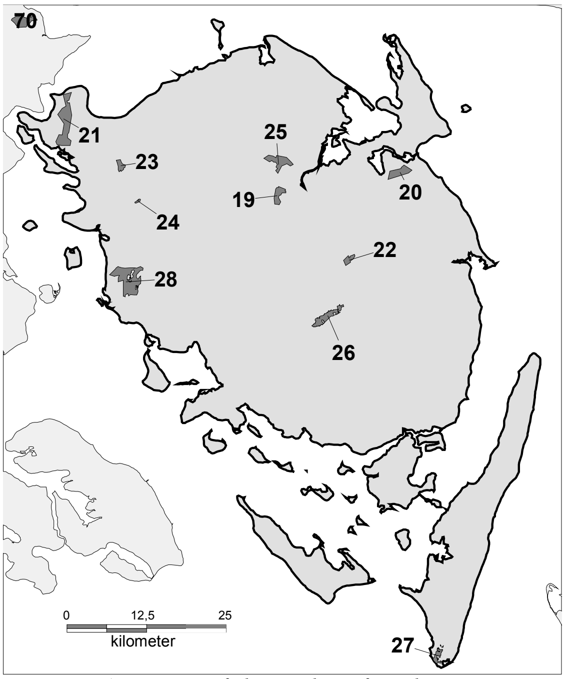

Figure 4: Assessment of the number of car-borne visitors to afforestation areas of the county of Funen. Numbers of the areas corresponds to the index number of 0.

GENERAL ASSESSMENT OF THE POTENTIAL OF AFFORESTATION OF THE DANISH LANDSCAPE

To assess the areas of the country where afforestation potentially would be most beneficial to car-borne recreation the yearly number of visits was estimated for 1000x1000 m. cells for the entire territory (figure 5). With reference to the previous discussion (for further details refer to Skov-Petersen, 2002) and as were the case in the previous section it is assumed that there is no 'intervening opportunity effect' of the introduction of new forest areas. In other words the resulting map cannot be interpreted as what will happen if all Denmark was covered by forest; each cell is evaluated individually assuming that the rest of the relevant land use is unchanged.

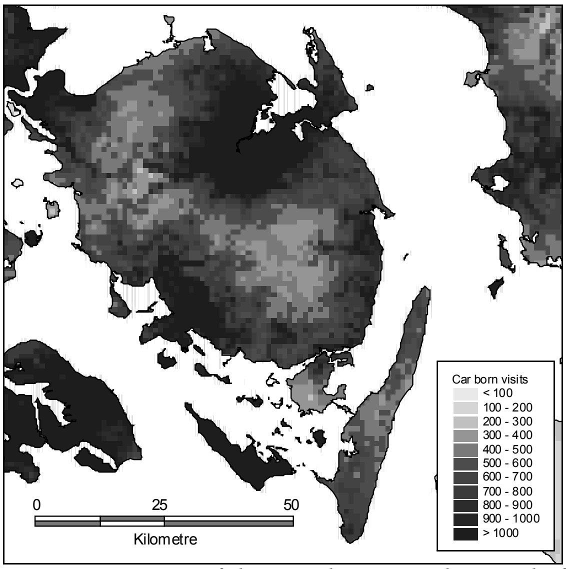

Figure 5: Estimation of the general recreational potential of afforestation of Funen (1000x1000 cells). It is important to notice that afforestation of each individual cell is evaluated independently, i.e. afforestation of adjacent cells does not influence calculation as intervening opportunities.

CONCLUSION

GIS has been proven to be an efficient platform for modeling the recreational activities in Danish forests. 'Reality-data' captured by questionnaire techniques and by registration of the number of cars at parking lots in the nature can be spatially generalized. Hereby it is not only possible to estimate the potential number of visitors to existing forests; it also provides the possibility of predicting the recreational gain by planned forests. The model demonstrated only includes car-borne activities. This is particular a problem in areas close to populated areas because there is a marked tendency of dominance by softer forms of traffic for shorter travel-distances between origin and destination. Further it is problematic that the populations frequency of trips to the nature is assumed to be independent of the amount of local recreational resources. Both the latter issues are obvious fields of future extensions of the work presented.

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