Visitor monitoring along roads and hiking trails: How to determine usage levels in tourist sites

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ABSTRACT

Best-practice visitor-monitoring techniques are crucial for the assessment of tourism-related impacts in natural areas of high conservation value. In such studies, ecosystem variables are typically compared between high and low usage tourist sites. We assessed visitor use at 80 sites in the Flinders Ranges gorges and compared 11 visitor variables for their potential to differentiate usage levels between sites either exposed to vehicle or hiker traffic. We show that the efficiency with which a visitor variable represents usage levels depends on the access mode to gorges, with the number of passing visitors best suited for monitoring of usage levels in gorges permitting hiker access only, and variables describing camping usage best suited for gorges permitting vehicle access.

Further, the distinct advantages and disadvantages of four visitor-monitoring techniques were examined; namely, the direct monitoring of visitor use by staff observers, the assessment of proxy variables from which past and present use can be inferred, GPS tracking of visitors and the survey of visitors by an interview-based questionnaire. We recommend GPS tracking because of the reliability and detail of data and the many sites per day that can be sampled. Due to a strong, positive correlation, the campground size and the number of fireplaces may be recorded in proxy of the camper numbers to increase time-efficiency and robustness of measures against short-term fluctuations in usage. Survey data gathered in relation to specific site-use were tempered by the memory of visitors and their ability to describe or reference the visited sites on a map. Visitor surveys were therefore useful only as a supplementary method for differentiating usage levels on a coarser spatial scale.

1. Introduction

The gathering of information on visitor use patterns is collectively referred to as ‘visitor monitoring’, which is essential for a variety of planning tasks in protected area management — such as facilities planning and the scheduling of maintenance; the determination of demand trends; budgeting; the calculation of the social, economic and political importance of the recreational use; tourism impact assessments; and the development of natural resource and tourism management policies (Cessford & Muhar, 2003; Hornback & Eagles, 1998; Wardell & Moore, 2004; Watson, Cole, Turner, & Reynolds, 2000). Visitor monitoring has acquired a new significance in protected area management with the realization that tourism use has impacts on the natural environment and that rising visitation levels may pose a serious threat to sustainable management.

This paper focuses on the processes and challenges involved in the determination of visitor usage levels with the aim of discovering those visitor variables and methods that achieve an effective visitor monitoring. The context was a comparison of vegetation and bird communities between sites of differing usage levels in the gorges of the Flinders Ranges, a well-promoted tourist region in South Australia. In this area, visitor usage patterns were further differentiated by mode of access to the gorges — by vehicle or by foot.

2. Literature review

2.1. Visitor usage levels in environmental impact studies

Typical visitor use patterns in protected areas are patchy where visitor numbers, their activities, group sizes and the locations and facilities that they use vary in time and space. Aggregation in particular sites occurs for numerous reasons like the attraction to special landscape features or favourable camping conditions. Other sites, even in close proximity, may be visited considerably less or
not at all. For instance, Arnberger and Hinterberger (2003) found that in a Danubian floodplain system 50% of visitor-kilometres encompassed only 20% of total trail-kilometres, indicating a high concentration of visitors on a few trail segments. The concentrated use patterns of tourists, thus spatially stratify tourist areas into high and low use sites, or any gradations in-between (e.g., Growcock, 2005; Magro & Barros, 2004).

A popular methodology for relating environmental impacts with tourism use is to compare natural resources or animal biology between sites of differing usage levels (e.g., Beale & Monaghan, 2004; Belnap, 1998; Griffin, Valois, Taper, & Scott Mills, 2007; Ikuta & Blumstein, 2003; McClung, Seddon, Massaro, & Setiawan, 2004; McLellan & Shackleton, 1989; Papouchis, Singer, & Sloan, 2001; Pelletier, 2006; Walker, Boersma, & Wingfield, 2005; Webb & Blumstein, 2005). Such studies often compare high with low use sites and these are hereafter referred to as ‘hi-lo impact studies’. However, studies are not constrained to dichotomous usage levels and may examine the impacts from a range of usage levels or a continuous gradient in the usage intensity. For example, McClung et al. (2004) examined the relationship between human disturbance and fitness parameters of Yellow-eyed Penguin (Megadyptes antipodes) chicks by comparing breeding areas with different levels of visitor frequency on Otago Peninsula, New Zealand. Belnap (1998) studied vegetation communities and soil variables of lightly and heavily used areas to identify potential impact indicators of tourism use in Arches National Park, U.S.A.

There appears to be a general lack, though, of comprehensive visitor data in protected areas or their inadequacy prohibits integration into tourism impact studies for the management of natural resources (Cole & Daniel, 2003; Cole & Wright, 2004; Newsome, Moore, & Dowling, 2002; Wardell & Moore, 2004). Hadwen, Hill, and Pickering (2007: 177), for instance, concluded that in many cases “existing monitoring programmes fail to deliver the necessary information to protected area managers... which facilitate the development of proactive management strategies in most protected areas”. Researchers attempting a hi-lo impact study therefore usually need to collect their own visitor data. However, little guidance is available on what visitor variables to monitor and how to do this. This poses a particular challenge in hi-lo impact studies where visitor usage levels may need to be monitored on many sites to account for local scale variation in visitor usage and its potential impacts on the environment.

2.2. Visitor variables

Hi-lo impact studies may anticipate changes in an environmental variable with an increasing tourism usage intensity provided that (1) the environmental variable is potentially sensitive to usage, (2) the increase in usage is sufficiently strong and (3) the usage has not yet reached levels where a further increase cannot cause additional impacts as these have either reached their maximum levels (e.g., campsites entirely denuded of vegetation due to trampling) or the ecosystem has changed to an altered state that is insensitive to usage (e.g., displacement of sensitive flora or fauna with disturbance-robust species).

The usage intensity itself may increase with increasing numbers of visitors, an extended duration and higher frequency of usage, as well as the activities or visitor behaviour that physically impact the environment. Therefore, as the usage intensity may be a complex result arising from multiple variables (Hammit & Cole, 1998), choosing the right visitor variables is one of the major challenges of a hi-lo impact study. The reliance on visitor numbers as the main or sole measurement for determining usage levels in many hi-lo impact studies (e.g., McClung et al., 2004; Pelletier, 2006) is likely inaccurate.

Thus the power to detect visitor impacts and to understand their mechanisms should increase if more detailed information is collected that accounts for the complexity of visitor usage (Hadwen, Bunn, Arthington, & Mosisch, 2005; Hadwen et al., 2007). Gonzalez, Arroyo, Margalida, Sanchez, and Oria (2006), for example, investigated tourism impacts on nesting Spanish Imperial Eagles (Aquila adalberti). They stratified visitor numbers by behaviour and found that passing vehicles did not significantly affect the eagles while stopping vehicles did. Had they not chosen to record visitor behaviour they might have wrongly inferred that all visitors had an impact instead of identifying the fraction that was actually responsible. In a hi-lo impact study, this could lead to a misclassification of sites into inappropriate usage level categories: for instance, if the number of stopping compared to passing visitors was higher at a site with fewer visitors eagles may have been more disturbed than at a site with more visitors.

2.3. Visitor-monitoring methods

Another important decision in a hi-lo impact study concerns the visitor-monitoring methods. Traditionally, the main sources of information for the monitoring of visitor use have been visitor surveys, anecdotal evidence (reviewed by Cessford & Muhar, 2003) and self-counting techniques such as voluntary registration (Watson et al., 2000). Visitor surveys are still an essential tool for park visitor research but visitor impacts on natural environments result more from what people do than what they say they do (Cessford & Muhar, 2003; Cole & Daniel, 2003). Further, the detail of the trip itineraries needed to examine variation in tourism usage intensity between sites, especially if it varies on a fine spatial scale, may likely not be adequately captured. Nevertheless, surveys may provide useful additional information for explaining travel patterns when they are combined with other monitoring methods.

There are a number of advances in monitoring options ranging from direct observations by staff observers (Hartmann, 1988; Keul & Kühberger, 1997; Murphy, 1992), self-administered travel diaries (Fennell, 1996; Thornton, Williams, & Shaw, 1997) or itinerary mapping (Connell & Page, 2008), the use of on-site counters (devices recording and storing visitor counts at sites) (Hornback & Eagles, 1998; Watson et al., 2000) through to proxy measures (e.g., camping permits) from which use can be estimated (Cessford & Muhar, 2003). Recently, improved video, digital imaging and transmission technology (Guilien et al., 2008; Kammel & Schernowsky, 2004) as well as global positioning systems (GPS) (reviewed by Shoval & Isaacson, 2010) and other tracking devices like the Alge timing system (ankle mounted transmitters that are recognized by receivers located along a constrained network) (O’Connor, Zerger, & Itami, 2005) have been employed for visitor monitoring.

Arnberger, Haider, and Brandenburg (2005) encouraged comparisons of the many available visitor-monitoring methods, such as their cost and the quality of data gathered, in order to facilitate decision-making on the appropriate methods.

3. Study aims

The aims of this paper are: (1) To illustrate the process of differentiating usage levels of tourism sites, exemplified in the gorges of the Finders Ranges, where no suitable tourism data existed. (2) To examine which of 11 tourist variables of passing, stopping and stationary/camping usage best described inter-site usage differences depending on access mode (sites with vehicle vs. foot access) to tourist sites. (3) To compare the advantages and disadvantages of various monitoring techniques in terms of their costs, ease of use, site efficiency (daily sampling rate of sites) and sensitivity towards short-term fluctuations in visitor use. In this
study, the monitoring of actual use directly by staff observers on-site, or through the assessment of proxy variables (e.g., number of fireplaces) or indirectly through GPS tracking was compared to the surveying of reported use through on-site interviews with tourists.

4. Methods

4.1. Study area

This study was conducted in the central and northern Flinders Ranges from the Flinders Ranges National Park (Wilpena: lat. 31° 30’ S, long. 138° 30’ E) into the Vulkathunha-Gammon Ranges National Park (Balcanoona: lat. 30° 30’, long. 139° 30’). In 2007, the Flinders Ranges and Outback South Australia attracted an estimated 589 000 overnight visitors that spent nearly two million nights there (South Australian Tourism Commission, 2008). This was more than any other region in South Australia except the capital, Adelaide. The Flinders Ranges offer a wide range of activities including bushwalking and scenic touring along designated recreational paths, camping on official and wild campsites, and Aboriginal and European cultural experiences.

This region is known for its spectacular scenery and gorges with extensive creek beds and its outstanding geological features. Four elements of the natural ecosystem are of regional and/or national significance: (1) a unique and very diverse vegetation community including 1233 native plant taxa (Brandle, 2001), (2) a diverse reptile community of approximately 90 species (Brandle, 2001) especially the rock-haunting variety, (3) more than 200 species of birds (Ried, Carpenter, & Pedler, 1996), and (4) four macropod species including the endangered southern population of the Yellow-footed Rock-wallaby (Petrogale xanthopus xanthopus) (Brandle, 2001).

The gorges in particular are magnets for tourism activities in the region and offer a refuge to most plant and wildlife species from the drier areas of the plains. This makes them the prime locations for people-nature interactions with a critical need for impact monitoring in relation to tourism use. However, any hi-lo impact study is hampered by the lack of visitor data to discriminate usage levels of the Flinders Ranges gorges, and sites within, at an appropriate scale. Visitor usage in the Flinders Ranges and Vulkathunha-Gammon Ranges National Park has mainly been assessed through survey questionnaires capturing general tourist profiles, visitor activities, satisfaction, expenditure, expectations and trip attributes like the duration of stay (reviewed by Morelli, 1996). In addition, some road surveys through direct observations have been conducted and a few road counters established on major travel routes. The number of camping permits and park entrance fees have also been recorded by park personnel at different self-registration stations inside the parks (Shirley Meyer, Park Management; Melanie Vears, Park Administration; Flinders Ranges National Park; pers. comm.) and by some private tourism operators (e.g., the Flinders Ranges Tourist Services Pty Ltd). Generally, data on sites other than the commercial centres and some of the official campgrounds are sparse and virtually non-existent for our study sites inside the gorges. Visitor data for the Flinders Ranges gorges under private lease are even rarer since there are no entrance fees and camping is wild.

4.2. Study sites

The sample comprised seven major gorge systems. Three gorges were mainly exposed to vehicle traffic and the other four gorges only permitted access to hikers. In the absence of suitable visitor data, extensive preliminary observations combined with input from park personnel were used to stratify gorge sections into high and low usage zones. Study sites were placed equally into the pre-determined high and low usage zones to promote a balanced design for the subsequent study on resource impacts but this did not preclude post hoc re-classification. A minimum distance of 250 m and usually not more than 500 m was maintained between adjacent sites. Due to the meandering nature of the gorges, further spatial independence of sites was attained by distributing most of them into separate bends (Fig. 1).

On each study site, belt transects were laid with a width of 50 m (along the trajectory of the gorge) and an average length of 92.5 ± 3.6 m (mean ± 1 SE; depending on the width of the particular gorge section).

4.3. Actual use

Tourism use was examined at each study site from July to December in 2006 and 2007. This time period covered the two shoulder and the peak tourist season (spring) for the Flinders Ranges. Due to the distance to any major cities, the Flinders Ranges and Vulkathunha-Gammon Ranges National Parks do not receive a noticeable influx of weekend vacationers (Danny Doyle, Acting District Ranger, Vulkathunha-Gammon Ranges National Park, pers. comm.); nor did we observe any obvious visitation peaks on any specific days during the weeks in our preliminary observations. Thus we monitored the number of passing cars or hiker groups, the passing speed, the percentage of stopping tourists and their stop time directly on each site from 9 am till 5 pm for two days regardless of the time of the week. The passing speed was calculated by measuring the time that tourists needed for passing through each of the 50 m wide transects. For stopping tourists the passing speed was calculated as the mean from the speed values recorded before and after the stop.

Further data on passing speed, percentage of stoppers and stop time were collected indirectly by GPS tracking of tourists on a total of at least 3 different days per gorge. Sample size ranged from 15 to 42 participants per gorge. At the gorge entrances, tourists were approached and those compliant with participation in the study were equipped with GPS data loggers (Trackstick I, Procure It Australia Pty Ltd, Banyo, Queensland, Australia). These were dropped off either at the original pick-up location or at the opposite access/exit point of a gorge when the tourist(s) completed their visit.

The average values of the passing speed, the percentage of stoppers and their stop time collected at each site via the GPS tracking were included with the corresponding variables recorded via the direct monitoring. That way we did not duplicate variables of the exact same meaning in the principal components analysis (4.5) but increased the reliability of the data from the direct monitoring. GPS tracking did not yield any information on the absolute, daily number of passing tourists, as participants were a sub-sample of such tourists. The percentage of this sub-sample passing a site could be used as a relative measure of visitation of sites within a gorge. This option was not pursued since the number of passing tourists recorded in the direct monitoring not only contained the same information but also more fully described the relative visitation of sites in all gorges without a sampling bias.

Apart from the passing speed and stop times of visitors, the GPS recorded the route that each participant had taken through a study site in the form of ‘trackpoints’, namely the current geographical position (latitude/longitude/altitude) of the visitors. The greater level of information contained in these data was not exploited for classifying our study sites but we will give one example (5.2.5, 6.3.3) as to how this knowledge, unobtainable with any of our other methods, may be implemented to advance the monitoring of visitor usage.

On ten different nights, we also noted the number of tourist groups camping in each gorge overnight. The nocturnal dwell time of campers was relatively uniform as most people arrived before
5:00 pm and stayed till 9:00 am and so was not used as a variable. More variation occurred in the daily dwell time of campers which was measured together with the number of day campers between 9:00 am and 5:00 pm in concert with the direct monitoring of passing and stopping visitors. For the purpose of our study, ‘stopping’ was defined as a temporary interruption to the journey without the setting up of camping gear in contrast to stationary (camping) use of sites. We differentiated between night and day campers because their numbers are not necessarily correlated. Some sites may be practical for overnight camping but do not tempt visitors to stay throughout the day.

Finally, proxy variables were measured, for which preliminary observations suggested a relation with visitor usage; such as the size of any campgrounds, the numbers of fire places, trash items and interpretation signs. We included the full extent of any campground crossed by a transect as well as abutting campgrounds, as long as their boundaries were situated within 30 m to the transect. The size of the campground was calculated with the area measurement function of a GPS unit eTrex Vista Cx (Garmin, Olathe, Kansas, U.S.A.) by walking along its boundaries. All other proxy variables were measured on the belt transects and their associated campgrounds.

Based on preliminary observations, we hypothesized that camping variables would be more relevant in vehicle gorges as camping appeared to be rare in hiker gorges and that differences in numbers of passing tourists would be more relevant in hiker gorges since tourists seemed to aggregate in the beginning of these gorges while vehicle gorges appeared to be used throughout.

4.4. Reported use

Questionnaire-based surveys were conducted by interview with adult tourists (>18 years) at wild and designated campgrounds within or close to our study gorges, and at the major visitor facilities in Wilpena and Balcanoona. A total of 357 questionnaires were
collected from the survey, but 15 questionnaires were eliminated prior to analysis because of missing data. Questionnaires underwent some pilot testing prior to their use, and were adapted where necessary. Surveys took place in the same time period as the actual use measurements. The first author and several trained volunteers administered the surveys to any randomly selected (every 10th person as determined by a click counter) tourist willing to participate (85% of those approached).

In the first part of the questionnaire, questions were asked to assemble visitor demographics, trip itineraries, trip motivations and preferred activities (Wolf, 2009). A few selected findings are presented here in the form of a visitor profile (5.1).

The second part of the questionnaire served to estimate usage of the study sites. Participants were presented with topographic maps and given a standard, brief orientation on the maps by pointing out certain landmarks that had been identified in a pilot study as outstanding/memorable features (e.g., certain campsites, springs/pools). They were then asked (questions listed in Table 1) whether they had visited a particular gorge and, if so, the access points they had used. Specific site-use within gorges was assessed by asking participants to indicate those sites they had passed (answering to “how far did you travel into the gorge”), stopped or camped at and the duration of these activities. If they had forgotten, then this response was recorded. Finally, participants were asked to rate the reliability and completeness of their answers on a five-point scale (1 = very unreliable/incomplete to 5 = very reliable/complete).

4.5. Data analyses

The following analyses were carried out separately for vehicle and hiker gorges to identify sites of different usage levels within each gorge type and to determine which tourism use variables drove possible differences in usage levels between sites depending on the access mode to the gorges.

Mean values were calculated for the multiple samples of visitor variables of observed use (= actual use variables excluding proxy variables). After having tested the normality by means of inspecting boxplots and frequency histograms of standardized residuals with normal curves fitted, Pearson’s correlations were employed to identify relationships between the visitor variables of observed use, and between them and their proxy variables.

All visitor variables were replaced by their ranks as a prerequisite to a principal components analysis (PCA). Ranking creates a common measurement scale, otherwise a PCA would be dominated by the input variables with the largest values. Furthermore, outlier-values, which would also make an unreasonable contribution to the PCA, are given much less weight (Clarke & Gorley, 2006).

Data were scaled so that high values of the visitor variables equaled high usage levels. The exception was ‘passing speed’ where a lower speed represented a longer dwell time (hence more use) and so the inverse value was ranked instead. A PCA with PRIMER v6 (Clarke & Gorley, 2006) was calculated to ordinate our study sites on a 2-dimensional plot based on their variation in the 11 visitor variables recorded in our monitoring of actual use. Euclidean distance was used as the distance measure which appropriately caters for the intrinsic characteristics of environmental variables (as listed in Clarke & Gorley, 2006) like our visitor variables.

Factor loadings were calculated to identify the PCA axis which separated sites based on a gradient in the usage intensity; namely the axis along which most of the visitor variables would increase/decrease in the same direction. A grouping of sites along this axis into different usage categories was performed visually (Manly, 2004) by looking for clusters of sites on the ordination plot. However, since the construction of a 2-dimensional PCA from an original 11 dimensions reduces the information contained in the whole set of input variables, the adequacy of this reduction was checked: Clusters generated by the dendrogram from a hierarchical cluster analysis (unweighted, group-averaged; using Euclidean distance to construct the resemblance matrix as a base for the cluster analysis) were overlaid to see if they matched the groups of sites with similar levels of tourism use as identified by interpreting the PCA. Further a similar profile (SIMPROF) permutation test was calculated which looks for statistically significant evidence of genuine clusters in samples which are a priori unstructured (Clarke & Gorley, 2006; Liu, Zhang, & Huang, 2007). It tests that the groups after being sub-divided at a node of a dendrogram have significant internal structure. This significance was postulated as a final condition for defining our clusters of sites differing in their usage levels.

To identify which tourism use variables drove differences in usage levels between sites in either vehicle or hiker gorges, the factor loadings were used, with high loadings on a particular PCA axis being assigned the most weight. A visual expression of this relationship was achieved by superimposing the tourism variables as vectors on the PCA plots. Further, we present separate PCA plots where specific variables have been excluded from the ordination to demonstrate that the choice of visitor variables determines the classification of sites into usage level categories, which consequently affects the conclusions drawn from environmental impact assessments that relate usage levels with impacts. Finally, to provide a further weighting as to which variables best differentiated usage, we looked for strong differences in the mean of the different visitor variables for the different clusters following the categorization.

Table 1
Memory, self-estimated reliability and completeness of answers provided by tourists (nquestion i = all 342 survey participants; nquestion 2a = 257 participants that had visited gorges) about their visitation to gorges in the Flinders Ranges and particular sites within these gorges as referenced on a topographic map.

<table>
<thead>
<tr>
<th>Details</th>
<th>Question</th>
<th>Visitors who remembered (%)</th>
<th>Reliability of answer (mean ± 1 SE)</th>
<th>Post hoc test (Rel.)</th>
<th>Completeness of answer (mean ± 1 SE)</th>
<th>Post hoc test (Compl.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site-unspecific</td>
<td>Q1 Did you visit one of these gorges?a</td>
<td>100</td>
<td>4.71 (±0.03)</td>
<td>A</td>
<td>4.89 (±0.02)</td>
<td>a</td>
</tr>
<tr>
<td>Site-specific</td>
<td>Q2 From which point did you access?</td>
<td>100</td>
<td>4.91 (±0.02)</td>
<td>A, B</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Q3 How far did you travel into the gorge?b</td>
<td>98.5</td>
<td>3.61 (±0.05)</td>
<td>A, B</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q4 Where did you camp?</td>
<td>78.6</td>
<td>3.82 (±0.08)</td>
<td>B, C</td>
<td>4.12 (±0.07)</td>
<td>b</td>
<td></td>
</tr>
<tr>
<td>Q5 How long did you camp there?</td>
<td>92.6</td>
<td>3.53 (±0.12)</td>
<td>B, C</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q6 How many times did you stop?</td>
<td>82.1</td>
<td>2.63 (±0.09)</td>
<td>C</td>
<td>2.35 (±0.09)</td>
<td>c</td>
<td></td>
</tr>
<tr>
<td>Q7 Where did you stop?</td>
<td>65</td>
<td>1.93 (±0.08)</td>
<td>C, D</td>
<td>1.97 (±0.08)</td>
<td>c</td>
<td></td>
</tr>
<tr>
<td>Q8 How long did you stop?</td>
<td>35</td>
<td>1.71 (±0.13)</td>
<td>D</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Questions that do not share a common letter in the post hoc test columns are significantly different in their estimated reliability (rel.) and completeness (compl.) of the given answers. In contrast to visitors who answered “don’t remember”, Participants were asked to rate the “reliability (‘How reliable do you think your given answers?’) and ‘completeness (‘How complete do you think your given answers?’) of their answers on a 5-point scale (1 = very unreliable/incomplete to 5 = very reliable/complete).

Seven gorge systems were given as choice. “Beginning”, “middle”, “opposite end” were given as choice.
A map of a gorge section containing two sample visitor tracks created in ArcView GIS 3.2 (Environmental Systems Research Institute, 1999) exemplifies how detailed the visitor data from the GPS tracking are and showcases their utility for protected area management.

The responses from the visitor surveys were entered into Data Entry 4.0 for Windows (SPSS, 2007) and subsequently analysed with SPSS for Windows 17.0 (SPSS, 2008). Cronbach’s alpha coefficients were calculated to examine the internal consistency of the survey items addressing the reliability (Cronbach’s alpha = 0.77) and completeness (Cronbach’s alpha = 0.73) of responses (Table 1). Given that the values were above the generally recommended lower limit of 0.70 (Kline, 1999), the scales were accepted for analysis. The point-scale data were treated as ordinal (Rhodeghier, 1996; Scheff, Saucier, & Cain, 2002) so that the mean ratings of completeness and reliability between questions could be compared with repeated measurements ANOVA followed by a Tukey LSD post hoc test with a Bonferroni correction. Since the data violated the assumption of sphericity, the Greenhouse-Geisser correction was applied which adjusts the degrees of freedom to produce a valid F-ratio (Field, 2005).

5. Results

5.1. Visitor profile

The survey revealed that the majority of participants (89.8%) were from Australia, and most of them travelled as elder (>50 years; 61.4%) adult couples (45.6%) or friends/relatives (29.8%) in a group of two (60.2%). The visitor demographics were similar to the ones found in a tourism survey of 305 visitors to Flinders Ranges National Park with self-administered questionnaires by the Department for Environment and Heritage in 2005 (unpublished data). Further, the predominance of elder adult travellers (Roy Morgan, 2009) and couples or friends/relatives (Blaney, 1998; Tourism Research Australia, 2009) in our study was consistent with other studies of visitors to protected areas and more generally nature-based tourists in Australia.

Many people (67.5%) had visited the same or other parts of the Flinders Ranges before and planned to stay 1–3 days (17.3%), 4–7 days (51.5%) or more days (31.2%) during their current visit. The main motivations (multiple answers) for travelling to the Flinders Ranges were the enjoyment of the natural environment/being outdoors/camping (71.6%), geology and landscape/scenic views (55.6%), wildlife observation (52.0%), relaxation (51.2%), vegetation/wildflowers (48.0%), solitude (37.1%), and walking/hiking/physical exercise (27.2%).

The tourist market was segmented into a large cohort of drivers (73.7%) and a smaller cohort of hikers (26.3%). Drivers spent on average almost three times as much daylight time (59.8%) with scenic driving and less than a third of daylight time (16.9%) with hiking compared to hikers. Drivers also planned to go on shorter hikes during their stay than hikers. Notwithstanding, even hikers preferred hikes of medium length (less than 3 km) over longer hikes, and both hikers and drivers commented that, given the choice, they preferred to camp at sites with vehicle access.

The gorges were a major tourist attraction. Most respondents (96.5%) indicated their interest to visit a gorge, and 61.1% of these stated that they would spend (or had spent) half or more of their time in the gorges of the Flinders Ranges.

5.2. Actual use

5.2.1. Vehicle-accessed gorges

The original 11 visitor variables of actual use measured in vehicle gorges (Table 2) were summarized into two statistically independent axes (PC1, PC2) by means of an unrotated PCA (Fig. 2a). These two axes with eigenvalues > 1 explained 58.8% and 10.3% (Table 2), respectively, of the total variation in visitor use between sites in these gorges. Given that the combined value of the first two PCA axes is >50%, the overall structure of the data is sufficiently represented by the first two PCA axes in spite of the reduction of information accruing from the ordination process (Clarke & Gorley, 2001).

PC1 described a gradient in decreasing tourism use as revealed by the factor loadings (Table 2) and superimposed PCA vectors (Fig. 2a): All (ranked) visitor variables were significantly, negatively correlated with PC1. The number of day- and night-campers, day-camp time, camp size and the number of fireplaces showed the strongest negative correlations; (inverse) passing speed, percentage of stoppers and stop time were also significantly negatively correlated but less strongly. PC2 mainly described usage differences of sites based on a gradient in the percentage of stoppers and their stop time. It also discriminated sites with a higher percentage of stoppers and stop time from those with more camping. Thus, this axis facilitates discrimination based on different quantities and qualities of usage.

The ordination along PC1 formed two distinct associations which were confirmed by the partitioning attained with a hierarchical clustering procedure at a 62% Euclidean distance between the

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Factor loadings (Pearson’s correlations; rP) of the ranked visitor variables (Var) on the component scores of the first two PCA axes derived from sites receiving (1) vehicle or (2) hiker traffic ordered in visitor use space.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Var</td>
<td>Description</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>Passers (no. d–1)</td>
</tr>
<tr>
<td>P2</td>
<td>Speed (km h–1)</td>
</tr>
<tr>
<td>P3</td>
<td>Stoppers (% of passers)</td>
</tr>
<tr>
<td>P4</td>
<td>Stop time (min stopper–1)</td>
</tr>
<tr>
<td>C1</td>
<td>Day-campers (no. d–1)</td>
</tr>
<tr>
<td>C2</td>
<td>Day-camp time (min day-camper–1)</td>
</tr>
<tr>
<td>C3</td>
<td>Night-campers/no. night–1</td>
</tr>
<tr>
<td>S1</td>
<td>Camp size (m2)</td>
</tr>
<tr>
<td>S2</td>
<td>Fireplaces (no.)</td>
</tr>
<tr>
<td>S3</td>
<td>Info signs (no.)</td>
</tr>
<tr>
<td>S4</td>
<td>Trash items (no.)</td>
</tr>
<tr>
<td>Variance explained (%)</td>
<td>58.80</td>
</tr>
</tbody>
</table>

Note: *P (sites with vehicle traffic) < 0.05; **P (sites with hiker traffic) < 0.001.
* The inverse value was used because low speed was thought to increase usage levels.
resulting clusters. At this level of partitioning, SIMPROF found statistically evident sub-structure within the clusters ($\overline{\lambda} = 7.0$, $P = 0.001$); namely, significant differences between the groups and not within each cluster. The clustering was illustrated at this particular Euclidean distance, among other significant (SIMPROF) partitioning options, because it separated the sites into two clusters of nearly balanced sample size with a distinct gap in-between, indicative of distinct usage levels. The three vehicle sites with the lowest PC1 values (marked as ‘1’ (Fig. 2a) and grouped separately on the ordination plot) were appropriately identified by the PCA as sites of highest use since they all contained big camping and rest areas.

5.2.2. Hiker-accessed gorges

A 2-dimensional PCA was also a good representation of site-relationships in the higher 11-dimensional space for sites in hiker gorges. PC1 accounted for most of the variability (52%) and PC2 for a further 11.2% (Table 2), both with eigenvalues $> 1$.

PC1 (Fig. 2a) described a gradient in decreasing tourism use of sites within hiker gorges expressed as negative correlations of all visitor variables with the component scores of PC1 (Table 2). Here the separation was mainly driven by the number of passers, the percentage of stoppers and their stop time. Camping variables distinguished a few sites from the majority of sites but were weak
differentiators for the main bulk of sites. For instance, hiker site ‘1’, ‘2’ and ‘3,’ (Fig. 2a), located near the entrance of hiker gorges, were exposed by the PCA because they belonged to the few places where people had camped. At site ‘4’ (Fig. 2a), visitors were attracted to stop for a longer time at an information sign on aboriginal culture. PC2 mostly separated sites based on the passing speed of visitors.

Cluster analysis at a 43% Euclidean distance divided the sites into one cluster of only three sites with exceptionally high usage and two clusters of equal sample size characterised by high or low usage with significant sub-structure as determined by SIMPROF ($\chi^2 = 2.59, P = 0.001$).

5.2.3. Comparison between vehicle and hiker gorges

PCAs on the same visitor variables, but calculated without any camping variables (C1–C3, S1–S2; abbreviations as in Table 2), illustrated that camping was of much higher importance for ordinating vehicle sites than hiker sites. Hiker sites with or without camping variables were similarly distributed along PC1 (Fig. 2b). In contrast, the ordination for vehicle sites without camping variables (Fig. 2b) was much more condensed and the gap between high and low usage sites closed so that previously separated sites (Fig. 2a) showed some overlap in their PC1 scores. Consequently, a classification of vehicle sites into usage categories without camping variables failed to adequately represent the existing differences in visitor usage. The pattern was exactly opposite for vehicle and hiker sites when the number of passing tourists was excluded (Fig. 2c). When the percentage of stoppers and their stop time were excluded, the separation of vehicle sites (Fig. 2d) was only mildly attenuated while the separation of hiker sites was weakened somewhat more.

The differences in the mean visitor values between vehicle sites assigned to the high or low usage clusters (Table 3) were considerable for all camping variables including the camp size and the number of fireplaces as well as for the percentage of stoppers and their stop time. In contrast, hiker sites (Table 3) were markedly different only in the mean number of passers, the percentage of stoppers and their stop time. Even though the camping variables ostensibly differ in their means, it should be noted that their values stem from only a few high usage sites where any signs of camping usage were found (11–28% of sites depending on the variable) and so are not representative of the whole group of high usage sites; this contrasts with vehicle gorges where 90–95% of sites contributed to the means of the different camping variables.

Overall usage in hiker sites was lower than in vehicle sites as several variables indicative of high usage hiker sites were similar in value to those in low usage vehicle sites.

5.2.4. Correlations between visitor variables

There were significant correlations among the visitor variables at vehicle and hiker sites (Table 4). The correlations between the proxy variables (camp size, number of fire places, information signs and trash items) and the rest of the variables were inspected to determine whether the former could be recorded in lieu of the latter. Indeed, the camp size and number of fire places showed moderate to strong ($0.5 < r_p < 0.9$) correlations in both vehicle and hiker sites with the number of day- and night-campers, and thus could be used as their proxy variables. Further, they can serve as a proxy for the day-camp time in hiker sites and number of stoppers in vehicle sites, respectively. In contrast, the number of information signs and trash items were too rare and showed weaker correlations with the visitor variables of observed use to be of reliable use in our study area for the task at hand.

5.2.5. Detailed visitor monitoring with GPS tracking

Our example (Fig. 3) of how the GPS data can further be exploited illustrates visitors deviating from official trails to approach a scenic feature. This was not uncommon at sites where, for instance, natural ponds were visible but not directly accessible from the official path. Knowledge of such behaviour may direct preventive management actions and should influence the placement of environmental monitoring plots in relation to the recreational track.

5.3. Reported use

A majority (257) of the 342 survey participants had already visited at least one of our study gorges, and a further 73 were planning to do so in the remainder of their trip. Differences in the percentage of visitation between vehicle ($\text{mean } \pm 1 \text{ SE} = 65.8 \pm 13.4$) and hiker gorges ($26.9 \pm 9.8$), were pronounced. Sites in the beginning of hiker gorges attracted more visitors on average than sites further inside (cumulative percentage of visitors in the beginning: 100%; middle: 48.9% ± 11.1, end: 24.5% ± 14.5). In contrast, tourist frequency in vehicle gorges appeared to be fairly similar throughout their entire length (cumulative percentage of visitors in the beginning: 100%; middle: 89.4% ± 8.3, opposite end: 83.9% ± 12.0). Furthermore, tourists, in particular hikers, seemed to prefer one access point into each gorge over alternatives (mean percentage of tourists accessing through the preferred access points: 86.4% ± 6.2).

Most respondents were able to answer at least some questions relating to their use of whole gorges (site-unspecific use) and even site-specific use within a gorge (Table 1). However, memory of site-specific use was weaker, especially when people had to indicate sites where they had stopped and how long they had stopped there.

<table>
<thead>
<tr>
<th>Var</th>
<th>Description</th>
<th>(1) Sites with vehicle traffic</th>
<th></th>
<th>(2) Sites with hiker traffic</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low usage</td>
<td>High usage</td>
<td>Low usage</td>
<td>High usage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SE</td>
<td>Mean</td>
<td>SE</td>
</tr>
<tr>
<td>P1</td>
<td>Passers (no. d&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>16.88</td>
<td>1.71</td>
<td>23.79</td>
<td>1.75</td>
</tr>
<tr>
<td>P2</td>
<td>Speed (km h&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>31.66</td>
<td>1.95</td>
<td>20.29</td>
<td>2.26</td>
</tr>
<tr>
<td>P3</td>
<td>Stoppers (% of passers)</td>
<td>5.23</td>
<td>1.49</td>
<td>30.46</td>
<td>5.09</td>
</tr>
<tr>
<td>P4</td>
<td>Stop time (min stopper&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>1.29</td>
<td>0.58</td>
<td>9.38</td>
<td>2.38</td>
</tr>
<tr>
<td>C1</td>
<td>Day-campers (no. d&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>0.26</td>
<td>0.10</td>
<td>4.82</td>
<td>1.39</td>
</tr>
<tr>
<td>C2</td>
<td>Day-camptime (min day-camper&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>55.10</td>
<td>20.96</td>
<td>337.53</td>
<td>17.79</td>
</tr>
<tr>
<td>C3</td>
<td>Night-campers (no. night&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>0.07</td>
<td>0.04</td>
<td>2.18</td>
<td>0.60</td>
</tr>
<tr>
<td>S1</td>
<td>Camp size (m²)</td>
<td>374.10</td>
<td>202.08</td>
<td>57 149.32</td>
<td>33 382.75</td>
</tr>
<tr>
<td>S2</td>
<td>Fireplaces (no.)</td>
<td>1.76</td>
<td>0.65</td>
<td>6.74</td>
<td>3.83</td>
</tr>
<tr>
<td>S3</td>
<td>Info signs (no.)</td>
<td>0</td>
<td>0</td>
<td>0.47</td>
<td>0.12</td>
</tr>
<tr>
<td>S4</td>
<td>Trash items (no.)</td>
<td>0.24</td>
<td>0.12</td>
<td>1.53</td>
<td>0.50</td>
</tr>
</tbody>
</table>
Respondents’ own perception of the reliability ($F_{(4,8,130)} = 33.71$, $P < 0.001$) and completeness ($F_{(2,3,148.5)} = 175.84, P < 0.001$) of their answers significantly differed between questions (Table 1) and followed the same pattern as for the memory. The more stops people had made, the more difficult it was to specify stopping locations: at 1–2 stops 74.7% of stopping locations could be referenced; at 3–5 stops the percentage dropped to 49.6% and at more than 5 stops to only 34.4%.

6. Discussion

6.1. Determination of usage levels

Our results clearly demonstrated a heterogeneous level of visitor use between the selected gorges of the Flinders Ranges and sites within them. Concentrated use at specific locations within a protected area is a typical visitation pattern (Hammit & Cole, 1998; Marion & Farrell, 2002) that mainly results from the attraction of visitors to specific natural or artificial landscape features, the accessibility of a site, its spatial relation to other sites (that allows/hinders possible joint visits) and its adequacy for camping, resting or parking.

Usage levels of our study sites differed substantially between vehicle and hiker gorges. Overall, vehicle gorges attracted a much higher load of tourism traffic. For instance, the mean number of visitors that passed by low usage vehicle sites reached similar values as that at high usage hiker sites. Thus variation in usage levels is context-based, in our study area by the mode of access. Regardless of context, sites with little use contrasted strongly with well used sites in each gorge.

Samples of both hiker and vehicle sites were divided into two clusters of contrasting usage level. In both cases the division between the clusters by their separation along PC1 (the first PCA axis) was pronounced and would validate a subsequent comparison of environmental conditions between high and low usage sites. The first two clusters with the lower PC1 values (Fig. 2a) for the data from the hiker gorges could be pooled to create a more balanced data set which aids various statistical analyses (Field, 2005). The hiker impact study could also be conducted with the percentage subset of sites with the highest and lowest PC1 values while the rest are excluded for being too similar.

If the separation of sites was more continuous along PC1 rather than in clusters, the level of usage may be better expressed as a continuous variable, namely the individual PC1 scores for each site, than in a categorical form of high vs. low usage. Finally, as in the case of PC2 for vehicle sites, a comparison may not only involve different quantities but also qualities of usage (e.g., sites that are well used by tourists for stops vs. sites used for camping).

Typically, an inter-site comparison of environmental conditions in relation to different usage levels either replaces or supplements a monitoring of impacts at the same site to uncover tourism-related changes over time. The great advantage of the former is that management actions can be taken before sites have diverged from a desired state which may be difficult to restore (Hadwen et al., 2007).
6.2. Choice of visitor variables

Our study also demonstrated the importance of recording a comprehensive set of visitor variables to classify sites according to their varying usage levels. This can ensure an appropriate classification of sites and consequently an adequate representation of the relationships between visitor usage levels and impacts in environmental impact assessments. The selection of visitor variables depended on the mode of access to visitor sites with different variables driving the separation of sites. Visitors in vehicle gorges nearly always traveled in their vehicle rather than alighting and walking. Hence, we hereafter refer to tourists at vehicle sites as ‘drivers’ and those at hiker sites as ‘hikers’.

Numbers of passing tourists discriminated usage levels better between sites in hiker gorges than in vehicle gorges. While vehicle traffic extended uniformly along most of the road through vehicle gorges, a gradient of use was found along the trail in hiker gorges, where the number of passing tourists decreased from the beginning (preferred access point) towards the end. A limited vacation time may favor short to medium hikes. In contrast, most people have time to explore the whole length of a vehicle gorge, especially if the journey was to be continued at the opposite end. Given that the majority of people in our study area were 50 years or older, physical limitations might have further restricted the length of hikes. More intensive use (or signs thereof) in the beginning sections of hiking trails has previously been reported (Bright, 1986; Hammitt & Cole, 1998).

Camping activities were operational in driving site-differences in vehicle gorges but were negligible for differentiating sites in hiker gorges. With the exception of sites in the very beginning, virtually no camping took place in hiker gorges. Given that visitors to the Flinders Ranges have a grand choice of official and wild campgrounds available, they tend to camp where they can remain close to their vehicles. That relieves them from having to carry equipment, water or firewood (the policy is not to collect firewood on-site) and offers the safety of a vehicle nearby. The mean number of day and night campers and the mean number of fire places were clearly higher at the high usage sites in vehicle gorges than at low usage sites. More extreme were the differences in the average campground size, but that was mainly due to a few exceptionally large camp grounds on high usage sites. The same variables differed little in hiker gorges where no camping took place on low usage sites and very little on high usage sites. Further, in hiker gorges visitors spent a very short time camping during the day, even on high usage sites. We noted that tourists that planned to go for a longer hike often arrived the night before to break up camp early in the morning so they could avoid the high ambient temperatures during the day. In high usage vehicle sites, people camped throughout the day and sometimes even stayed for a few days in a row without necessarily leaving their camp site.

The percentage of stoppers and their stop time were moderately efficient discriminators in both types of access mode. In vehicle gorges this difference is ascribed to the existence of ‘ordinary’ sites that visitors ignored and ‘attraction’ sites, distributed throughout the gorge, containing car parking, scenic or informative features and shade. In hiker gorges, hikers behaved differently at the beginning of their hikes where they took more time to observe the scenery and were more inclined to take longer breaks (e.g., for picnicking or photography).

Of minor (albeit statistically significant) importance for discriminating usage between sites was the passing speed. Hikers already traveled at a speed that enables a comfortable observation of their surroundings and even though drivers may reduce their velocity while traveling through scenic sites, they generally drive rather slowly because of the rough unpaved roads and the chance of wildlife crossings. Equally unimportant discriminators were the number of trash items and information signs as both were rare. However, in the few places with information signs the percentage of stoppers increased markedly.

6.3. Comparison between visitor-monitoring methods

Each of the methods employed to monitor actual visitor use have advantages and disadvantages in terms of costs, ease of use, site efficiency (daily sampling rate of sites) and their sensitivity towards short-term fluctuations in visitor use. These costs and benefits need to be considered before a method is utilized in a hi-lo impact study.

6.3.1. Direct monitoring via staff observers

The direct monitoring of use required a vehicle and associated fuel (and maintenance) costs, which were substantial due to the long distances between sites. Another drawback was that the method was very time-consuming (Keul & Kühlberger, 1997; Murphy, 1992) and due to the low site-efficiency only one site could be monitored per day and person with the exception of the night-camper numbers (many sites can be assessed in one evening). Further, on-site counts may be more sensitive to temporal fluctuations in visitor use than the recording of proxy variables.

Little initial training was required, and given the comparatively low traffic volume in our study area inter-observer reliability was high as validated by no significant differences in simultaneous data taken independently by two observers in a pilot study. However, direct monitoring may become increasingly more error prone with higher traffic volumes, faster traffic and more variables to be quantified. Arnberger et al. (2005), for instance, found that at peak times (>120 visitors per hour), observers compared to video-interpreters underreported visitor numbers of walkers and bikers by 30%. Under such circumstances, traffic thresholds need to be identified beyond which the monitoring task is allocated to several observers.

On-site counting had the advantage that it was the only method that allowed quantification of the absolute number of passing tourist units (vehicles or hiker groups) at a site. Traffic, beam or gate counters would also quantify the passage of vehicles or pedestrian traffic but they would be too expensive for a large sample of sites. Further, they may be prone to underestimation (multiple persons counted as a single passage) or overestimation (triggered by another mammal species) and require thorough calibration (Dixon & Council, 2004; Wardell & Moore, 2004). Since the number of passing tourists was the variable of choice to discriminate sites accessible on foot based on usage, it needs to be pointed out that relative numbers can be used instead of absolute numbers — as the intention was to compare relative and not absolute usage of sites — and those can be calculated from the GPS tracking data as well.

6.3.2. Assessment of proxy variables

It may be possible to replace some of the variables of observed use with proxy variables of use since the latter measure a change in the environment caused by visitor activities. Bratton, Hickler, and Graves (1978), for instance, found a strong correlation between visitation levels and disturbances such as bare soil at campsites and the number of fire places. In our study such a positive correlation was detected between the number of day and night campers with the number of fire places and the campground size, and so the use of the latter variables as a surrogate can be recommended (Cesford & Muhr, 2003; Cope, Oxford, & Probert, 2000). The main advantage is that proxy variables can be measured on several sites per day (reduced monitoring effort English, Kocis, Arnold, Zarnoch, & Warren, 2003) and that they should be less sensitive towards...
short-term fluctuations in visitor use as they are unlikely to vary from day to day.

6.3.3. Indirect monitoring via GPS tracking

For an indirect observation of visitor activities GPS tracking was employed, which is a relatively new method in visitor monitoring (Kemperman & Joh, 2003; McKercher & Lau, 2008; O’Connor et al., 2005; Shoval & Isaacs, 2006, 2007). The GPS-recorded travel routes of visitors were downloadable into the software (Track Stick Manager) provided by the manufacturer (Procure It Australia Pty Ltd, Banyo, Queensland, Australia) and could then be exported into spreadsheet, text and Google Earth file format. Data were also accessible for import into a geographical information system (GIS) software for a sophisticated spatial analysis of visitor activity. The training to handle the GPS units and software was more demanding compared to the other monitoring techniques.

Overall, GPS tracking was most rewarding as no other technique provided such detailed data (Hallo, Manning, Valliere, & Budruk, 2005) at such a high site-efficiency with most visitors travelling to many different locations per day. Further, GPS data may be more reliable than similar data gathered by human observers particularly if the traffic volumes are high. The data gathered with GPS tracking can also be analysed in ways far beyond the goal of this study to construct intricate models of the spatio-temporal behaviour of visitors (O’Connor et al., 2005; Shoval & Isaacs, 2010). Our example of visitor tracks illustrated that usage may vary even within study sections and that visitors may not necessarily adhere to pre-defined routes. Such knowledge will aid hi-lo impact studies in detecting the actual cores of the disturbance so they can properly relate impacts (e.g., trampling of vegetation) with the distance to the recreational disturbance.

One major drawback of GPS tracking, however, was the relatively high initial cost. Fortunately, prices of GPS units have dropped dramatically in the last decade and there is some powerful GIS software available now as freeware (e.g., QGIS). In addition, the use of GPS units is so versatile that this investment may easily pay off if the tracking units are employed for various other tasks. Other practical disadvantages of GPS units are: (1) they may be stolen because of their utility, (2) they may be tampered with, (3) they may be displaced and lose satellite coverage, (4) they may fail to be returned through oversight, and (5) they may change visitor behaviour, especially illegitimate activities, through the perception of being constantly monitored. To overcome these disadvantages we (1) chose a GPS model whose utilities were already disguised as it lacked a display, and we hid them even further by enclosing the GPS unit in a sealed case which (2) also secured it from tampering, (3) then we installed it with a tape on the car dashboard or in the top pockets of a hiker’s backpack or jacket to improve satellite reception, (4) provided an easy self-regulated drop-off location and a postal address for return, and (5) provided a participation statement that indicated the privacy of the data and that goals of the project were research not enforcement.

6.3.4. Questionnaire-based visitor surveys

Survey data related to specific site-use were impaired by the lack of memory of visitors and their ability to describe or reference the sites of their journey on a map. Fewer people remembered where they had camped or stopped than whether they had visited a particular gorge or from which side they had accessed it. In addition, the lower ratings of reliability and completeness of the answers given about specific site-use cast doubt on the utility of these data. The questions on more transient use of sites (i.e., any stopping events compared to camping) appeared especially difficult to answer.

Recall in visitor surveys has been reported as a source for error (Faulkner & Raybould, 1995; Hallo et al., 2005) and travel diaries (Fennell, 1996; Thornton et al., 1997) might have provided a more reliable data set since visitors record the information whilst they are travelling. Even so, there are limits to the amount of information that you can ask of people who are on vacation. Moreover, we would have had to distribute a system of site markers to facilitate the correct identification of sites for the descriptions in the diary.

Given that conducting and evaluating the survey was also very time-consuming and that a discrepancy may exist between what people do and what they report they do, we cannot recommend visitor surveys as a stand-alone method for quantifying usage levels between sites where variation in use occurs on a small spatial scale.

However, some valuable additional information was retrieved that gave a good indication of difference in usage on a coarser spatial scale (between gorges, sections of a gorge, access points). Further, the visitor profiling helped to interpret the results from the other monitoring methods like the lower engagement in hiking activities and the preference to camp at sites with vehicle access.

7. Conclusions

Our research revealed that access mode was a major factor influencing visitor behaviour in the Flinders Ranges gorges, which needs to be reflected in the selection of visitor variables as part of a best-practice visitor-monitoring approach. Gorges with vehicle access attracted the main influx of campers and while most people explored these gorges from the beginning to the opposite end only some of multiple sites were selected for camping. Therefore, we recommend using camping variables including those that were quantified in proxy, namely the camp size and number of fireplaces, to discriminate between vehicle-accessed sites based on usage. The number of passing tourists was too uniform to differentiate usage levels. In gorges with hiker access the pattern was exactly opposite. Here, within-gorge visitation varied strongly as sites towards the middle or opposite end of the more accessible entrance point were substantially less frequented as visitors usually remained within a few kilometres from where they had accessed a gorge. Very little camping occurred. Hence, the number of passing tourists best discriminated site usage in hiker gorges. For both modes of access, the percentage of stoppers and their stop time may attain some additional discrimination of sites. Thus the generality of our results are qualified by both the way tourists access a site (by roads and trails from a few access points in our study), and the visitor market under observation (preference for low to moderate physical activity and camping at sites with vehicle access).

Based on our examination of several visitor-monitoring methods we suggest tracking visitors with a GPS as it is (1) unbiased, (2) provides a high resolution of data if desirable and (3) has the potential for simultaneous sampling of multiple sites. However, for quantifying absolute visitor numbers usage needs to be monitored directly by human observers or traffic-counters on-site. To reduce sampling effort visitor numbers may be recorded at the access points and in the middle of the gorges rather than throughout the whole gorge. Questionnaire-based visitor surveys appeared to have low value for differentiating usage levels as the information required about the trip itinerary was simply too detailed for people to recall. Notwithstanding, visitor surveys gave a good indication of difference in usage on a coarser spatial scale and they can retrieve additional information that aids in interpreting the results from the other monitoring methods.

Finally, we recommend designing an impact study where equal effort is allocated to the visitor and environmental monitoring. In protected areas, where tourism use varies on a small spatial scale it may be of great benefit to GPS-track a larger number of visitors and
generate a fine-scale map of usage as a base for further monitoring of 
environmental conditions. With such detailed visitor informa-
tion, usage levels can be appropriately determined and as a conse-
quence visitor impacts identified.

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