Port Campbell National Park: Patterns of Use

A report for the development of visitor typology as input to a generic model of visitor movements and patterns of use.

Prepared for:

Parks Victoria

Visitor Research

Bourke Street Melbourne

Victoria, Australia

June 2003

Colin Arrowsmith and Prem Chhetri

Department of Geospatial Science, RMIT University, Melbourne, Victoria

ACKNOWLEDGEMENTS

This research was undertaken with the assistance from many people. However , we would like to specifically acknowledge the assistance we received from the following organizations and individuals. Firstly we would like to acknowledge the financial support received from Parks Victoria (Visitor Research) and from RMIT University (Research and Development). Without this financial support the project could not have proceeded. We would like to thank the efforts of both Dino Zanon and Claire Burton from Parks Victoria (Visitor Research) for their advice on the research approach, questionnaire design and feedback on this report. Also thanks are extended to Kathryn Williams from The University of Melbourne (Department of Psychology) for advice on the questionnaire design. Bob Itami from GeoDimensions Pty. Ltd. also provided valuable input both in the initial stages of the research and developing the questionnaire, and later in providing the simulation results from RBSim2 and feedback on this report. The rangers from Port Campbell National Park, and in particular John McInerney provided much needed assistance in conducting the surveys for which we are most grateful. Finally we would like to acknowledge the many nameless participants who provided the survey data which provided the basis for this research. Their efforts are very much appreciated.

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LIST OF ACRONYMS

AMG	Australian Map Grid
GIS	Geographic Information System(s)
GPS	Global Positioning System(s)
IUCN	International Union for Conservation of Nature
KMO	Kaiser-Meyer-Olkin measure of sampling adequacy
PCA	Principal Components Analysis
PCNP	Port Campbell National Park
PDA	Personal Digital Assistant
RBSim2	Recreation Behaviour Simulator 2
RMIT	Royal Melbourne Institute of Technology
SPSS	Statistical Package for the Social Sciences

EXECUTIVE SUMMARY

It is becoming increasingly important to understand how tourists are utilising nature-based tourism resources to ensure that tourist attractions, and facilities and services provided in parks are not over-used, become over-crowded, and therefore diminish the tourist experience. Understanding how visitors interact with nature-based tourist destinations will enable park managers to predict and therefore plan for managing impacts and appropriate infrastructure to deal with tourism, as well as predict the location of particular tourist types in times of crises (for example risks from bush/forest fires). Prediction is particularly important when considering park planning and evaluating options on how best to manage a park.

This report documents a study conducted at Loch Ard Gorge, Port Campbell National Park, to pilot test the efficacy of using handheld global positioning system (GPS) receivers to monitor the movement patterns of tourists through a popular and well-known nature-based tourist destination in southwest Victoria, Australia. The approach taken was to ask a random sample of visitors to complete a simple socio-demographic questionnaire and then undertake their visit to the park carrying a handheld GPS receiver. Recorded locations were downloaded onto a geographic information system (GIS) where spatial, including topological, analyses were conducted.

From the GPS and socio-demographic survey of 102 participants, cluster analysis revealed four tourist types visiting Loch Ard Gorge. The first type visiting was referred to as the 'single groupie'. This person is likely to be travelling within a group comprised of young people. They tend to travel widely once at a given destination and will spend longer than their counterparts. The second group is made up of what has been called 'international couples', who are young and generally well educated. This tourist type will stay longer than average and will visit in the order of three attraction nodes. Elderly citizens are represented in the third tourist group, the 'elderly couple', and tend to stay at tourist destinations for a shorter duration than average. They also tend to restrict their visitation to concentrated locations near the entry and exit points to a destination. The final typology is the 'local family'. This group tend to visit an average number of attraction nodes at a given destination.

The typologies identified as part of this study can be used as the basis for characterising agents within the RBSim2 simulator. However given the small number of participants (102), it is suggested that the study be repeated for a similar park site at the Port Campbell National Park initially, and then to extend the surveys to other parks with different characteristics (for example the Grampians National Park).

The study has also shown that for a selection of alternative track routes open to tourists, more than half commenced their visit at the same location, i.e. the Loch Ard Story Board adjacent to the first car park, before moving on to the Beach at Loch Ard. About half of these then moved on to the Loch Ard Lookout. The average number of nodes visited was 3.5 and the average length of stay was 65 minutes.

A comparison of observed against predicted movements of visitors using the RBSim 2 simulator shows that the simulator is able to predict correctly the movements observed in reality. However more remote regions are under-represented in visitation as predicted by the RBSim2 simulator.

PART A: REVIEW OF VISITOR MANAGEMENT APPROACHES

A1 INTRODUCTION

This report documents a research project that investigates patterns of behaviour and movements throughout a section of Port Campbell National Park. Data collected, as part of this research will be used to validate and develop agent-based rules for the RBSim 2 Agent-Based Simulator developed for Parks Victoria. RBSim2 models park visitor movements using agent based decision-making rules.

Garmin ETrex handheld global positioning systems (GPS) receivers were used to monitor the movements of 102 visitors to Loch Ard Gorge within the Port Campbell National Park (PCNP) during one weekend in June 2002. In addition to the GPS logged data, brief questionnaires were administered to participants in order to provide basic demographic profile data.

Part A of this report includes a discussion into the background leading to this study, and reviews monitoring visitor behaviour in national parks as well as methods for building a spatial-temporal model for park management. A literature review of typologies of tourists to parks, and survey techniques used to monitor visitor movements are also included in this section.

Part B of this report documents the field techniques applied in this research, and discusses and analyses movement patterns for the various surveyed participants.

A2 BACKGROUND TO THE PROJECT

Tourism in parks and protected areas is expected to continue to increase. This will subsequently increase the potential risk from human impacts on natural and cultural resources within these parks. In addition to the increase in tourist numbers, there is a corresponding increase in the new types of recreational activities that people pursue within parks, for example mountain biking, rock climbing, scenic flights, horse riding and hand gliding. Each of these new recreational pursuits has its own environmental requirements (Itami and Gimblett 2001). The adverse impacts on the park do not result from tourist visitation itself but rather from the amount of utilisation, its distribution within a region, seasonal use and from the particular leisure activity undertaken (Ziener 2002). Blazejczyk (2002: 418) for example, found that 75% of the annual 2.5 millions tourists to the Tatra National Park in Slovakia, visit during the summer season. Similar seasonal visitation patterns are observed in the Grampians National Park (Arrowsmith 2003) and Port Campbell National Park (Parks Victoria 1998). Manning and Cormier (1980) note that facilities and services in parks may go largely unused for much of the year, but for short periods, their capacity is exceeded during peak loads. They also noticed that such periodic peaking of recreational use not only increased the potential for conflict but also presents management problems with respect to personnel scheduling (*ibid.*: 81).

Many of our ecologically sensitive tourist destinations are already experiencing stress from overcrowding (Harris and Leiper 1995). With growing visitor pressure user satisfaction is diminished and the ecological base for the attractions, which tourists are coming to see, is also actively degraded. In addition to the deleterious impacts associated with overcrowding, there has also been an observed alteration in visitor behaviour in many parks. Arnberger and Brandenburg (2002) noticed that visiting times vary and people's habits will change in an effort to accommodate overcrowding. People have different perceived levels of crowding, and further research into these varying perceptions is required (Manning 1999; Arnberger and Brandenburg 2002). Lawson *et al.* (2002) for example has applied a simulation model that has estimated numerical values of social carrying capacities for hikers and vehicles within the Delicate Arch and Arches National Park, Utah, USA. The model determined that a maximum of 315 hikers and 750 vehicles was an estimate of the social carrying capacity limit for the 5.00 a.m. to 4.00 p.m. time frame for the park.

Lawson *et al*. (2002) stated that most of the earlier approaches to park management, for example Limits of Acceptable Change and Visitor Impact Matrices, adopt a "reactive approach". They expressed the need for a "proactive approach" for managing carrying capacity of the park. This approach should estimate the "level of visitor use" that will calculate a threshold value above which the "standard of quality" of visitor experiences will start declining. They also state that park managers need to ensure that such levels of visitor use are not exceeded (*ibid.*). Zanon and Ware (2000) has also expressed the need to proactively "control" visitor behaviour by restricting the number of "desire paths" being formed at the Twelve Apostles and Loch Ard Gorge sites. For example, trampling has been noticed to be a major problem at PCNP, especially when visitors engage in aberrant behaviour like walking off the tracks, particularly where the soil type and vegetation have difficulty in recovering from excessive use.

Parks Victoria frequently conduct visitor surveys which makes it possible to quantify and classify parks visitors on the basis of tourist type, motivations for visit and satisfaction of the visit. However, little or no data currently exists that records movement patterns throughout a park such as sites visited, duration of visit, speed of movement through the park and walking off designated walking tracks.

A3 CURRENT RESEARCH IN PORT CAMPBELL NATIONAL PARK

Parks Victoria manages more than 3.8 million hectares of parks and reserves throughout Victoria. This makes up about 16% of the total area of the state. The total number of visits to Victoria's parks and reserves are estimated to be 42.8 million (27.6 to national parks and 15.2 million to metropolitan parks) a year for the year September 2001 to August 2002 (Parks Victoria 2002). Current research shows that there has been a significant increase in tourist numbers to PCNP. The PCNP and Bay of Islands Coastal Parks Management Plan (Parks Victoria 1998) estimated a 5.7% growth rate in the number of visits to the area. Future growth is expected to originate from the west, particularly Warrnambool and Portland, although currently 65% of visitors to Port Campbell and 20% to the Bay of Islands Coastal Parks enter from the east via the Great Ocean Road. The PCNP Management Plan (Parks Victoria 1998: 25) has identified a higher concentration of visits to several sites in PCNP. In particular the Twelve Apostles, Loch Ard Gorge and Port Campbell foreshore and London Bridge have had high numbers of visitors (*ibid*.). These concentrations of visitors have been noticed during the summer and autumn seasons when visitor numbers often exceed existing parking and trail capacities (*ibid.*). This has resulted in traffic and park management problems at the Twelve Apostle and Loch Ard Gorge where there are 970,000 and 620,000 annual visits respectively, representing 54% of the 2.96 million visits to all sites at Port Campbell National Park.

Parks Victoria (1998) has identified problems associated with overcrowding and behaviour of tourists that diminish both the environment and experience of other visitors as key issues that are seen as significant to park management. In response, Parks Victoria has suggested a proactive approach that addresses these issues in two ways. Firstly, by adding or removing facilities (for example toilets and walking tracks) and secondly through regulating visitor behaviour (for example via restrictions, schedules and booking reservations), overcrowding can be effectively minimised (Reality Mechanics undated). How successful such measures are, for example the new car park developed at the Twelve Apostles site, are yet to be ascertained.

Parks Victoria is currently implementing a computer-based simulation approach that uses agent-based modelling for supporting decision-making for their parks and reserves. The simulator has so far only been applied to Port Campbell National Park and the Bay of Islands Coastal Park. The modelling software called RBSim 2 (Recreation Behaviour Simulation) uses computer generated agents to represent humans in a geographic recreation environment. Each agent in the model is built using object-oriented programming. Agents can be programmed to make decisions based on a defined set of rules. They are then able to move through a park at predetermined speeds and make simple decisions about which path to take when confronted by alternatives based on a set of established rules. These rules are empirically developed from field studies. This project is expected to validate the predictions that the simulator produce and shape the rules for visitor types that can then be programmed into the agents.

Within the simulator, a linked database acquires information from each simulation so that park managers can identify points of over-crowding, bottlenecks in circulation system and potential conflicts between different user groups.

A4 BUILDING A SPATIAL-TEMPORAL MODEL FOR PARK MANAGEMENT

Currently there is a paucity of information regarding the behaviour of park visitors and the factors influencing their behaviour within parks. RBSim 2 uses GIS data to represent travel networks and site facilities and attractions. It integrates agent modelling with GIS to simulate human behaviour on linear networks in recreational settings. It utilises a database of visitor types that describe typical modes of travel, visitor preferences, and typical travel itineraries within a designated park. The current version of RBSim 2 relies on traffic count data and projected changes in use to generate rates of arrivals to individual sites. However pedestrian behaviour must be simulated since systematic data collection of pedestrian movements has not been studied (Itami *et al*. 2002). Pedestrian behaviour is simulated using a combination of network algorithms to calculate shortest distance paths, a set of assumed preferences for site attractions, a set of context sensitive hierarchical rules, constrained by trip duration and the availability of site facilities (Itami *et al*. 2002).

With the advancement of agent-based modelling software, it is now possible to program in more complex algorithms that emulate visitor behaviour more accurately. However there is correspondingly an increased need for more reliable observed actual data required to develop such algorithms. In addition there is a need to more accurately identify those factors that influence visitor movements within park settings. There is a need to capture the dynamics of the visitor-environment interaction. Traffic counting and other visitor surveys have provided detailed yet static information about visitor numbers, and their socio-demographic backgrounds. Further information regarding behaviour and movement patterns such as sequential order to points of attraction, duration at each site and distance travelled, direction and speed of travel through to monitoring deviation of visitors from designated walking tracks, is required. A better picture emerges when such information is combined with other spatial information such as walking tracks, distribution of attractions, physical characteristics (slopes, height) and other infrastructure facilities (toilets, car parks). From this information it is then possible to determine visitor flows and visitor loads at key nodes in the park. Management of visitors becomes much more comprehensive and effective when their attitudes and behaviour characteristics can be integrated in the model. The proposed framework is an attempt to integrate spatial, temporal and behavioural data sets into the system in order to build a relatively more realistic prediction and simulation of visitor movements. The following section will briefly investigate those elements that can be incorporated into the proposed integrated behavioural model for visitor management.

A4.1 Integrating spatial and temporal information

All visitor activities in a tourist destination take place within a spatio-temporal framework. Each tourist visit involves some form of geographic movement and possible social interaction with other visitors. Spatial representation can be determined from recorded x and y coordinate pairs and recorded time will give duration of visit.

Integration of spatio-temporal data within modelling software will allow interactions and movements of visitors to be defined. This data will also allow the potential area accessible to a visitor with given time constraints to be predicted. Forer (1995: 172) considered recreational behaviour as a typical process wherein time and space are intricately linked through the scheduling of activities subject to a range of constraints. Goodchild *et al*. (1993) stated that the analysis of social (recreational) processes need time-dependent, multidimensional relative space rather than static, two-dimensional and absolute space. Their study modelled space-time behaviour in an urban environment both at the individual level as trajectories in three-dimensional space-time and at the aggregate level as time-slice replications.

Spatio-temporal characteristics of visitor movements can be recorded using parameters such as sites visited, time of day (when), duration (how long) and sequence (what order). Changes in these parameters indicate changes in a visitor's position and therefore their exhibited behaviour. Some of the spatio-temporal parameters used in this report are:

A4.1.1 Position

Position refers to a geographic location at which an activity or an event occurs. Positioning information can be measured in absolute location (x and y information) using a coordinate system. It can also be defined on a relative location using a spatial framework giving position in relation to other objects. Relative positioning is found to be a more useful concept in visitor management in parks as most of the decisions are based on those relative spatial and social relations. For example the location of car park or toilets can significantly influence the sequence and duration of a trip.

A4.1.2 Duration

Duration is defined as a period of time of an activity or a trip. It consists of an interval between at least two or more points in time. Each activity has a given duration that takes place at specific points or locations within the space-time framework (Huisman and Forer

1998). Duration can be calculated at several scales ranging from entry and exit to specific attractions, through to the total duration of visit to an entire park. The longer the time spent by visitors at each site in a park indicates their attraction to a particular location and therefore identifies a potential site for visitor crowding.

A4.1.3 Sequence

The sequence is the order in which an individual visits a number of attractions. The sequence provides information about how people travel through landscapes by following a particular order. Such sequences exhibit decision-making processes carried out by individuals whereby they select certain paths and attractions to visit. The sequence that people follow is partly affected by the contextual environment (for example weather, moods, fatigue or the biophysical make up of landscapes). In addition they are influenced by mental images formed from available tourist information. Some of these decisions are pre-determined prior to the visit. The sequential pattern of a day trip visit may be quite different to that of a longer holiday with overnight stay.

A4.1.4 Flow

Visitor flow is another parameter that can be used to measure the intensity of visits to a particular location. Flow relates to the movement of tourists along a pathway, which is dealt with in the next sub-section, but is regulated by the width of the track along which they pass. Flow will be reduced and pathways will become congested where the pathways are narrow and offer visitors attractions that slow their progress along the path. Several studies (for example Itami 2002) have used total number of visits as a measure of visitor flow calculated in visitor or vehicle counts using counters or other form of detectors.

A4.1.5 Speed and orientation

Speed and orientation are measurable properties relating to visitor movements within parks. Such measures can be easily collected using GPS and show how intensively certain tracks are being used by different visitor segments. For example the walking velocities and patterns of movement are likely to vary between children and elderly citizens. Such variations could also be produced due to differences in the physiological ability or simply due to differing interests.

A4.2 Monitoring visitor movements and behavioural patterns

Monitoring is a process through which changes in the characteristics of a particular object/phenomenon are assessed. It is a repetitive measurement taken over a period of time. Monitoring visitor behaviour results in capturing changes in a range of spatial, temporal and behavioural parameters. Whilst recreational activities such as hunting, fishing and boating can be monitored through the issue of licences, monitoring of visitors and their activities and behaviour are more difficult and is often reported in total visits per year (Manning and Cormier 1980). Monitoring of visitor movements provides information through which patterns of use can be assessed. This can lead to an assessment of biophysical and social carrying capacities of a park. It also can lead to the identification and prediction of potential conflicts between different user groups so that adequate measures can be put in place.

Visitors can be spatially monitored using tracking devices that capture changes in locations. Such monitoring becomes more useful when coupled with temporal information. For example a standstill position will not produce any location change but may indicate visitor interest at that location. There is a need to incorporate temporal dimension for monitoring visitors' behaviour. Recent positioning technologies (for example GPS) provide spatial and temporal data to be collected in real time.

A4.3 Mapping visitor behaviour

Spatio-temporal data should provide sound understanding of patterns of movement of visitors in a park setting. Placed within a geographic framework such as GIS, these movement patterns can be analysed at particular locations throughout a park. This will improve understanding of individual visitor behaviour by providing attributes relating to the various settings which visitors are passing. The intention of the RBSim2 simulator is to incorporate the processes involved with visitor decision-making that will be reflected in visitor behaviour. The question is whether the decision making processes of visitors can be captured as a set of rules that relate to variables captured in the simulator relating to environmental attributes and the interactions with other visitors and whether differences in behaviour can be attributed to different classes of users.

A5 REVIEWING TYPOLOGIES OF VISITORS

Many of our environmentally sensitive tourist destinations are already undergoing environmental stress and impacts developed from overcrowding and over utilisation of natural resources. This has resulted in deterioration in the quality of visitor experiences. Though research has attempted to relate socio-demographic characteristics, beliefs and recreational activities to environmental impacts, little has been done to observe the nature and character of behavioural sequences exhibited within the action space. Existing tourism research considers volume, distribution, and the type of use or activities are significant factors of recreational behaviour affecting the environment (Archer and Cooper 1994, Stankey 1990). In addition, rules that determine an agent's behaviour in RBSim2 are built on simple typologies of visitors based upon their preferences, motivations and intentions. Several studies in tourism and behavioural research have identified clustering patterns in visitor behaviour using variables derived from motives (Ryan and Glendon 1998; Pearce *et al*. 1996; Greenwood and Moscardo 1999; McKercher 2002), attitude (Kuppam *et al.* 1999; Uysal and Jurowski 1994), roles (Yiannakis and Gibson 1992) and personality (Plog 1974; Cohen 1972 and 1979; Jackson *et al*. 1999). Uysal and Jurowski (1994) have extended this and taken visitor aberrant behaviour as a potential risk capable of damaging the environment and therefore, recreational experience.

The objective of segmentation studies is to isolate distinct groupings within a sample by examining common characteristics (William and Lawson 2001). Such segments are created to minimise inherent variation within the group and maximise variation between the groups. Kuppam e*t al*. (1999) have identified two potential problems in using attitudinal data in tourism research. First, it is difficult to collect detailed data regarding tourist attitudes using the traditional "household travel" survey and second, attitudinal variables for example Plog's (1974) allocentric/pyschocentric attitudinal scale, cannot be easily extracted. Segmentation approaches based on psychographic characteristics, produce clearly identifiable groupings of individuals with similar personalities, life-styles and interest patterns (Plog 1974). According to Plog (*ibid.*) the typical statistical approach to segmentation requires a three-step process. The first step is to undertake a factor analysis to highlight any "hidden" variables within the questionnaire data. The second step is to apply a cluster analysis to identify distinct groups or clusters of tourist types. In the third and final step, a prediction of behaviour patterns with psychographic characteristics is undertaken. In a typical park environment there is a need to understand why different types of visitors visit different types of attractions and what types of behaviour are they most likely to exhibit at those sites.

Cohen (1972) was one of the first social researchers to categorise tourists into different types. He identified two fundamental tourist types. Institutionalised tourists, whom he further subdivided into organised mass and individual mass tourists, preferred security and home comforts whilst travelling, whereas non-institutionalised tourists preferred isolation and adventure. He further subdivided this second group into what he termed the explorer and the drifter. Plog (1987) later developed a tourism typology based on personality in an attempt to identify tourist patterns and behaviour. Plog (*ibid.*) classified individual tourists on a continuum scale of tourist types ranging from psychocentrics through mid-centrics to allocentrics. Psychocentrics are characterised to be those tourists or visitors that are found to be anxious, non-adventurous and inner focussed preferring organised tours and seek out all the benefits and comforts of home. Allocentrics are the antithesis of psychocentrics and are those tourists and visitors found to be more adventurous, risk taking, and self-confident. Allocentrics have been found to be generally from higher income groups.

Jackson *et al.* (1999) have attempted to re-categorise tourist types based on psychological concepts in tourism. Based on Plog's studies, Jackson *et al.* (*ibid.*) have adopted personality profiles determined via questionnaire and factor analysis, to better describe tourists, their preferences and behaviours.

A6 A BRIEF REVIEW OF SURVEY TECHNIQUES

Many techniques for monitoring visitor movements and behaviour in national parks have been applied. These techniques range from relatively simple survey methods such as questionnaires administered to a sample of visitors entering parks of interest, to more sophisticated techniques of data collection using GPS receivers and keeping personal journals associated with maps. Tracking of tourists can follow methods adopted by Goodchild *et al*. (1993) and Janelle (1997) where participants were required keep journals on their diurnal movements in urban areas. This technique was adopted by Fennell (1996) to monitor space-time movements of tourists in the Shetland Islands. Only four sets of techniques have been evaluated in the following section based upon their appropriateness against the conceptual and operational requirements for the project.

A6.1 Questionnaire and interviewing techniques

Surveys are a commonly used technique applied in visitor satisfaction and behaviour research (Brown and Daniel 1987; Kroh and Gimblett 1992). They have been found to be powerful tools when conducting both qualitative and quantitative research. Surveys consist of several methods through which data about visitor behaviour and travel patterns can be determined. On-site surveys using questionnaire or detailed interviews have been commonly used to investigate needs, preferences, attitudes, experiences and satisfaction of visitors. Traffic surveys using observers located at strategic locations and automatic traffic counters have been used to collect information of flows and movements patterns of visitors and mode of transport.

Interviewing visitors is another way of understanding visitor behaviour. This technique can be undertaken using either a structured or unstructured format or a combination of both (Ryan 1995). Structured interviews follow a set sequence of questions. Unstructured interviews follow a planned interview led conversation where both parties are aware of the research agenda and are prepared beforehand. Unstructured interviews require excellent inter-personal skills to elicit maximum information from participants.

Administering questionnaires have several advantages over other methods of data collection. From a self-administered questionnaire it is relatively easy to determine personal backgrounds of participants along with their anticipated actions and activities whilst in the park. Although what activities people actually do engage in are not readily assessable through a questionnaire. Moreover the nature of depreciative behaviour such as walking off designated tracks or annoying other visitors, cannot be ascertained via a questionnaire. Several authors suggest the use of attitudinal surveys to understand the hidden nature of visitor travel behaviour where attitudes towards the environment, tourism and other tourists are reflected in their behaviour (Uysal and Jurowski 1994; Kiiskilä 2001; Jackson 1986; 1987).

The effectiveness of a visitor survey is highly dependent upon questionnaire design and its implementation. Questionnaires have been found to be useful in collecting a range of information whilst detailed analyses of visitors on a personal level can be explored through personal interviews.

A6.2 Video monitoring

Video has traditionally been used in monitoring wildlife behaviour. This technique has been successfully applied in humanistic and phenomenological research in order to acquire an in-depth understanding of people at the individual level. Recently video analysis has been used for collecting vehicle counts. Masoud (2000) from the University of Minnesota proposed a new system for tracking and analysing human motion in using real-time video. Video monitoring in parks has been found to be an effective technique in assessing visitor load over heavily used sites. Recently Janowsky and Becker (2002: 297) have combined the use of different techniques (video, personal interviews and GIS) to monitor specific user groups and identify their needs in urban forests. Data about the number, composition and time schedules of visitors were monitored using video, and then their needs and conflicts with other user groups were determined through personal interviews. The technique has, however, been seen as an intrusion into visitor privacy and is therefore subject to several ethical issues. Nonetheless video cameras can be set up in such a way that will not identify individual visitors and therefore protect their anonymity.

The predictive and forecasting capability of this technique is rather limited at present time despite rapid technological advancements. One of the advantages of video monitoring is its capability to vary the size of the observed area to enable capturing aberrant behaviour from a distance. Other tools such as zooming, panning, sound recording are useful in examining social stress at sites that are heavily used. There are however, several limitations of this technique. Monitoring visitor behaviour using video involves difficult ethical issues that need to be addressed. Protection of visitor identity in order to avoid possible litigation is required. Video monitoring has been found to be an expensive technique. Installation and maintenance costs are relatively high and the instruments/devices are prone to vandalism. The data (in the form of images) generated from video is relatively difficult to analyse and is tedious to quantify. Currently it is commonly used in qualitative research but shows potential in the quantification of visitor movements and flows in parks.

A6.3 Detectors and Sensors

Detectors are generally found to be powerful tools for counting motor vehicles in transport research. Detectors are generally categorised as being either active or passive. Active detectors transmit and receive electromagnetic radiation. The distance of the intercepted target can be determined by measuring travel time of the reflected signal. Detector types include microwave detectors, active infrared detectors and ultrasonic detectors. Passive detectors use environmental radiation (for example passive infrared detector and video cameras) rather than emitting their own radiation. Detectors can also be classified as static or dynamic wherein the former can detect fixed objects whilst the latter can detect moving objects.

Active infrared sensors emit infrared light in wavelength close to visible spectrum of electromagnetic radiation. Such sensors require a special mounting position for light barrier in order to receive interrupted light beam (Keßel *et al*. 2002). These sensors are only capable of detecting moving objects. They use a pyro-electric element that generates an electric current trigger due to a rapid change in the environmental infrared radiation. Such sensors are generally used in automatic doors and for automatic illumination. Typical microwave detectors consist of an antenna capable of computing the distance of a target by measuring travel time of the reflected wave. The application of the Doppler effect enables detectors to measure the velocity and direction of a target (Keßel *et al*. 2002).

Mat detectors enable detecting the presence of visitors within a confined area. These devices use pressure plates that detect the pressure of a passing visitor. Keßel *et al*. (2002) notes that there are two types of pressure sensitive mats. The first type is comprised of piezo-electric coaxial cables embedded in rubber mats. An electric voltage is generated when pressure is exerted such as people standing on, or walking across the mat. The second type detects change in the optical properties of glass fibres. There are also other detectors that use laser (infrared) and radar (microwave) scanners for detecting, counting and measuring the distance of a target by computing travel distance. Mowen (2002: 436) has used inductive loop encounters to estimate recreational visitor numbers. Inductive loops are commonly used in collecting data from moving cars where a signal is collected by a computer every time the inductive loop is triggered by a moving car. McKenzie and Katic (2002: 430) have used a combination of active and passive trail counters, remote photo stations along with observational reporting for monitoring frequency and intensity of recreational trail use in Banff National Park.

One of the disadvantages of using sensor mats in detecting visitor movements and flows is its inability to determine walking speed and direction as well as the sequence of visitor movements. These parameters are significant in visitor management research particularly for agent-based studies. The use of infrared photoelectric barriers and counting machines for estimating the intensity of visitor flows in recreation areas have been used successfully. Recently Keßel *et al*. (2002) have expressed a need for a system that is capable of detecting objects or people at a detailed scale, for example movement detection within a small room. The system must be able of detecting presence, speed and direction of a walking person, something that is quite difficult to implement using overhead mounted scanners and cameras. They techniques require dedicated personnel to install, monitor and adjust for sensitivity.

A6.4 Global Positioning Systems (GPS)

Another approach to monitor the spatio-temporal dimensions of visitor movements in park is to use global positioning systems or GPS. GPS is one such technology that allows a user to capture the positioning of visitors to a park both spatially and temporally. Information is transmitted through a network of 24 NAVSTAR satellites orbiting in space around the Earth. For location positioning at least three satellites are required. Altitudinal information requires four satellites. Continuous collection of data will enable measurement of the speed and orientation (bearing) of the travelling direction.

Acquiring tourist movements in time and space has potential in providing arrival and departure times, nodes visited, the sequence of visited nodes, walking speed and orientation. These parameters are necessary inputs for constructing predictive models and testing future management scenarios. Forer (1995) believes that movement data can be assessed for decision making by tourists at several points during a visit as well as providing detailed information on how tourists interact with the environment. Patterns of demand for additional location-based services (LBS) including guidance and support can also be assessed. He further states that such data will provide a context for examining the needs and demands for new utilities and infrastructure.

The application of this technology to map individual visitor's movements then can aggregated to identify some meaningful hidden pattern in the data. Several studies (Forer 1995; Kwan 1998; Huisman and Forer 1998) have shown that the aggregated pattern from individual tracking data can be derived and is found to be highly significant in solving accessibility problems. LBS have been widely applied to the management of urban provision and utility but only few studies have applied the technology in non-urban environments. LBS could provide real time information to be placed in the 'context' by linking it with local information. In other word LBS can become smarter due to its capability of self-modifying in response to local knowledge as well as knowledge to some larger frame of analysis as stored in the data collected device.

There are two fundamental limitations of this positioning technology. It is necessary to have at least four satellites for three-dimensional locations to be determined. Canopy cover can restrict the number of satellites required for high positional accuracy. In addition, this technology alone is not capable of interpreting the nature of visitor behaviour but rather provides spatio-temporal data related to movement patterns of visitors.

A7 RECOMMENDATIONS

This review has examined some of the ways in which park visitor research in PCNP could be applied. Agent-based modelling will assist Parks Victoria to improve its decision-making management capability. Using the predictive capability of the model several scenarios can be developed and evaluated to identify and maximise visitor satisfaction and optimise resources for the future. However further refinements are currently required and the following recommendations are proposed:

1. The current model uses data extrapolated from surveys conducted from other study areas in the Northern Hemisphere. Although current studies in PCNP use data collected from traffic counts and visitor surveys, actual understanding of visitor

behaviour in parks and their trip and group characteristics is still not properly understood. This requires examination of visitor behaviour as exhibited in their movement and sequential patterns. There exists a need to develop a library of visitor types using factors such as motivations, socio-demographic backgrounds and attitudinal characteristics.

2. Earlier surveys have used traffic counts along with the visitor surveys as a means of collecting visitor numbers and socio-demographic data at several discrete locations. However, data relating to visitor movements including movement sequences, duration, entry and exit time, direction and walking speed are still relatively unknown. Therefore the use of GPS receivers is being suggested. GPS technology will enable researchers to collect spatio-temporal data that can be transferred into agent-based models and GIS. In addition, the biophysical characteristic of PCNP, being relatively flat with low canopy vegetation cover, lends itself to the use of GPS.
3. A hybrid approach to data collection is recommended. This would comprise a brief socio-demographic visitor survey along with track movements of visitors using GPS and a traffic count in order to ascertain numbers of overall visitors to the park. Trip characteristic data collected with GPS when coupled with socio-demographic and attitudinal information of visitors can accurately describe the typical patterns of visitor preferences and behaviour sequences. This information is also critical for defining the behaviour of the autonomous agents in RBSim 2.
4. Loch Ard Gorge within PCNP is suggested as the study area. This is because Loch Ard Gorge is one of the more heavily visited sites within PCNP and is currently exhibiting locations where overcrowding and environmental impacts are a potential problem. The site has also been targeted as a location in which Parks Victoria would like to provide additional tourist facilities. Within the Loch Ard Gorge precinct there is a network of walking trails that lead to a variety of attractions, where opportunities exist for visitors to make decisions as to which paths from a series of alternatives should be traversed.
5. Further use of RBSim2 at Loch Ard Gorge requires a spatial database for the area to be built for more accurate simulation. Information including environmental, recreational and infrastructure data including existing roads, trails, historic and cultural sites and scenic lookouts should be stored within a GIS. This of

geographic information will provide a basis to modify, parameterise and replicate current and prospective infrastructure developments within the park.

PART B: PATTERNS OF USE IN NATIONAL PARKS: A CASE STUDY AT LOCH ARD GORGE

B1 INTRODUCTION TO THE SURVEY

Visitor attitudes, personality and socio-demographic backgrounds have been identified as important determinants of travel behaviour in parks (Uysal and Jurowski 1994; Jackson 1987; Jackson *et al*. 1999). The threat is potentially exacerbated in those areas that are heavily visited and are highly fragile. Overcrowding and depreciative behaviour have also been identified by Parks Victoria as an issue for PNCP (Parks Victoria 1998, Zanon and Ware 2000). Such behaviour has resulted in adverse social and environmental impacts. Changes in itinerary or alterations in visiting habits reflect the effects of overcrowding in many parks (Arnberger and Brandenburg 2002), whilst environmental impacts such as trampling and walking off designated tracks over fragile areas reflect visitor depreciative behaviour. Arrowsmith and Inbakaran (2001) propose a spatial approach using the *'Spatial Resiliency Model'* for the Grampians National Park where cumulative environmental impacts can be minimised or spread more evenly throughout the region by developing multi-path trails.

The following research objectives have been set up according to the recommendations that align with the current research undertaken by Parks Victoria in PCNP. These objectives include:

1. *Identify typical behaviour sequences within a park site; including where visitors are going and how long visitors are spending at each location.*
2. *Examine the relationship between these behaviour sequences and visitor characteristics including demographic and attitudinal measures; and*
3. *Utilize this information to develop a typology or library of day visitors.*
4. *Examine the proportion of visitors that exhibit depreciative behaviour, i.e. walking off designated paths.*

B2 STUDY LOCATION

Loch Ard Gorge has been selected as an appropriate study location for three key reasons:

- The site is heavily visited, exhibiting pressures from overcrowding and environmental stress, particularly at peak tourist times;
- Parks Victoria has expressed a desire to plan new infrastructure to support tourism at Loch Ard Gorge; and,
- A complex existing network of walking tracks will enable some of the decision-making processes by tourists to be ascertained.

Port Campbell National Park is one of the most important tourist destinations in Victoria. The park is located along the Great Ocean Road in southwest Victoria situated approximately 250 km from Melbourne. The Twelve Apostles and Loch Ard Gorge have been considered as 'Jewels in the Crown' for the region for their outstanding coastal views and spectacular geomorphology (Parks Victoria 1998). Port Campbell National Park was established in 1964 as a result of the National Parks Act (Victoria) 1964 which was then extended in 1981 to include almost all of the coast between Peterborough and the mouth of the Gellibrand River. PCNP has been assigned IUCN Category II status of the United Nation's list of National Parks and Protected Areas and is managed for conservation and appropriate recreation (Parks Victoria 1998). The park forms a narrow coastal strip that consists of steep, often vertical and even overhanging or precipitous cliffs up to 70 metres high. The park's geology is composed of a series of calcareous silts (marls) up to 150 metres thick, and fine-grained sandy limestone that were laid down in the sea during Miocene period between 10 and 25 million years age (Bird 1993: 64). The narrow continental shelf (only 60 km wide) of the park is exposed to the high wave energy generated from the prevailing southwesterly ocean swell and storm wave crashing against the base of the cliffs along the coast. The incessant coastal processes of the physical marine environment have been eroding relatively soft, horizontally bedded rock strata along intersecting joint planes. The erosion processes are exacerbated by closely spaced joints in the rock, forming an indented coastline with narrow, elongated bays and headlands such as Loch Ard Gorge and the Grotto. These processes have produced numerous shoreline features such as cliffs, natural arches and stacks, blowholes, caves, coastal gorges and beaches that now have become a tourist icon for their spectacular scenic value. The terrain of the park shows a broad flat to gently undulating plain with little variations in slope. The landscape is predominantly covered with coastal heathland vegetation. Other native vegetation communities are also widely distributed throughout PCNP that include estuarine swamp sedgeland, cliff top grassland/shrubland, sand dune shrubland, open forest, riparian open forest, dune-swale community and swamp communities (Grant 1987).

In addition to the natural attractions of Loch Ard Gorge, the site is an important cultural/historic site and was the location of a nineteenth century shipwreck, where a cemetery was established for those bodies recovered from the tragedy.

B3 RESEARCH METHOD

Part 1 of this report recommended a hybrid approach, which has been adopted for collecting the data at Loch Ard Gorge. This study has combined the use of three different techniques of data collection. These techniques include GPS tracking of visitors, and visitor surveys using administered questionnaire to those visitors participating in the GPS survey and traffic counts. GPS has enabled trip characteristics to be collected, whilst visitor socio-demographic profiles have been collected via the questionnaire. At the same time, Parks Victoria collected traffic counts in order to quantify numbers of visitors participating in this study to overall numbers specifically visiting this site, as well as PCNP in general. This hybrid approach is found to be highly successful in monitoring visitor movements and use patterns in parks (Sterl *et al*. 2002; Nagy 2002; Janowsky and Becker 2002).

B3.1 Survey design

In an effort to reduce the inconvenience to participants in the survey, it was important to design an approach that was easy for participants to complete and only required minimal intervention. The survey made use of hand-held eTrex Garmin GPS receivers along with self-administered questionnaires at Loch Ard Gorge in Port Campbell National Park. The GPS receivers were tested several times prior to the actual surveys and showed reasonable spatial accuracy of between four to eight metres. Landform and land cover characteristics of Loch Ard Gorge are conducive to using hand-held GPS technology because of the relatively flat terrain and low-lying vegetation cover.

Survey participants were recruited using an on-site random intercept method, where people were approached in their cars entering the Loch Ard Gorge site. Where groups of people were encountered, one person was asked to complete the questionnaire and carry the GPS receiver, essentially becoming the representative for that group. All participants were given questionnaires for self-completion at the commencement of their trip. The same participants were given a GPS receiver that they were requested to carry during their visit to the park. They were then requested to return the GPS receiver at the end of the trip.

B3.2 Questionnaire design

To enable Parks Victoria to compare results from this survey with past surveys, the questionnaire format was kept similar. A copy of the questionnaire with ethics approval from RMIT University's Ethics Committee is provided in appendices A and B.

Basic socio-demographic data including age, gender, level of education, lifecycle classification, group visitor characteristics and activities to be undertaken within the park were collected.

B3.3 Inventory development

Parks Victoria supplied digital 1:25,000 Land Victoria topographic data for the region. This included contour data, road networks, major tracks, and hydrology in AMG66 coordinates. This data was then transferred to ArcView (V3.2) as base GIS data. Figure 1 shows an aerial photograph of the study site at Loch Ard Gorge with the road and track network overlayed from the base GIS data.

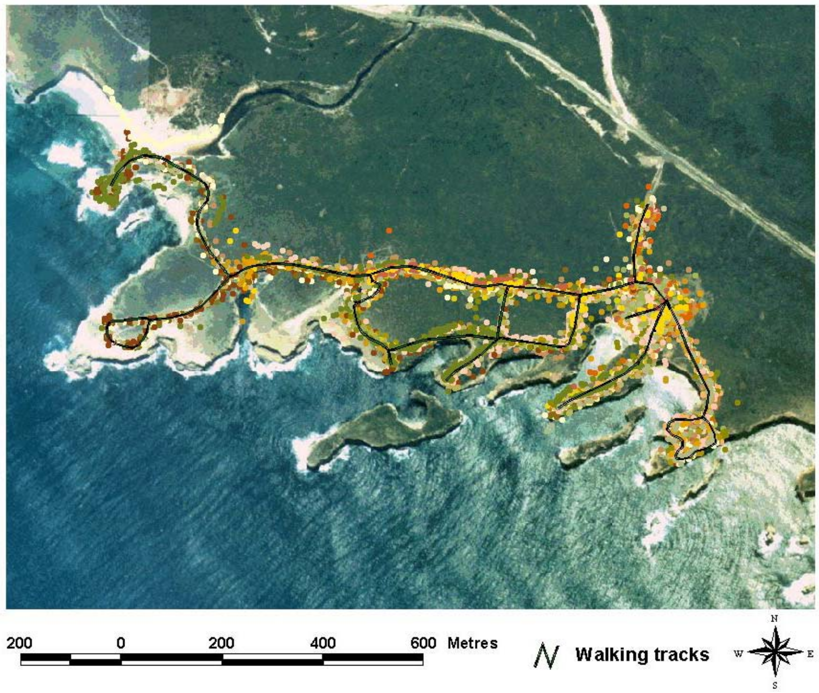

Figure 1: *The study site at Loch Ard Gorge showing the road and track network with GPS recorded locations*.

B3.3.1 Measurements of track properties

A field survey conducted in February 2002 was undertaken to measure track width, surface type and slope of track. These tracks were then classified according to their surface type as bitumen, concrete, gravel, bare rock and sand and timber and attributed as such within the GIS.

B3.3.2 Building an inventory of attractions

In July 2002, a GPS survey using a Garmin eTrex hand-held GPS, was undertaken to record the locations of 25 different attractions at Loch Ard Gorge. These attractions were stored as point features within the GIS and are made up of natural, cultural and historical interest. Table 1 shows a list of attractions found at the Loch Ard Gorge site.

Attraction_id	Attraction_type	Name
1	carpark	Carpark 1
2	lookout	Loch Ard View
3	lookout	Limestone Curtain
4	lookout	Cliff lookout
5	lookout	Razorback
6	lookout	Razorback
7	lookout	Loch Ard lookout to beach
8	lookout	Razorback
9	lookout	Loch Ard Point - The Wreck
10	lookout	Top of Stairs - The Survivors
11	sign	Loch Ard story
12	carpark	Carpark 2 - The Cemetery
13	lookout	Mutton Bird Island
14	lookout	Cliff lookout
15	carpark	Carpark 3
16	lookout	Blow Hole 1
17	lookout	Blow Hole 2
18	lookout	Over cliffs
19	intersection	to Blow Hole
20	lookout	Thunder Cave
21	lookout	Broken Head West
22	intersection	to River
23	cemetery	Loch Ard Cemetery
24	lookout	Broken Head East
25	river	Sherbrooke River
26	beach	Loch Ard Beach

Table 1: *List of attractions at Loch Ard Gorge*

In addition to the above surveys, a visual inventory of walking tracks and attractions has been developed based on data collected using a digital camera and video.

B4 BUILDING THE SPATIO-TEMPORAL DATABASE OF BEHAVIOUR PATTERNS

102 participants completed GPS and questionnaire surveys over one weekend (two days) in May 2002. Data logged with each of 18 Garmin eTrex hand-held GPS receivers was downloaded as a series of text files, one per participant, onto a field laptop computer. Each

questionnaire completed was assigned an identifying code (survey_id) so that it could be matched against each of the GPS text files. The text files were then edited using Excel software, removing unwanted header information, and imported into the GIS database as a series of point files, with each point having an unique point identification number (point_id) as well as the survey number (survey_id) for that participant. A total of 13146 points for the 102 surveys were transferred.

Attributes stored for each point are shown in table 2.

Attribute	Units
point_id	integer
survey_id	integer
Easting	AMG66 metres
Northing	AMG66 metres
Date	dd/mm/yyyy
Time	hour:min:sec
Altitude	metres
Leg_length	metres
Leg_time	seconds
Leg_speed	kmph
Bearing	Whole degrees

Table 2: *Attributes stored against GPS recorded locations*.

Leg lengths, times, speeds and bearings were recorded with logged locations within the GPS. These refer to the individual line segments traversed immediately prior to the logged location. Figure 2 shows the relationship between the leg attributes and the individual logged location

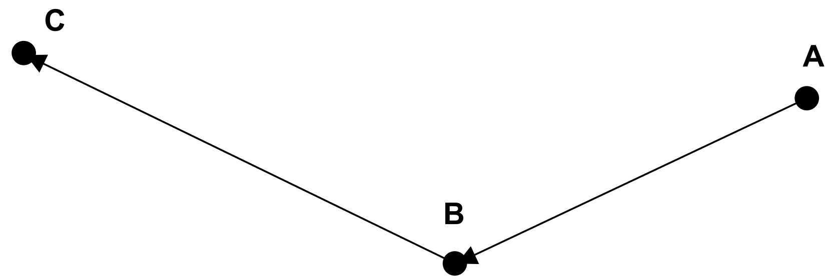

Figure 2: *Leg speed, time and bearing recorded at point C refers to the line segment between B and C. Leg speed, time and bearing recorded at point B refers to the line segment between A and B.*

Lines connecting each of the recorded points were generated purely to give an indication of visitor movements along walking tracks.

B5 DESCRIPTION OF THE SOCIO-DEMOGRAPHIC DATA

B5.1 Socio-demographic profile of participants

There were 102 participants in the survey with the following socio-demographic characteristics:

B5.1.1. Age groups:

The bulk of participants were in the 18 to 29 year age group. However the 60 plus age group was also well represented with nearly 25% of respondents coming from this age category.

Age group	Number*	VSM (N = 199)
18 – 29	40	35%
30 – 39	10	28%
40 – 49	19	13%
50 – 59	8	15%
More than 60	25	7.1%
Total	**102**	**199**

Table 3: *Participant age groups*.

*Note: because the actual number of respondents to the survey was 102, percentages have not been calculated. These will be close to the actual numbers recorded.

B5.1.2 Gender

Of the 102 respondents, 43 were male and 59 were female. Rather than a reflection on visitor profile, the imbalance between females and males is most likely due to females, as passengers in the vehicle, filling in the survey questionnaire.

Gender	Number
Male	43
Female	59
Total	**102**

Table 4: *Participant gender*.

B5.1.3 Educational background

The bulk of respondents had completed secondary education. It is likely that of these, there would be some that would be undertaking tertiary studies, considering the large number of participants in the 18-29 age group.

Educational level attained	**Number**	**VSM (N = 199)**
Not completed secondary	13	3.5%
Completed secondary	45	26.4%
Completed tertiary	44	70.1%
Total	**102**	**199**

Table 5: *Participant education level*.

B5.1.4 Residency status

Nearly 67% (67) of respondents resided within Australia. Of these 38 came from Victoria with a further 29 from interstate (predominantly from New South Wales). Of the 35 participants who reside overseas, 21 came from Europe (5 from Germany) and 9 came from North America (6 from the USA).

Normal Residence	Number	VSM (N = 199)
Victoria	38	33.1%
New South Wales	16	13.1%
South Australia	7	7.6%
Other interstate	6	13.1%
Europe	21	Overseas = 33.1%
North America	9	
Asia	5	
Total	**102**	**199**

Table 6: *Participant home residence*.

B5.1.5 Group characteristics

Participants were asked questions relating to who they were travelling with on this particular visit to Loch Ard Gorge with the following responses:

Group type	Number
Travelling alone	0
With spouse/partner	57
As part of an organised group	0
With children	18
With friends and relatives	27
Total	**102**

Table 7: *Participant group characteristics*.

From this table it can be seen that the bulk of participants were travelling with their spouse/partner as an individual couple.

B5.2 Visiting characteristics

In addition to socio-demographic data, data was collected in order to ascertain information relating to visiting characteristics including whether or not the participants had previously visited the Loch Ard Gorge site and the duration of their visit. Duration of visit was determined from return data collected in the GPS receivers. The VSM percentages are those provided by Parks Victoria staff from the vehicle survey monitoring conducted in 2002.

B5.2.1 Previous visits

Respondents were asked to record the number of times they had previously visited the site in the last 12 months. This was recorded in order to ascertain the number of repeat visitors to the site.

Number of times previously visited in last 12 months	**Number**	**VSM (N = 199)**
Once	65	94.8%
Twice	35	1.6%
More than twice	2	3.6%
Total	**102**	**199**

Table 8: *Participant previous visits to site.*

B5.2.2 Duration of visitation

Number of sequence nodes visited and average duration is shown below. Refer to figure 7 in section B6.2 for each sequence node location.

Number of sequence nodes visited	Number of participants	Average duration (mins)
1	3	65.67
2	21	38.14
3	40	54.20
4	17	67.94
5	10	87.00
6	8	128.00
7	1	111
8	1	105
9	1	212
Average = 3.48	**102**	**65.12**

Table 9: *Number of sequence nodes visited.*

Length of stay at the site was determined from GPS signals recorded at the start of visitation and deducted from when the receiver was returned upon exit from the site.

In addition to determining duration spent within region, overall trip duration was calculated for each participant based on the total time spent within the Loch Ard Gorge site. The average time spent by visitors amounted to 65.13 minutes with a standard deviation of plus or minus 39.9 minutes. This ranged from a minimum duration of 12 minutes through to a maximum of 233 minutes.

B5.3 Analysis of visitors to Loch Ard Gorge

B5.3.1 Analysis of duration of visit

The total trip duration planned by visitors to the Loch Ard Gorge site, is statistically correlated ($r^2 = 0.432$) with the actual duration of their visit. Therefore it can be concluded that visitors generally adhere to their planned schedules, and tailor their visit to enable time constraints to be met. However, at this stage it is uncertain as to whether visitors have adhered to their planned schedule within the site and matched their actual schedule to the one planned.

Those visitors travelling to Loch Ard Gorge for the first time, stay on average 10 minutes longer than those who have been there previously. Visitors who plan to stay overnight near the park spend longer (approximately 30 minutes longer) than those visiting for a day trip.

In addition to duration of visit at the site, participants were asked to record the context of their visit to the site:

Trip type	Number
Day trip from home	25
Day trip as part of a larger holiday	43
Holiday with overnight stay	34
Total	**102**

Table 10: *Context of site visit in overall holiday*.

B5.3.2 Analysis of visitor characteristics

Principal Components Analysis (PCA) was applied in order to explore some of the underlying dimensions between visitor behaviour and basic visitor socio-demographic variables. Variables included are shown in the SPSS output shown in tables 13 and 14. Variables were standardised by subtracting the mean observation value from individual values and dividing by the standard deviation for that variable (Hair *et al*. 1995; Burley and Brown 1995). This converts each raw data score into a standardised value with a mean of 0 and a standard deviation of 1. Variables and their respective rankings are tabulated in table 11.

Variable	Description	Units	Categories
Age group	Age of participant	Years	1 = 18 – 19 2 = 20 – 24 3 = 25 – 29 4 = 30 – 34 5 = 35 – 39 : 12 = 70+
Duration	Duration of visit	Minutes	Nominal
Education	Educational level attained		1 = completed primary 2 = completed secondary 3 = completed tertiary
Expected duration	Expected duration of visit to site		1 = less than 2 hours 2 = half a day 3 = full day 4 = overnight stay
Group type	Type of group participant was travelling with		1 = travelling alone 2 = travelling with spouse/partner 3 = travelling in organised group 4 = travelling with children 5 = travelling with friends and relatives
Life cycle	The life cycle of the group participant was travelling with		1 = young single 2 = young couple with no children 3 = young family (youngest children less than 6 yrs) 4 = middle family (children 6-15 yrs) 5 = middle family (children 6-15 yrs) 6 = Older couple/no children at home 7 = mature single

Variable	Description	Units	Categories
Number of nodes	Number of nodes visited		Ranges from 1 to 9
Number of people	Number of people in group		Ranges from 1 to 3
Trip type	The basis or context for the visit		1 = trip from home 2 = a day trip as part of a longer holiday 3 = a holiday with at least one overnight stay
Number of previous visits	Number of previous visits to the site prior to current visit		Ranges from 1 to 3.

Table 11: *Variables used in the PCA with respective rankings*

Hair *et al.* (1995: 373) recommend sample sizes in excess of 50 (preferably 100) for factor analysis techniques (including PCA) to work effectively. They state that approximately five times as many observations as variables should be included. For this analysis there are 102 observations with 10 variables, and therefore would appear suitable for PCA. For factor analysis techniques to work affectively there needs to be a number of statistically significant correlations among input variables (Hair *et al.* 1995: 372). Table 12 shows that for 10 variables there are 45 correlations. Using the "t-test" to test the significance of "r", the correlation coefficient using the equation from Grimm and Wozniak (1990: 376):

H_0: r = 0, the null hypothesis that there is no significant correlation
H_1: r > 1 or r < 1, the alternative hypothesis that there is a significant correlation.

$$t = r\sqrt{\frac{N-2}{1-r^2}}$$

For N = 102 correlations at the 95% confidence level, r = 0.164. Table 11 shows that 80% (36) of the correlations among variables are significant. Hence it can be assumed that PCA is appropriate.

	Age group	Duration	Education	Exepected duration	Group type	Life cycle	Number of nodes	Number of people	Trip type	Number of previous visits
Age group	**1**									
Duration	**-0.41953**	**1**								
Education	0.03559	**-0.22584**	**1**							
Expected duration	**-0.27456**	**0.43233**	**-0.39946**	**1**						
Group type	**-0.35387**	**0.29532**	**-0.3834**	**0.48521**	**1**					
Life cycle	**0.83909**	**-0.36496**	0.05324	**-0.24288**	**-0.3871**	**1**				
Number of nodes	**-0.37061**	**0.60423**	**-0.51415**	**0.55296**	**0.4696**	**-0.32301**	**1**			
Number of people	**-0.27749**	**0.36804**	**-0.54437**	**0.7067**	**0.76242**	**-0.30617**	**0.50783**	**1**		
Trip type	**-0.28585**	0.15482	0.08104	-0.12113	-0.04215	**-0.43661**	0.07871	**-0.26231**	**1**	
Number of previous visits	**-0.25384**	**0.19264**	**0.22286**	**0.33129**	0.05985	**-0.2183**	-0.05082	**0.24104**	**-0.28296**	**1**

Table 12: *Correlation coefficient matrix. Bolded figures indicate statistical significance at the 95% confidence level.*

From the PCA, three factors were extracted with an eigenvalue greater than 1. These factors account for more than 73% of the variability in the observations.

Factor	Eigenvalue	Percentage	Cumulative percentage
1	3.98087	39.8	39.8
2	1.90235	19	58.8
3	1.44002	14.4	73.2
4	0.85357	8.5	81.8
5	0.49347	4.9	86.7
6	0.48023	4.8	91.5
7	0.35173	3.5	95
8	0.24535	2.5	97.5
9	0.15042	1.5	99
10	0.102	1	100

Table 13: *Factor eigenvalues and variability explanation within the new factors*.

The factors were extracted using a varimax rotation with the following results:

	Factor 1	Factor 2	Factor 3
Age group	-0.20835	-0.85615	-0.19069
Duration	0.49086	0.47888	0.06271
Education	-0.76919	0.14112	0.34407
Expected duration	0.75344	0.12898	0.32875
Group type	0.73194	0.22106	0.09148
Life cycle	-0.19041	-0.8937	-0.10784
Number of nodes	0.75728	0.30815	-0.18134
Number of people	0.8725	0.05771	0.28471
Trip type	-0.21518	0.66113	-0.53464
Number of previous visits	0.01875	0.16947	0.91055

Table 14: *Factor loadings for new factors*.

For the PCA, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy came in at 0.68 clearly exceeding the critical 0.5 level.

From the rotated factor matrix of factor loadings, weights (or correlations with each factor) give some indication of the relationship between our input variables. Factor 1, is heavily loaded positively with the number of people in the group, the number of nodes visited and the expected/actual duration of the visit. Negatively loaded are the variables, education, and age group. Hence it can be deduced from this factor that the longer the expected duration of the visit, the longer the actual visit is, and that the ages of the group the participant is visiting with is younger (and therefore less likely to have completed tertiary education). In addition it is expected that these people, because of their longer stay at the site will result in a more complex visit (that is more nodes will be visited). With a larger group size (that is group type) it would appear that more nodes are visited. This factor therefore, could be termed "visit complexity".

Factor 2 is positively loaded against trip type (as part of a longer holiday visit) and duration, and negatively loaded against age group and life cycle. This factor could be termed "holiday characteristic" and relates to the type of holiday (for example backpacker holiday for longer duration).

The last factor, number three, is positively loaded against previous number of visits, education level, and negatively against trip type (that is day visit), the age group and number of nodes visited. This final factor indicates a focussed visit and could be termed "targeted visit" whereby these visitors have previously been to the site and are now focussing on a specific but reduced number of attractions within the site.

B6 DESCRIPTION OF THE SPATIO-TEMPORAL DATA

B6.1 Development of regions

In order to spatially classify and describe behaviour using the GPS observations 13 separate "regions" were generated for the Loch Ard Gorge site. Within a number of these regions, sub-regions were generated for particular point attractions, in order to ascertain times in and out of these sub-regions. A total of 27 sub-regions were delineated. These are shown in figure 3.

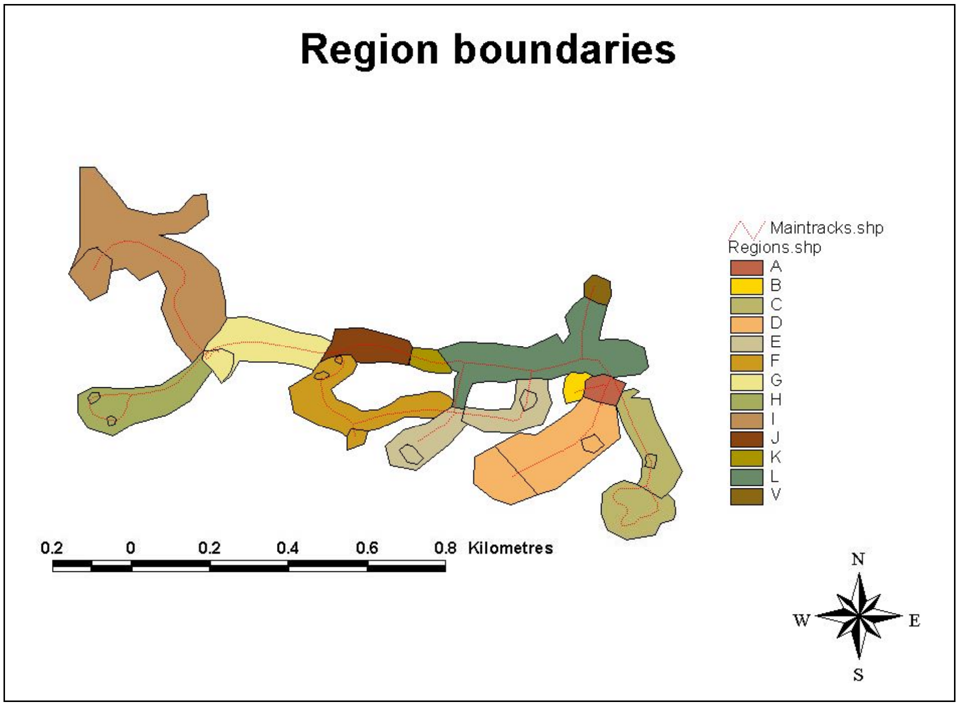

Figure 3: *Region boundaries for the study site.*

Boundaries for each of the regions were delineated in a manner that enabled GPS observations to be encapsulated, and separated according to walking track surface and point attraction location. The purpose of the regions was to assist in describing behaviours for different locations throughout the Loch Ard Gorge site. Each lookout and walking track segment was assigned to a separate region. Using regions it was then possible to ascertain fundamental behaviour statistics including maximum, minimum and average walking speeds as well as duration of time spent within each region. Duration was determined by calculating the entry and exit times into each region.

Maps showing walking speeds and duration of visit for the 27 different sub-regions are shown in figures 4 and 5, respectively.

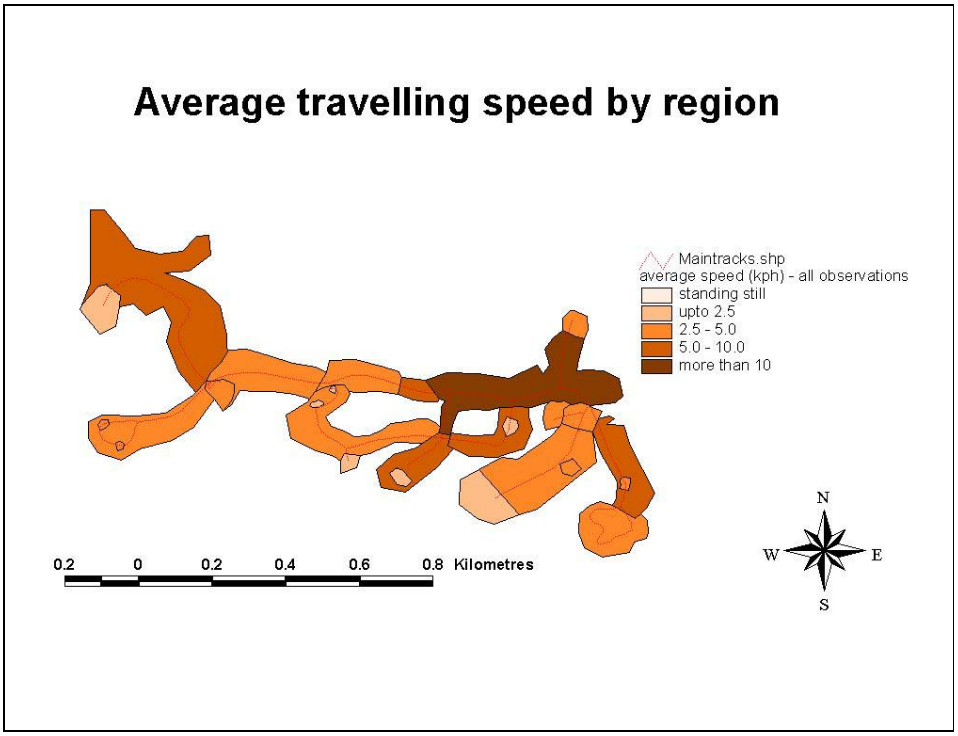

Figure 4: *Average travelling speeds by region.*

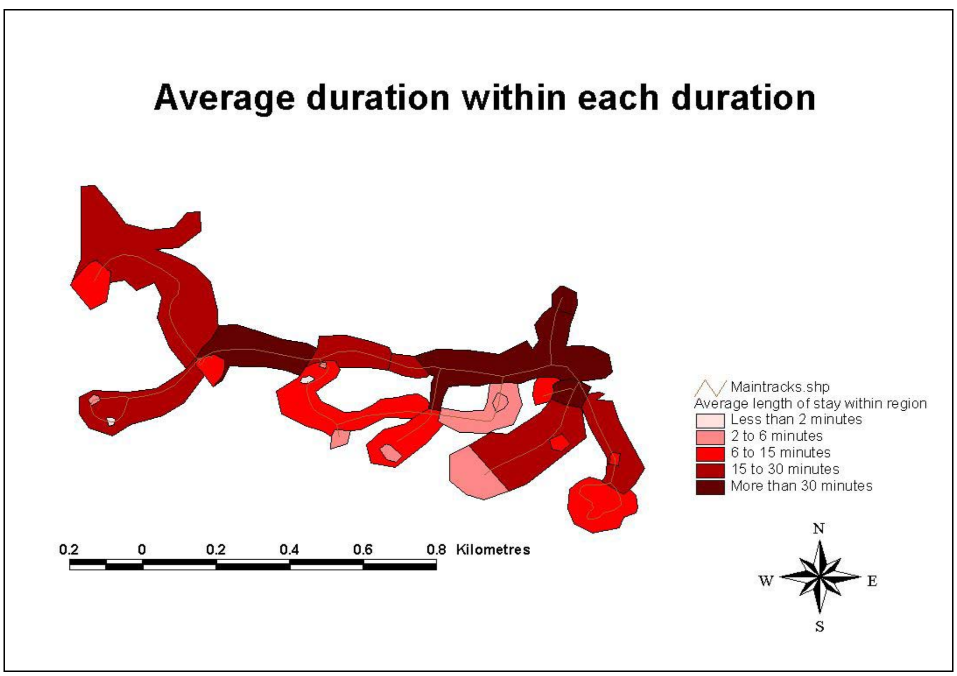

Figure 5: *Average length of stay within each region.*

B6.2 Topology of walking tracks at Loch Ard Gorge:

Topological relationships for spatial information include orientation, adjacency and connectivity.

Networks are defined as a "set interconnected lines making up a set of features through which resources can flow" (Heywood *et al*. 1998: 123). If we consider these interconnected lines connect a series of locations and that people can travel along each of these interconnected lines, then the series of walking tracks that form the Loch Ard Gorge site can be considered a network.

Locations that are connected include attractions, endpoints of walking tracks or connectors between alternate paths. Figure 6 is a map of the track network at the Loch Ard Gorge site. In order to describe the topology of the network using network metrics, it is useful to simplify the network into a diagram that is topologically correct. Figure 6 shows the topology for locations and links between those locations at the Loch Ard Gorge site. Visitors will traverse along one or several of these links commencing at one of the nodes and passing through one or more of the other nodes. For example, all surveyed recipients commenced and finished their GPS surveys at node number 1, after passing through several of the other nodes.

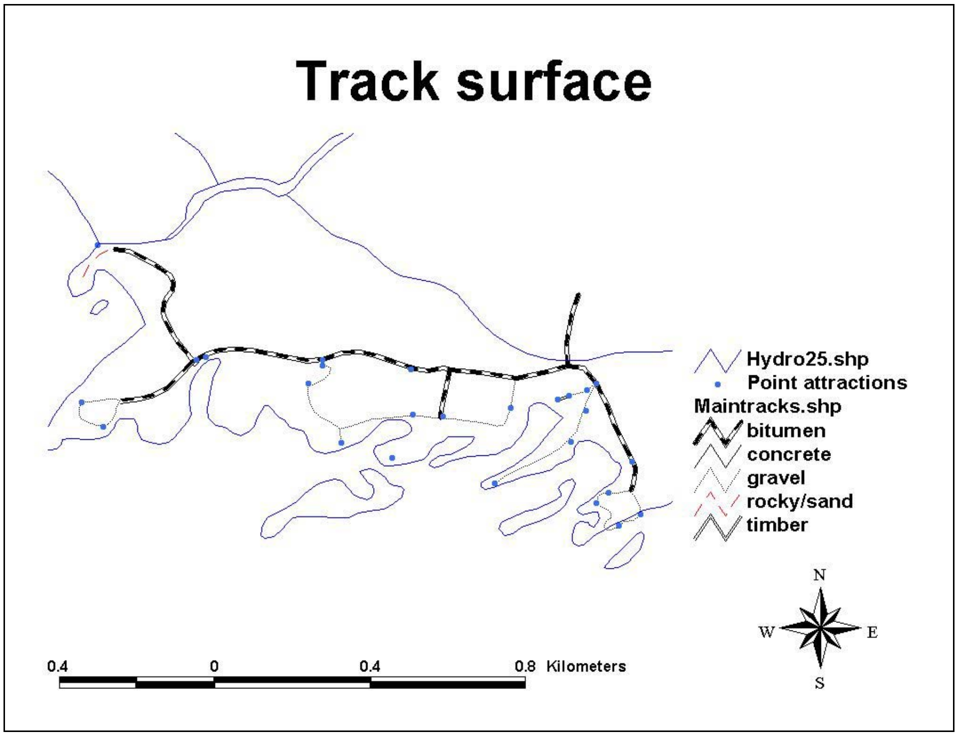

Figure 6: *Roads and walking tracks at Loch Ard Gorge.*

To ascertain movement patterns of visitors it is important to determine the order in which they moved through the path network. To assist in determining their movements, it was useful to label each track endpoint or key node through which they passed, with an alpha character. These have been termed "sequence nodes" and are discussed more fully in section B6.4.

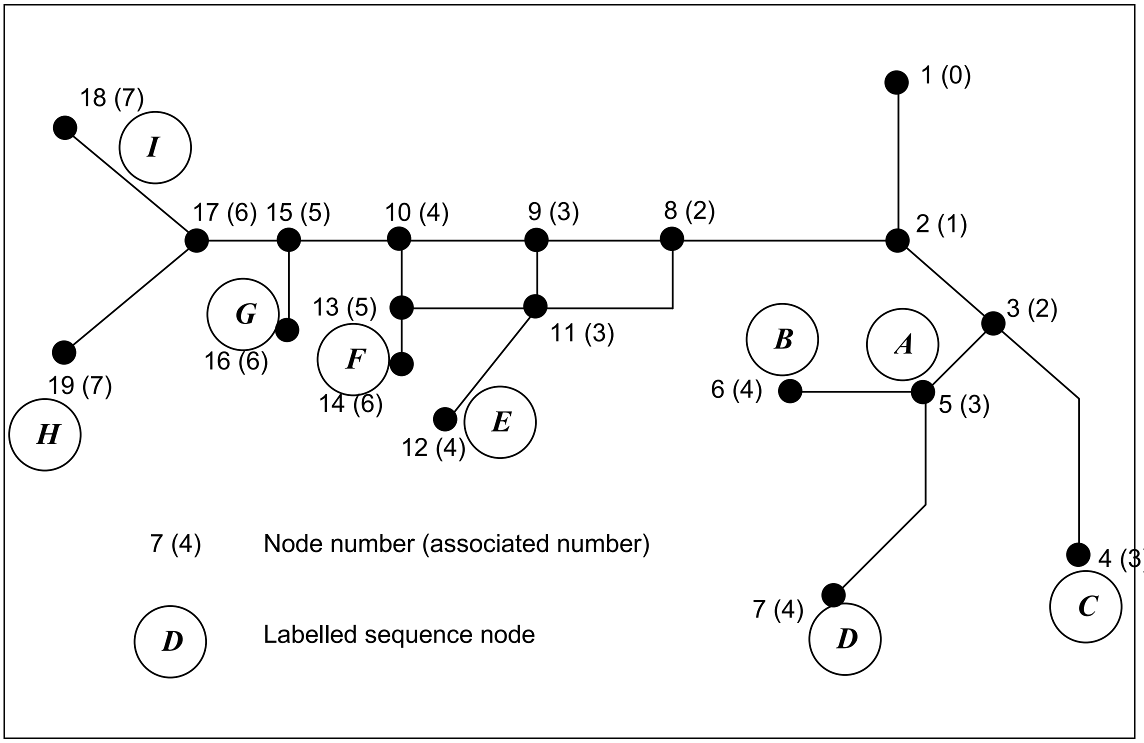

Figure 7: *Topological network diagram for Loch Ard Gorge with associated numbers. The labelled sequence node was used for determining visitor sequence patterns.*

From figure 7 it can be seen that there are 19 separate nodes, interlinked by 20 paths or links.

B6.3 Network metrics

The structure of a network can be evaluated using a number of metrics. These metrics are well documented in Haggett (1967) and Chou (1997).

B6.3.1 Network diameter

The diameter of a network represents the maximum number of steps required to move from any node to any other node through the shortest possible routes within a connected network. At this site the maximum number of steps possible is 9. This is calculated by counting the number of steps from either node 6 or 7 to node 18 or 19. Note that it is possible to traverse through 11 lines (moving from 6 or 7, to 5, 3, 2, 8, 9, 11, 13, 10, 15, 17, to 18 and 19) but this is not the shortest possible route. The diameter for this network is therefore 9. The diameter can be used to assess how remote or central, that is its accessibility, individual nodes are within the network.

B6.3.2 Accessibility

Relative accessibility can be measured using the associated number (Campbell 2001: 197). Associated numbers are shown in figure 7. The associated number of a node is the topological distance from that node to the most remote node in the network. For this network, because all visitors must commence and finish their visitation at node number 1, the associated number has been measured from node 1. From the diagram it can bee seen quite clearly that nodes 17, 18 and 19 are the most remote, and are therefore the least accessible. From this we could hypothesize that visitation numbers to these nodes should lower than for the other nodes.

B6.3.3 Connectivity (the gamma index)

The gamma index is defined as the ratio of the actual number of links to the maximum possible number of links in a network. Those networks with a gamma index close to 1 are said to be highly connected and complex, whilst those with a gamma index close to 0 have minimal connection and are simple..

$$\gamma = \frac{l}{l_{\max}} = \frac{l}{3(n-2)}$$

where: l = actual number of links in a network

l_{max} = maximum possible links in a network (i.e. if all nodes were connected to every adjacent node – this has been found to be 3(n – 2).

n = number of nodes

For this network:

$$\gamma = \frac{l}{3(n-2)} = \frac{20}{3(19-2)} = 0.39$$

A gamma index of 0.39 indicates that this network is relatively unconnected.

B6.3.4 Network structure (the alpha index)

The alpha index evaluates the structure of a network through calculating the ratio of the actual number of circuits to the maximum number of circuits possible. More developed circuit networks have higher alpha indices.

$$\alpha = \frac{c}{2n - 5}$$

where: c = number of circuits
n = number of nodes

$$\alpha = \frac{2}{2x19 - 5} = 0.06$$

The alpha index for this network is quite low, indicating that there are a small number of circuits that can be traversed. Obviously this is the case, where the site shape is relatively linear bounded tightly by the rugged coastline. Topographical limitations prevent many circuit paths to be constructed. Nevertheless, the site does have two circuits that take visitors from the Cemetery past the middle car park and turnoff to Mutton Bird Lookout back via the Blowhole Lookouts to the third car park.

B6.4 Sequential movement patterns through the site

To enable spatial movement patterns through the site to be described, it was decided to label each node marking the endpoint of the network (C through to I) as a “labelled sequence node” or as a node in which participants passed through (A and B). These are shown in figure 8.

Sequence node	Location description
A	The Loch Ard Storyboard
B	Loch Ard Gorge beach
C	The Razorback loop
D	The Loch Ard Lookout
E	Muttonbird Island Lookout
F	Cliff lookout
G	Thunder Cave
H	Broken Head loop
I	Sherbrooke River

Table 15: *Location description for sequence nodes*.

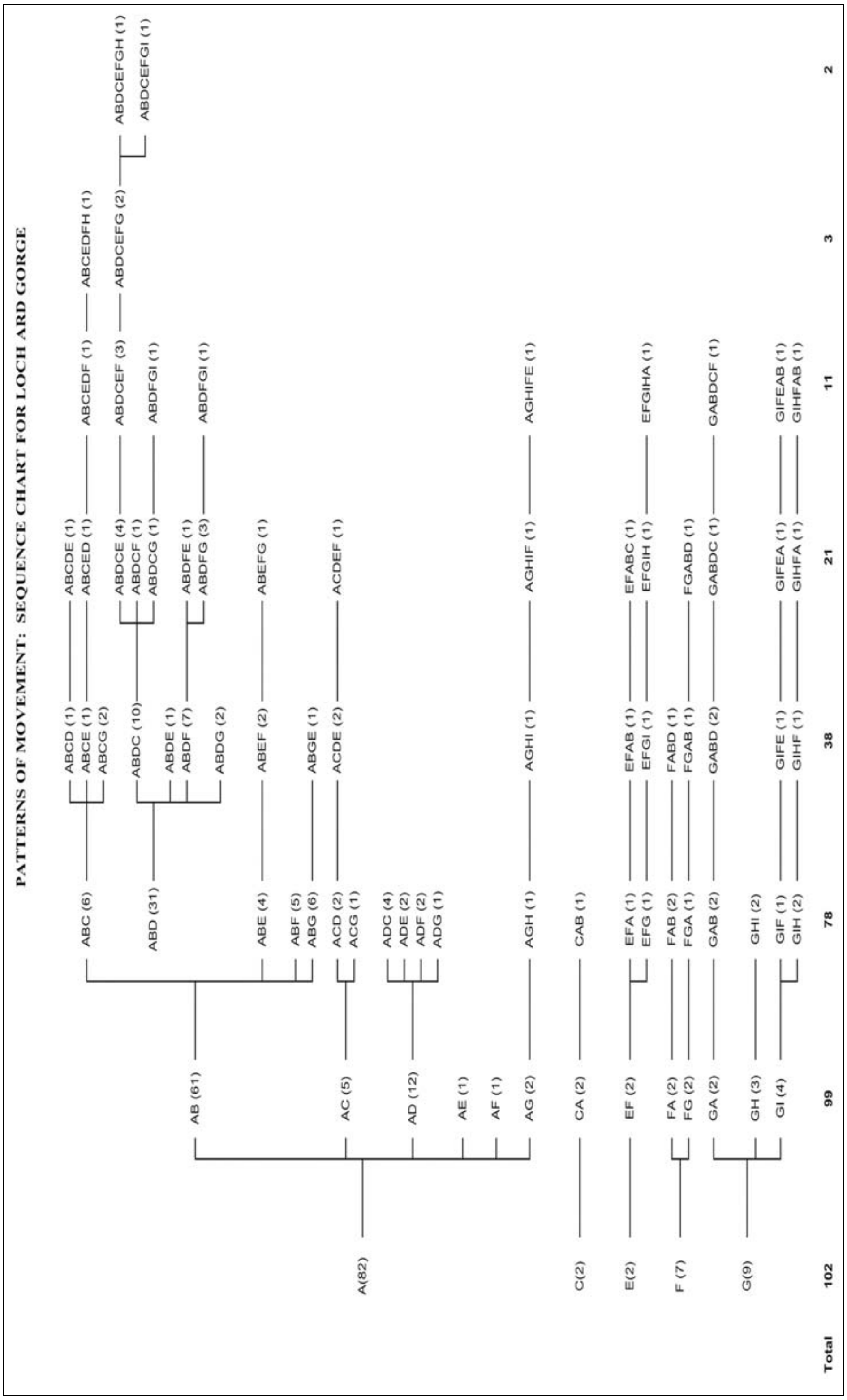

Figure 8: *Sequence of movements through the site network. Figures in parenthesis indicate absolute numbers (close to percentages) of visitors taking that path sequence. Total number* of surveys 102

From figure 8, for example, out of the total of 102 participants, 61 individuals (or 60%) chose to visit node A (the Loch Ard story board) then moved to node B (the beach at Loch Ard Gorge). Of those moving from A to B, 28 of the 61 chose then to visit node D (Loch Ard Lookout) next. It is interesting to note that out of 102 participants, only one elected to visit all nodes.

By summing the numbers in parenthesis downwards the total numbers of sequence nodes visited by individuals can be ascertained. By subtracting sums of visitation from sums of visitation of increasing numbers of sequence nodes visited, it is possible to determine how many individuals visited a particular number of sequence nodes. For example, out of the 102 participants who visited at least one sequence node, 99 of them went on to visit a second sequence node. Hence, 3 participants only visited one sequence node. Of the 99 participants visiting 2 sequence nodes, 77 of them went on to visit a third sequence node. That is 22 of them only visited 2 sequence nodes. Numbers of visitors visiting different numbers of sequence nodes are tabulated in table 9.

B6.5 Comparisons between the observed and predicted movement patterns using RBSim 2:

The Recreational-Behaviour Simulator (RBSim 2) is a computer program that simulates the behaviour of human visitors to a recreational park. It uses autonomous agents to model movements through a network of walking tracks, based on behaviour rules.

The simulator agent rules were set using observations by Parks Victoria staff of vehicular traffic made over the same two days period as the observed GPS surveys. Only car trips were simulated since the GPS surveys only sampled visitors arriving in cars. In this instance, an agent represents all passengers arriving within a single vehicle, this therefore corresponds to the GPS surveys where only on member of a party was surveyed. This would enable comparisons between the simulated agent movements based on vehicle counts and the GPS surveys, to be made. Counts were made for initial entry of individual agents when they first entered one of the regions identified in section B6.1 and figure 3. Six independent simulations were generated within RBSim2, each with 446 individual agents. Results for these were then averaged. Counts were also made for the observed survey participants from the GPS positions tracked. All counts were converted to percentages in order to standardise agent numbers and survey participant numbers. These are shown in table 16.

Region	**RBSim2 Simulations**								**Observed**		**Diff**	
	1	**2**	**3**	**4**	**5**	**6**	**Mean**	**%**	**Count**	**%**	**(d)**	**$(d)^2$**
A	150	168	160	163	157	161	159.83	35.84	70	68.63	32.79	1075.21
B	71	69	45	50	56	61	58.67	13.15	20	19.61	6.45	41.65
C	243	244	235	232	246	266	244.33	54.78	30	29.41	-25.37	643.71
D	222	228	248	235	256	218	234.5	52.58	64	62.75	10.17	103.36
E	136	155	144	157	133	136	143.5	32.17	29	28.43	-3.74	14.01
F	111	128	121	126	98	105	114.83	25.75	46	45.10	19.35	374.45
G	0	0	0	0	0	0	0	0	29	28.43	28.43	808.34
H	0	0	0	0	0	0	0	0	8	7.84	7.84	61.51
I	0	0	0	0	0	0	0	0	13	12.75	12.75	162.44
J	0	0	0	0	0	0	0	0	40	39.22	39.22	1537.87
K	50	44	60	53	45	43	49.17	11.02	38	37.25	26.23	688.06
L	94	77	95	90	99	91	91	20.40	66	64.71	44.30	1962.69
V	446	445	446	446	446	445	445.67	99.93	90	88.24	-11.69	136.66
										Σ	186.73	7609.97

Table 16: *Simulated and observed entry into separate regions within the study site.*

In order to test whether RBSim2 is predicting movement behaviour of visitors in accordance with observed movements via GPS tracking, a T-test was conducted to see whether there is a difference between the observed and simulated surveys. The hypothesis to be tested can be stated to be:

H_0: there is no difference in visitation patterns between the observed and simulated surveys.

H_1: there is a difference in visitation patterns between the observed and simulated surveys

Using the t-test for paired samples:

$$t = \frac{\sum d}{\sqrt{\frac{N\sum d^2 - (\sum d)^2}{N-1}}}$$

where: t = calculated "t" value

d = difference between standardised mean simulated count and observed count

N = number of observations or in this case, regions

The calculated value of t is therefore 2.556. From tables, the critical value of t at the 99% confidence level for N-1 degrees of freedom (i.e. 13-1 = 12) is 2.681. Because our calculated value of t is less than the critical value of t, we can accept the null hypothesis; that is, there is no difference between the simulated individual counts into different regions with those observed in the field. In other words, RBSim2 is predicting correctly the movement patterns that were observed in reality from the GPS survey.

However despite accepting of the null hypothesis, it would appear that for the more remote regions G, H , I and J the simulator is showing that no agents will travel to these regions. This is not the case and it would appear that adjustment for distance needs to be made. Because these four regions are furthest from the point of entry, that either walking speeds or time of duration into the park have been under-estimated and have not permitted the simulator to enable agents to travel to these regions.

B6.6 Movement patterns

As part of the GPS data collection, participants were asked to compete a simple socio-demographic survey. Results from this survey are documented in section B5.1. Maps of movement against each of the demographic parameters have been generated in order to determine whether socio-demographic variables influence how people move through a recreational area.

B6.6.1 Age group

From figure 9, it can be seen that for the 30 to 59 and more than 60 year old age groups, movements tend to be somewhat more restricted to regions closer to the entry point. However, the 18-29 year old age group exhibit a greater spatial travelling distance, where some participants have extended their walk to include the Sherbrooke River.

B6.6.2 Group type

Participant groups travelling with children are obviously more restricted in where they can travel. This is shown in figure 10. The track down to Sherbrooke River whilst paved, is relatively long and steep. The pathway is also furthest from the point of entry to the site and would therefore require additional time and energy to be expended to get to this location.

B6.6.3 Trip type

Figure 11 shows how type of trip can influence the movement of people through the study area. Including an overnight stay in the vicinity of the park enables visitors to extend their visitation to the park and explore regions further away from the entry point.

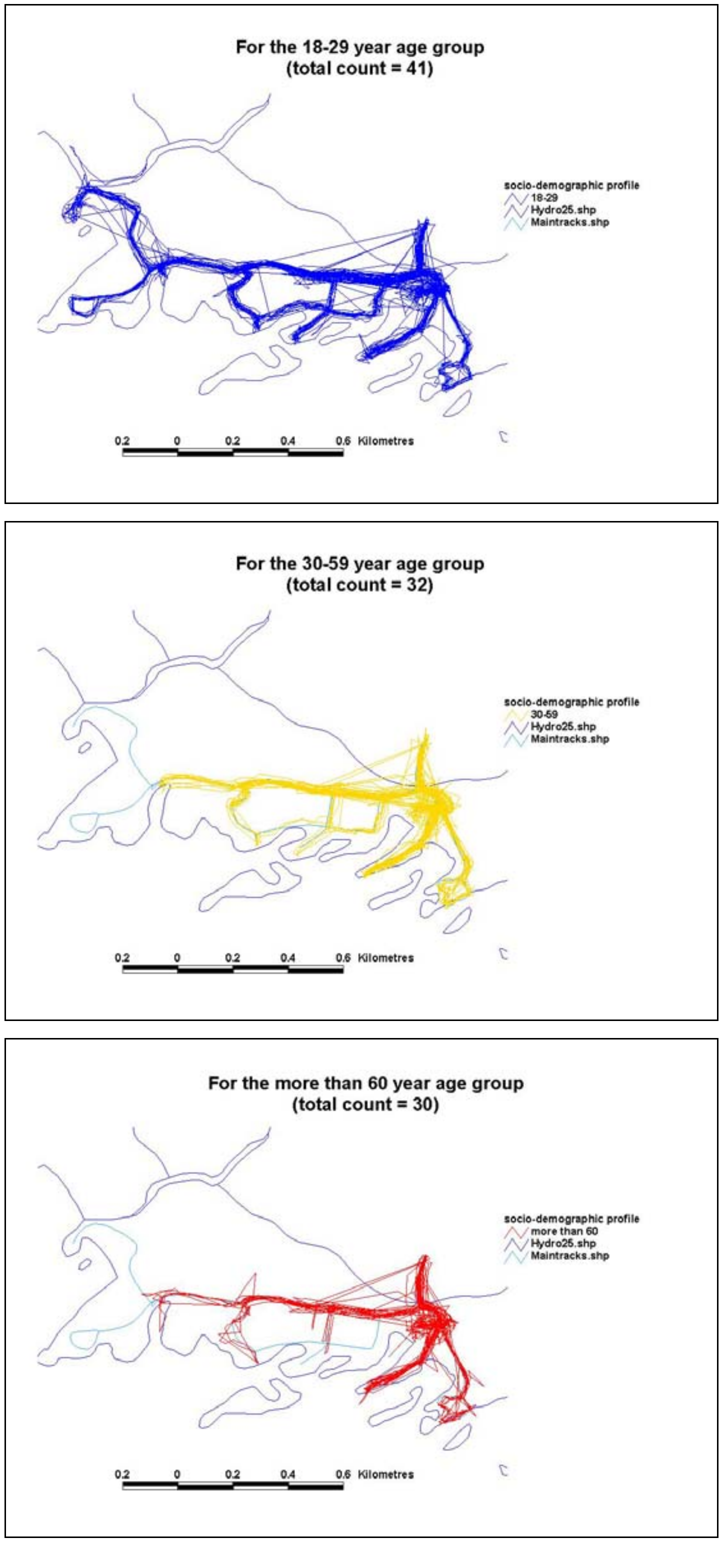

Figure 9: *Movements based on age group.*

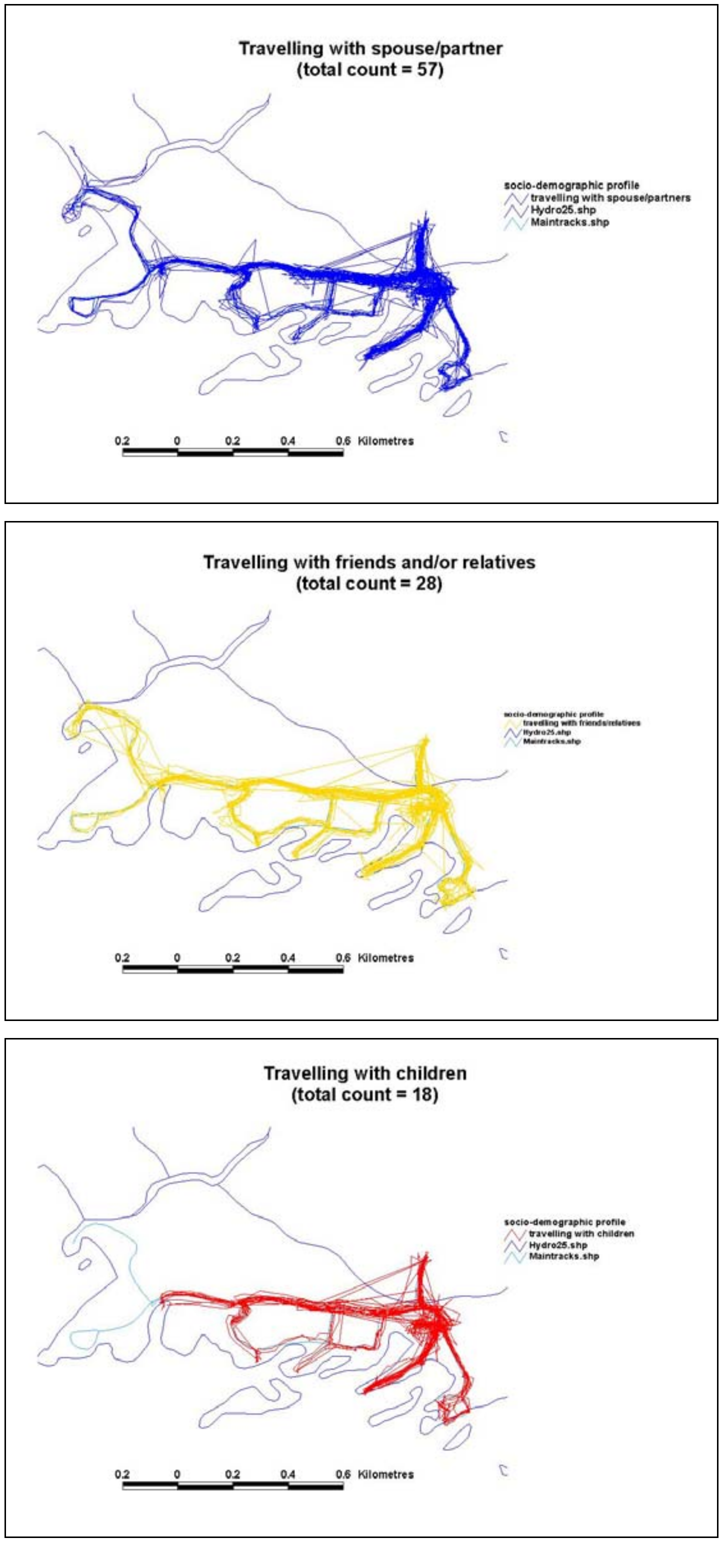

Figure 10: *Movements based on group type.*

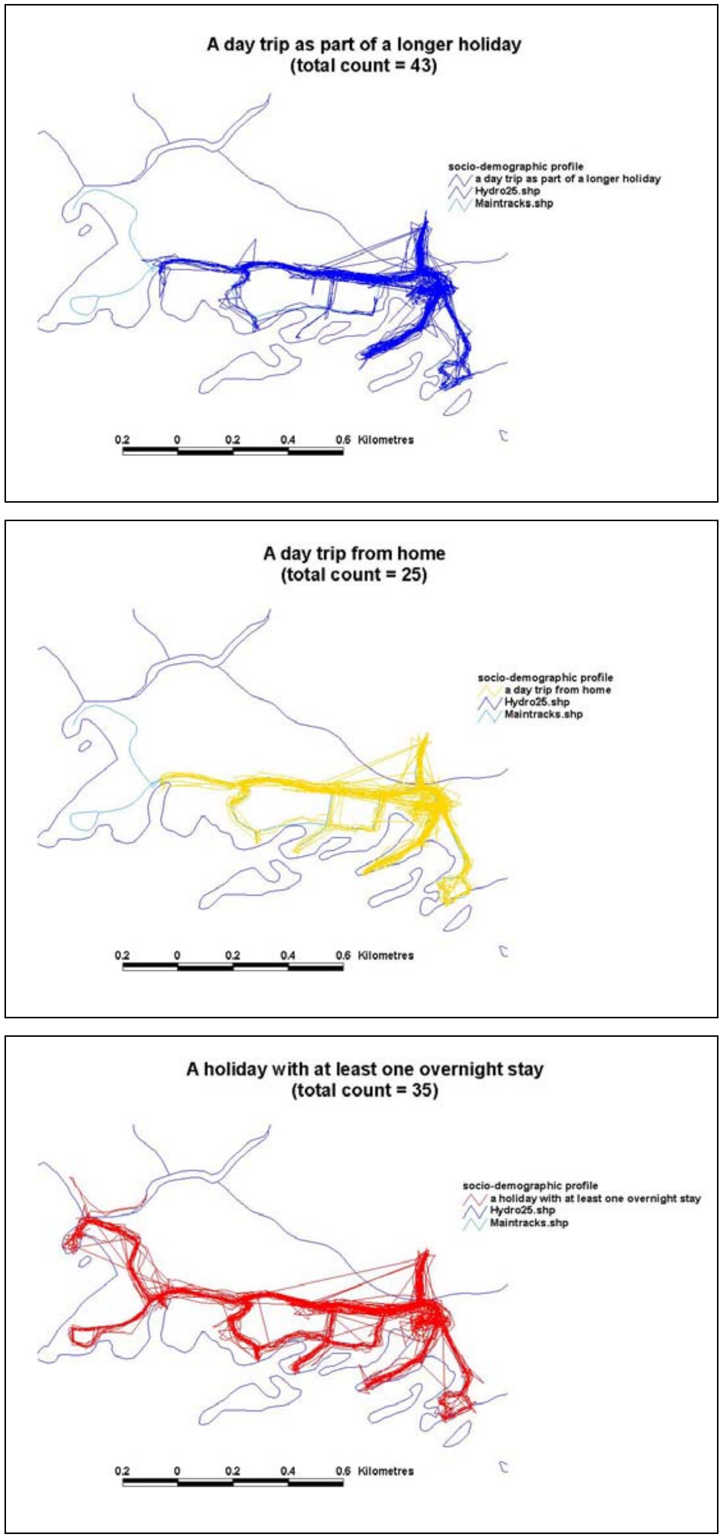

Figure 11: *Movements based on trip type.*

B7 BUILDING A VISITOR TYPOLOGY

The third research objective specified in this project was to *…utilise* [behaviour sequence and visitor characteristics] *to develop a typology or library of day visitors* [to the study area]…. From the socio-demographic survey results a cluster analysis and four clusters were determined. Results from the analysis are detailed in table 17.

```
Final Cluster Centers.

  Cluster       AGEGRP        DURATION      EDUCATIO      GROUPTYP      LIFECYCL      NODESVIS      PEOPLNUM      TRIPTYPE

        1         1.0000        4.6923        1.2308        5.0000        1.1538        6.0769        3.8462        2.9231
        2         1.2222        3.1852        2.8519        2.2222        1.6667        3.0741        2.1111        2.5185
        3         2.7941        2.2059        2.3529        2.1765        5.8529        2.7353        2.0000        2.0588
        4         1.8929        3.0357        2.2143        4.3571        3.3929        3.5000        3.7500        1.3214

  Cluster       VISITNUM      GENDER        RESIDENC

        1         1.0769        1.0000        1.0769
        2         1.5926        1.8148        1.5556
        3         1.0294        1.3824        1.0588
        4         1.7500        1.8571        1.1071

Distances between Final Cluster Centers.

  Cluster              1             2             3             4

        1          .0000
        2         5.1262         .0000
        3         7.4956        4.7218         .0000

Number of Cases in each Cluster.

  Cluster      unweighted cases    weighted cases

        1                  13.0              13.0
        2                  27.0              27.0
        3                  34.0              34.0
        4                  28.0              28.0

  Missing                     0
  Valid cases             102.0             102.0

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Table 17: *Cluster analysis output from SPSS.*

From table 17 it can be seen that four clusters or typologies of visitors can be determined from responses to the socio-demographic survey. A breakdown of these typologies and their characteristics is discussed in the following sections.

B7.1 Visitor typology 1 (the single groupie):

This cluster or tourist typology is comprised of generally young local (i.e. Australian) visitors, mostly in the 18 to early twenties age group, having completed primary and secondary education. They are young and single, but travelling as a group of friends and therefore will tend to stay longer at the location and travel more widely once at the destination. On average they will travel to six attraction nodes. Figure 12 shows a plot of the locations this typology visited whilst at Loch Ard Gorge. The total number of visitors within this typology is 13.

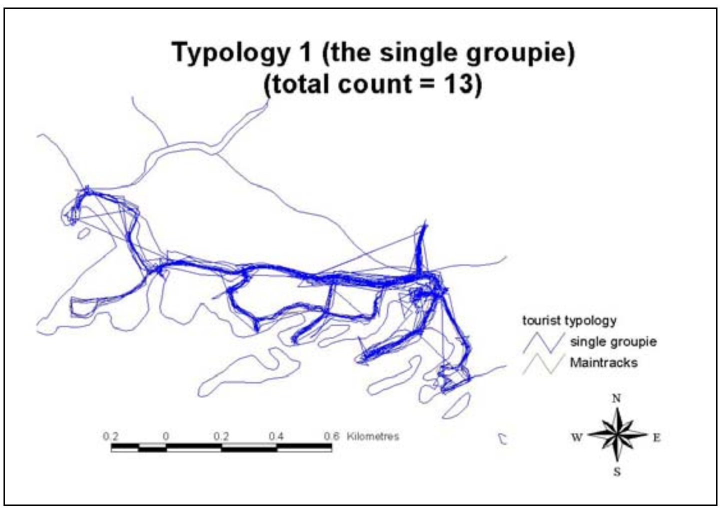

Figure 12: *Tracked events for the single groupie.*

B7.2 Visitor typology 2 (the international couple):

This typology of visitors is largely comprised of tertiary educated male/female couples predominantly from overseas, who are likely to stay for longer than average (from 50 to 70 minutes) visiting in the order of 3 attraction nodes. They are generally young, predominantly within the 18 to 29 year age group. There were 27 cases that fitted this typology.

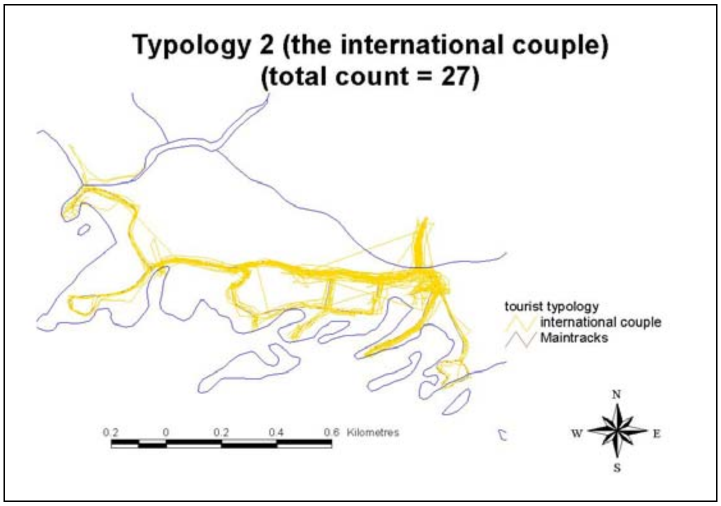

Figure 13: *Tracked events for the international couple*.

B7.3 Visitor typology 3 (the elderly couple):

This third group of visitors are largely those local tourists who are elderly citizens, 60 years or older, on an extended holiday who are perhaps passing by the location on their way to somewhere else. Their visits tend to be shorter with fewer nodes visited (less than 3). Their stay at Loch Ard Gorge tends to be shorter (in the order of 30 minutes).

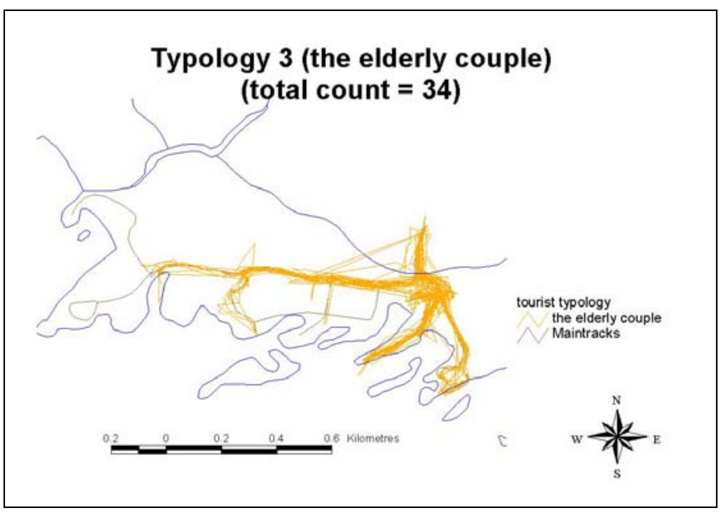

Figure 14: *Tracked events for the elderly couple*.

B7.4 Visitor typology 4 (the local family):

This final grouping of visitors is primarily comprised of the Australian middle-age family travelling to Loch Ard Gorge as part of a longer holiday. They stay an average of 50 to 70 minutes and visit 3 to 4 attraction nodes.

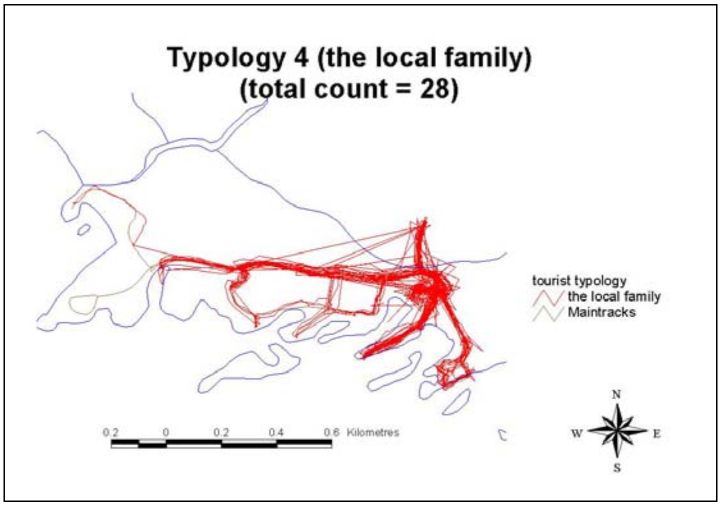

Figure 15: *Tracked events for the local family.*

B8 FUTURE RESEARCH

This project has shown that spatial technologies such as GPS can be used to ascertain movements of visitors through national parks. These movements can be input, displayed and spatially analysed within the assistance of GIS. However it still remains largely unknown how visitors interact with their environmental surroundings and how decisions in the field by these visitors are actually made. For example, we do not know how biophysical variables such as vegetation, path construction, and signage influence how visitors made decisions when confronted with bifurcation points along a pathway. At this stage these decisions can only be inferred from the GPS observations recorded using hand-held receivers. It is proposed that future research should be undertaken to adopt spatially referenced personal digital assistants (PDAs) to acquire decision making processes in real-time through location based surveys. Location based service provision is currently being researched in the Department of Geospatial Science at RMIT to investigate the utility of providing visitors with supplementary park information via mobile devices (including mobile phones or PDAs) as they move through a national park (Hadley *et al.* 2003).

Further research into examining how visitors from differing socio-demographic backgrounds make decisions is required. We need to understand whether visitors from different cultural backgrounds or within different age groups respond differently when posed with alternative pathways. We need to research whether these visitors will respond differently to biophysical variables and social contexts. For example are visitors from one cultural background more or less comfortable with crowding? Will crowding alter visitor behaviour when visiting a particular location such as a lookout at a national park?

This study has made limited attempt to explore and understand the relationships between visitor characteristics and the sequence of movements made by those visitors. Simple analysis of numbers of nodes visited, and the spatial extent of visitation for four types of tourists have been reviewed in this study. These four types were determined from cluster analysis based on the survey responses for the 102 participants in the study. More extensive surveys are required to validate these tourist types, and to provide a more rigorous set of parameters for the RBSim2 simulator in order to determine generic agent parameters for a wide range of national park settings.

Finally the 5 to 10 metre spatial resolution achieved by the GPS receivers did not enable the final objective to be achieved; that is the determination of depreciative behaviour exhibited by visitors, such as leaving marked pathways. Whilst the GPS surveys observed in this study did show recorded locations away from the marked tracks it could not be determined with certainty whether this was an artefact of the spatial resolution of the GPS and recorded position, or an actual incident of depreciative behaviour. In addition it is likely that by merely participating in the survey, a participant might modify his or her behaviour to conform to what is considered to be acceptable behaviour. This is a difficult issue, since visitors are more than likely to modify their behaviour if they feel park managers are observing them. We did observe several instances of depreciative behaviour where visitors were leaving marked pathways to take photographs, despite warnings of cliff instability. Videoing visitors raises concerns regarding invasion of privacy, costs associated with setting up observation points, and susceptibility of equipment to vandalism. The mere presence of park rangers will also result in modified behaviour of visitors, so straightforward observation by park management will be difficult, as well as time consuming and expensive.

B9 CONCLUSIONS

This report documents a research project that investigated the patterns of behaviour and movements of tourists throughout the Loch Ard Gorge site within Port Campbell National Park. Data was collected via on-site questionnaires to ascertain the socio-demographic characteristics of visitors to the site. This data was supplemented with GPS surveys that monitored the movement patterns of the surveyed participants. Using the GPS recordings with a spatial database or geographic information system, it was possible to investigate the movement characteristics for different tourist types. In addition, observations of tourists in to, and out of, various regions within the Loch Ard Gorge site were compared to predictions made using the RBSim2 agent-based simulation software. These initial results show that with statistical confidence, RBSim2 is predicting movements throughout the park, which match those observed from visiting tourists. However, weightings for more distant locations need to be adjusted within the simulator to enable the automated agents to travel to these regions.

Cluster analysis enabled four tourist types visiting Loch Ard Gorge to be discriminated. The first type visiting was referred to as the ‘single groupie’. This person is likely to be travelling within a group comprised of young people. They tend to travel widely once at a given destination and will spend longer than their counterparts. The second group is made up of what have been called ‘international couples’, who are young and generally well educated. This tourist type will stay longer than average and will visit in the order of three attraction nodes. Elderly citizens are represented in the third tourist group, the ‘elderly couple’, and tend to stay at tourist destinations for a shorter duration than average. They also tend to restrict their visitation to concentrated locations near the entry and exit points to a destination. The final typology is the ‘local family’. This group tend to visit an average number of attraction nodes at a given destination. Their duration of stay ranges from 50 to 70 minutes.

The typologies identified as part of this study can be used as the basis for characterising agents within the RBSim2 simulator. However given the small number of participants (102), it is suggested that the study be repeated for a similar park site at the Port Campbell

National Park initially, and then to extend the surveys to other parks with different characteristics (for example the Grampians National Park).

The study has also shown that for a selection of alternative track routes open to tourists, more than half commenced their visit at the same location, i.e. the Loch Ard Story Board adjacent to the first car park, before moving on to the Beach at Loch Ard. About half of these then moved on to the Loch Ard Lookout. The average number of nodes visited was 3.5 and the average length of stay was 65 minutes.

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APPENDIX A: Copy of questionnaire and covering letter handed to participants

APPENDIX B: Ethics approval for survey participation

APPENDIX C: Letter of support from Parks Victoria