CHAPTER 1 - INTRODUCTION

1.1 BACKGROUND TO THIS STUDY

This research has been undertaken at a time when interest in long-distance walking within the Wet Tropics region of North Queensland was arguably at an all time high. Increasing demand for long-distance walking tracks within the region has recently resulted in the development of the Misty Mountains Trails, a network of over 130 kilometres of hiking trails situated in predominantly high altitude tropical rainforest (Arts Queensland, 2004). The Misty Mountains Trails were funded by the Queensland Heritage Trails Network, a joint initiative between the Queensland State Government and the Australian Federal Government and officially opened on 29 August 2003 (Arts Queensland, 2004). The completion of the Misty Mountains Trails was closely followed by the construction of one of the Great Walks of Queensland in 2005, which is a 110 kilometre walking track that links Wallaman Falls and Blencoe Falls between Ingham and Cardwell (Environmental Protection Agency, 2005). Both walking track networks are located within the protected area estate managed by the Wet Tropics Management Authority and the Queensland Parks and Wildlife Service. When considered in conjunction with existing long-distance walking track infrastructure, long-distance hikers within the region have never had such an abundance of choice.

Although the Wet Tropics Walking Strategy defines long-distance walks as ‘walks which involve overnight camping or accommodation, being of more than one day’s duration’ (Wet Tropics Management Authority, 2001. p. 17), it was believed that this definition was somewhat restrictive since some individuals choose to spend more time and stay overnight on a relatively short walking track, while others elect to complete a longer walk more quickly and therefore do not require an overnight stay. Consequently, a revised definition was adopted which defined long-distance walking tracks as any track that required a minimum of eight hours walking for the majority of hikers and provided them with the opportunity to stay overnight along the route. The revised definition did not require that all walkers stayed overnight during the course of their hike, but rather indicated that they must have the opportunity to do so. Similarly, the revised definition of a long-distance walk did not require that all hikers spent eight hours completing their walk, but rather that the majority of hikers required at least this amount of time.

There has been limited research conducted to date in relation to biophysical impacts associated with use along the entire course of long-distance walking tracks within Australia, although some studies have addressed track erosion and impacts upon campsites and vegetation (Parks and Wildlife Service, 1998). There has also been a similar lack of research undertaken in relation to visitors' psychosocial experiences whilst using long-distance walking tracks within tropical rainforests, although some research has been conducted in association with short-distance walking tracks within the Wet Tropics region, typically those requiring less than one hour to complete (Turton, 2005). As a consequence of the recent expansion of long-distance walking track infrastructure within this region, this project provides a timely investigation of the impacts and experiences associated with this recreational activity.

This research is fundamentally about *visitor impacts* and *visitor experiences*. It investigates the biophysical impacts and psychosocial experiences of visitors using two established long-distance walking tracks within the Wet Tropics region, namely the Mt Bartle Frere Track in Wooroonooran National Park and the Thorsborne Trail on Hinchinbrook Island National Park. Both of these walking tracks are well patronised and are considered to be representative of the diversity of long-distance walking experiences available in the region, as they encompass a mix of lowland and upland tropical rainforest, coastal and montane environments, and offer hikers varying degrees of difficulty and availability of facilities. While there is limited management control over access and visitor numbers using the Mt Bartle Frere Track, access and visitation levels are highly regulated for the Thorsborne Trail. Established long-distance walking tracks have been preferred to the more recently developed walking networks described above due to the fact that the former have a reasonably consistent level of visitor use and a pre-existing level of impacts that are commensurate with the timeframe permitted for this study. Furthermore, since the vast majority of visitors to Hinchinbrook Island arrive via commercial ferries, this presented an opportunity to make contact with large numbers of hikers which was not readily available at mainland walks.

The dual focus upon *visitor impacts* and *visitor experiences* is consistent with the research priorities identified in the Wet Tropics Walking Strategy which is the policy blueprint for future walking track management within the Wet Tropics region. The following two quotations are ‘research issues’ that have been taken directly from the Wet Tropics Walking Strategy and highlight the need for additional walking track research within the Wet Tropics region.

> ‘*There is little relevant information or research into walkers’ experiences, use of tracks, behaviour, demand and satisfaction levels in the Wet Tropics region. This will be useful when assessing priorities for managing current walks or creating new ones’* (Wet Tropics Management Authority, 2001. p. 51).
>
> ‘*There is a need to identify potential adverse impacts on walks’* (Wet Tropics Management Authority, 2001. p. 52).

The Wet Tropics Walking Strategy also articulates four priority research areas.

1. Coordinate available research funds, particularly those from the Wet Tropics Management Authority and land managers, to ensure research specifically addresses the needs of walk managers.
2. Undertake research on walker demand and satisfaction.
3. Undertake research to measure and monitor walker impacts and their relationship to walker behaviour.
4. Undertake research into the economic and social benefits of walking.

(Source: Wet Tropics Management Authority, 2001. p. 52).

1.2 RESEARCH GOALS

This thesis goes some way towards addressing the research deficiencies that surround use of long-distance walking tracks within the Wet Tropics region. The theoretical dimension aims to explore the human-environment interactions associated with visitor use of long-distance walking tracks, while the applied dimension will have direct relevance to both protected area mangers and the tourism industry. Although the research draws heavily upon the philosophy and methodology of previous studies conducted in largely temperate zones, particularly North America, it has been tailored to suit the particular ecological and social parameters that exist within tropical North Queensland.

Five key goals were established.

1. To assess biophysical impacts associated with visitor use of selected long-distance walking tracks within the Wet Tropics region.
2. To enhance knowledge about the psychosocial experiences of visitors undertaking selected long-distance walking tracks within the Wet Tropics region.
3. To assess the appropriateness of using human-environment transactional models as a theoretical framework within which to assess the experiences of visitors using extensive long-distance walking tracks.
4. To utilise biophysical impact and psychosocial experience findings to enhance current understanding of human-environment interactions.
5. To develop site specific management recommendations for each of the two walking tracks under consideration, and to develop general management principles for long-distance walking tracks within the Wet Tropics region.

1.3 RESEARCH METHODOLOGIES

Two principal methodological approaches were used to achieve these goals.

1. Collection and analysis of biophysical impact data associated with visitor use of selected long-distance walking tracks within the Wet Tropics region using *rapid assessment methodology*.
2. Collection and analysis of psychosocial experience data obtained from visitors undertaking selected long-distance walking tracks within the Wet Tropics region using a *survey instrument*.

1.4 RESEARCH QUESTIONS

1. What are the biophysical impacts associated with visitor use of long-distance walking tracks within the Wet Tropics region and how do these impacts vary over space and among vegetation types along tracks?
2. How do biophysical impacts associated with visitor use of long-distance walking tracks within the Wet Tropics region vary in response to changing seasonality (wet and dry seasons)?
3. What is the profile of visitors (with respect to demographics, logistic arrangements, motivations) using selected long-distance walking tracks within the Wet Tropics region?
4. How do visitors perceive the natural, social and built environments associated with the two long-distance walking tracks being examined, and the management of these environments?
5. How satisfied are visitors with their experience of hiking the two long-distance walking tracks under investigation and what specific factors enhance or detract from the quality of their experience?

It should be noted that no specific research hypotheses were utilised due to the investigative nature of the research.

1.5 SYNOPSIS OF THESIS CHAPTERS

The thesis is presented in eight chapters and is organised around the research questions outlined above. Each chapter contains both an introduction and summary. Extensive use has been made of colour coding to assist the reader to quickly distinguish among data from the Mt Bartle Frere Track, the Thorsborne Trail, and Combined Data. Colour has also been used to differentiate between Site Management and Visitor Management, and between the Biophysical Setting and the Psychosocial Setting in figures and tables where appropriate. These colours are applied consistently and repeatedly to aid navigation and comprehension.

The thesis commences with an extensive literature review, **Chapter 2,** which provides an overview of protected area management, and presents the theoretical framework used to conceptualise human-environment interactions. This chapter also reviews literature considered relevant to both biophysical impacts and psychosocial experiences associated with visitor use of long-distance walking tracks. The literature review demonstrates that there has been a lack of research effort applied to date in relation to long-distance walking tracks within tropical rainforest environments.

Chapter 3 provides an overview of the study area, the Wet Tropics region of North Queensland, Australia. It also provides a summary of current long-distance walking activities and management arrangements for walking tracks within the region. The chapter describes the two study sites, namely the Mt Bartle Frere Track and the Thorsborne Trail.

Chapter 4 details the research methods used. The first part of the chapter describes the biophysical impact assessment methods including a description of the environmental indicators used in the rapid assessment methodology, an overview of the sampling strategy and data collection phase, and a review of data analysis techniques. The second part of the chapter describes the methodology used to collect psychosocial experience data and the research design, sampling methodology, composition of the visitor survey instrument, survey distribution mechanisms and data analysis techniques.

Chapter 5 presents the results from the biophysical impact assessment sampling. These are presented in the context of the research questions and include both spatial and seasonal comparisons of impacts, although seasonal data have been placed in an Appendix. Spatial comparisons of impacts were made among different sampling zones (tread, buffer, control), among vegetation types, and where appropriate, between tracks, while temporal comparisons were made between wet and dry season sampling.

Chapter 6 presents the results from the psychosocial experience sampling with results again structured around research questions. Particular emphasis is placed upon describing the profile of long-distance walking track users, including their demographic characteristics, motivations, and logistical arrangements. The chapter also reports respondents' appraisals of the natural, built, and social environments they encountered, in addition to their perceptions of the management of those environments. The chapter concludes with a discussion of the issues that influenced visitor satisfaction, including the factors that both enhanced and detracted from enjoyment.

In **Chapter 7** results are discussed within a human-environment transactional framework in order to extend theoretical understandings of human-environment interactions in a long-distance walking track context. The chapter also presents a number of specific management recommendations for each field site, in addition to general principles for future management of long-distance walking tracks within the Wet Tropics region.

The principal findings are succinctly summarised in **Chapter 8**. Additional related research questions are also identified.

The thesis concludes with an extensive **Reference List** and a collection of relevant **Appendices** that support the information presented.

1.6 TROPICAL CYCLONE LARRY

As the final write up stage was nearing completion a Category 5 cyclone, Cyclone Larry, crossed the North Queensland coast near Innisfail on the morning of 20 March 2006. This storm had a maximum measured wind gust of 294 km/hour and a lowest reported central pressure of 959.3 hPa (Bureau of Meteorology, 2006). Cyclone Larry created extensive damage to residences, public infrastructure, agricultural crops, and natural ecosystems in the region between Cardwell and Cairns (Bureau of Meteorology, 2006).

As a result of the very destructive nature of this cyclone both long-distance walking tracks under investigation in this research required closure. Whilst damage to vegetation and infrastructure on the Thorsborne Trail was only slight and the trail reopened within a few weeks, the Mt Bartle Frere Track was extensively damaged and requires extensive work before the track can reopen to the public. This event further highlights the critical importance of this research given it is the only substantial and systematically recorded *baseline* data set available for which damage and recovery over time can be credibly documented.

CHAPTER 2 – LITERATURE REVIEW

2.1 INTRODUCTION

Biophysical impacts and *psychosocial experiences* of visitors were investigated along two long-distance walking tracks within protected areas in the Wet Tropics region of North Queensland. Since visitor impacts and experiences are fundamentally connected, the analytic and operational framework is distinctly multidisciplinary, drawing upon previous research that has been conducted within various disciplines including behavioural, human and environmental geography, environmental psychology, natural resource management, recreation ecology, and the leisure sciences. The research has a theoretical dimension that seeks to better understand human-environment interactions along both temporal and spatial continuums, in addition to an applied dimension that seeks to generate recommendations to resolve practical 'on the ground' problems which exist in association with selected long-distance walking tracks. Given that the principles of sustainability and sustainable development have been widely embraced by policy makers in relation to recreation and tourism within natural areas (Newsome *et al*. 2002), these principles underpinned the framing of the research.

At the outset it is important to define a number of terms that are used in order to enhance clarity and understanding for the reader. For the purpose of this literature review the 'biophysical setting' refers to various components of both the natural environment (soil, vegetation, water, and wildlife), and the built environment (human infrastructure including visitor facilities and signage) associated with recreational sites. The 'psychosocial setting' refers to the social environment (including visitor numbers and behaviour, group size and perceptions of crowding and conflict), and the psychological environment or individual responses (including values, perceptions, prior expectations, motivations, and previous experience) of each visitor (Bentrupperbäumer and Reser, 2000). 'Biophysical impacts' can be both the manifestations of human behaviour or human behavioural responses to the environment, and the result of ongoing environmental phenomena and natural processes such as weather. 'Psychosocial impacts' are the psychological responses of visitors to the environments encountered (Bentrupperbäumer and Reser, 2000). A broad definition has been adopted for the term ‘experience’ which is understood to encompass the moods, emotions and feelings of individuals moving through natural landscapes (Chhetri *et al*. 2004). ‘Perceptions’ are mental constructs that develop as a consequence of past experiences, present values, motivations and needs (Pigram, 1993). A ‘transactional approach’ is a mode of inquiry that considers the environment as part of an event in time, the components of which are so intermeshed that no part is understandable without the simultaneous inclusion of all the other parts (Bell *et al*. 2001). ‘Person-environment congruence’ refers to the notion that the setting promotes the behaviour and goals within it, or the degree of ‘fit’ between people and their environment (Bell *et al*. 2001).

Although the review primarily sought to evaluate literature related to long-distance walking tracks in tropical rainforest environments this would have been insufficient since limited research has been conducted within these recreation settings. Consequently the review has been widened to encompass literature from a range of recreational settings and from environments other than tropical rainforests. This literature review is presented in five sections as follows:

Protected Area Management Overview (Section 2.2)

This section provides an overview of protected area management and summarises the principal roles and objectives of protected areas and the international context within which they exist. The review considers the concept of planning and summarises a number of integrated planning frameworks that have been applied within the field of protected area management. This is followed by a review of a number of protected area management techniques and strategies, with these being categorised as either *site management* or *visitor management*. This section of the review also provides an overview of a number of protected area management strategies that have particular relevance to the Wet Tropics region of North Queensland.

People-Environment Interactions (Section 2.3)

The second section of this chapter provides a synopsis of people-environment interactions, and places particular emphasis upon the use of a transactional model within outdoor recreation settings. The review explores various psychological responses to the environment, the personal benefits that result from people-environment interactions, and various theories that seek to explain these responses.

Biophysical Impacts of Visitation and Use (Section 2.4)

The third section of this chapter reviews literature pertaining to biophysical impacts associated with visitor use of natural recreation areas within predominantly tropical rainforest environments. It commences with an examination of the concepts of 'resistance' and 'resilience' from recreation ecology and the impacts of outdoor recreation, in particular visitor use of long-distance walking tracks, upon soil, vegetation, water and wildlife. As impacts vary over space and time, the discussion considers factors that result in spatial and temporal variations in impacts.

Psychosocial Experiences of Visitors (Section 2.5)

The final section examines literature of relevance to the psychosocial experiences of visitors and considers various factors that impact upon quality of experience in outdoor recreation settings. This section reviews the influence of the natural, built, and social environments, and the management of these environments, upon visitor experiences. It concludes with an exploration of literature relating to the psychological domain and considers satisfaction, the influence of motivations, previous experience, and psychological preparedness upon visitor experience.

Conceptual and Theoretical Orientation of the Thesis (Section 2.6)

The chapter finishes with a short section that seeks to clarify the conceptual and theoretical framework used for the research and attempts to elucidate the linkages between the literatures reviewed above.

2.2 PROTECTED AREA MANAGEMENT OVERVIEW

There are currently in excess of 100,000 protected areas in the world, covering more than 11.5 percent of the terrestrial area of the planet or a combined area larger than South America (Naughton-Treves *et al*. 2005; Worboys *et al*. 2005). The internationally accepted definition of a protected area is ‘an area of land and/or sea dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means’ (International Union for the Conservation of Nature, 1994. p.7). One of the principal objectives underpinning the reservation of land within a protected area is to protect the biological and recreational resources of the area from exploitation by a few, in order to enable their enjoyment by the broader society (Newsome *et al*. 2002). To this end protected areas can be considered ‘social spaces’ as they represent areas that people have determined deserve preservation (Ghimire and Pimbert, 1997). Protected areas are essential for the conservation of biological diversity, and provide a range of ecosystem services including watershed protection, waste assimilation, reduce carbon dioxide, and help to shield human communities from natural disasters (Font and Tribe, 2000; Worboys *et al*. 2005). Many protected areas are also important because they have scientific, educational, and cultural significance, provide opportunities for tourism and recreation, and provide a sustainable supply of resources, especially for indigenous peoples (Holdgate and Philips, 1999; Font and Tribe, 2000; Naughton-Treves *et al*. 2005). In addition to generating economic benefits, outdoor recreation within protected areas is valuable because it helps to foster environmental awareness and a conservation ethic more effectively than can be achieved through ‘in-class’ environmental education, which has become even more important with ever increasing budgetary shortfalls in government support for protected areas (Bushell, 2003).

The concept of formal protected areas is a relatively new phenomenon in much of the world (Holdgate and Philips, 1999; Newsome *et al*. 2002; Boyd, 2004), although Australian Aboriginal people have long related to land and revered certain places in a manner consistent with what we now define as protected areas (Worboys *et al*. 2005). Protected areas within many developed nations (e.g. United States, Canada, New Zealand and Australia) were initially regarded as ‘worthless lands’ before later gaining wider community acceptance (Boyd, 2004). The first dedicated national park was

Yellowstone National Park in the United States which was established in 1872 to protect the recreation and landscape values of the area (Holdgate and Philips, 1999; Newsome *et al*. 2002; Boyd, 2004). The first national park to be declared in Australia was Royal National Park near Sydney which was established in 1879 (Newsome *et al*. 2002), although Jenolan Caves was declared a water reserve in 1866 primarily for the protection of the caves and could arguably be regarded as Australia's first non-Aboriginal protected area (Worboys *et al*. 2005). In contrast with developed nations, more than 50 percent of protected areas in the Middle East, South-east Asia, China, the Caribbean, North Africa, Central America and the former republics of the Soviet Union have been established since 1982 (McNeely *et al*. 1994). Similarly 80 percent of all protected areas in the world have been established since 1960 (Holdgate and Philips, 1999). The majority of protected areas are established and managed by either government agencies or private conservation organisations (Newsome *et al*. 2002; Naughton-Treves *et al*. 2005).

Protected area management within Australia occurs within an international context and is increasingly influenced by international events, conventions and initiatives. The establishment of the World Heritage Convention in 1972 (which Australia ratified in 1974) and the creation of World Biosphere Reserves in 1976 under the UNESCO Man and the Biosphere Program led to the creation of additional Australian protected areas of international significance (Worboys *et al*. 2005). Similarly, protected area management is increasingly influenced by a range of international initiatives that have been designed to promote sustainable resource management including the publication of the Brundtland Report (Our Common Future) in 1987, Agenda 21 (an outcome of the Earth Summit held in 1992), the Convention on Biological Diversity (1992), the Kyoto Protocol (resulting from a forum to discuss global climate change in 1997), the Millennium Summit (2000), and the World Summit on Sustainable Development held in 2002 (Worboys *et al*. 2005). The two walking tracks under investigation, the Mt Bartle Frere Track and the Thorsborne Trail, are located within World Heritage listed national parks and are consequently subject to the requirements of the World Heritage Convention.

2.2.1 Increasing visitation to protected areas

The increased global emphasis on sustainability is particularly poignant given the growth in tourism and recreation that has occurred within protected areas over the past few decades (Boo, 1990; Buckley, 1998; Bushell, 2003; Fennell, 2003). Tourism is currently one of the world's largest and fastest growing industries, with natural area tourism being the most rapidly growing segment (Newsome *et al*. 2002; Fennell, 2003). Whilst there were 625 million tourists in 1998, this is anticipated to increase to one billion by 2010 and reach 1.6 billion by 2020 (Newsome *et al*. 2002; Fennell, 2003). Tourists are continually seeking to obtain new experiences, particularly within ecologically complex environments or biodiversity 'hot spots' such as coral reefs and tropical rainforests, which are also potentially fragile ecosystems (Evans, 2000; Wong, 2004; Turton and Stork, 2006). Increased visitation to protected areas is a global phenomenon that has been experienced in many countries including Canada (Anders Sandberg and Midgley, 2000), Costa Rica (Place, 1998; Farrell and Marion, 2001), Indonesia (Kinnaird and O'Brien, 1996), New Zealand (Hall and Higham, 2000; Kearsley, 2000; Ward *et al*. 2002), Singapore (Henderson, 2000), Uganda (Obua and Harding, 1997), the United Kingdom (Ryan, 1991), and the United States (Hendee *et al*. 1990; Cole, 1996), to name but a few. Although the impacts of visitation to protected areas can be positive and negative (Bentrupperbäumer and Reser, 2000; Tribe *et al*. 2000), a range of undesirable natural resource impacts have previously been attributed to tourism and recreation within protected areas in various parts of the world (Ryan, 1991; Hunter and Green, 1995; Kearsley *et al*. 1998; Holdgate and Philips, 1999; Font and Tribe, 2000; Kearsley, 2000; Ward *et al*. 2002; Bushell, 2003; Fennell, 2003; Wong, 2004). In the absence of effective management the future sustainability of some protected areas will be threatened by over-visitation and inappropriate behaviour, the construction of resorts and facilities within ecologically sensitive locations (Ryan, 1991; Davenport *et al*. 2002; Worboys *et al*. 2005), and as a consequence of the actual recreational activities of visitors (Buckley and Pannell, 1990; Font and Tribe, 2000; Fennell, 2003).

High profile protected areas within Australia have also experienced substantial increases in tourist numbers in recent years (Buckley and Pannell, 1990; Newsome *et al*. 2002). During 2002 an estimated 84 million visitors were hosted by the combined protected area organisations of Australia, with protected areas receiving more visitors per year than any other outdoor destination type (Worboys *et al*. 2005). Over 90 percent of visitors to protected areas within Australia are Australian residents, with the majority of these (70%) from urban areas, although a substantial number of visitors are international tourists, especially to World Heritage listed sites such as Kakadu National Park and the Great Barrier Reef Marine Park (Worboys *et al*. 2005). During 1995 approximately half of all international visitors to Australia visited at least one national park during their stay (Blamey, 1995). As a consequence of sustained growth in visitation levels to protected areas within Australia, land managers face a constant challenge to maintain the quality of the natural resource base, while still providing enjoyable recreational experiences for visitors (Prosser, 1986; Absher, 1994; Smith and Newsome, 2002). It has been estimated that the annual level of visitation to official recreation sites within Queensland's Wet Tropics World Heritage Area is in the order of 4.4 million visits per year, comprised of both local residents (40%) and domestic and international tourists (60%) (Bentrupperbäumer and Reser, 2002). As the Wet Tropics World Heritage Area is managed for both conservation and recreation, it is important that planning and management is integrated to achieve both ecological and social sustainability given the large number of visitors who access the area.

2.2.2 Principles for managing visitation within protected areas

Although this review is primarily focused on protected areas within the context of their role as recreational settings for human use, it is important to emphasise that these areas also have a number of conservation objectives which management has to consider when managing visitation. As the biophysical and psychosocial components of visitation to natural protected areas are linked, managers have to adopt an integrated approach to ensure that both remain sustainable and that environmental decision making is undertaken in a holistic and integrated manner, at both regional and local scales (Margerum, 1999). This necessitates that protected area managers have to consider the competing demands of conservation and visitation to ensure resource protection for the benefit of both current and future generations, and for preservation purposes (Bushell, 2003). To this end protected area management has progressively become largely a social science as managers increasingly attempt to understand social and cultural landscapes (political priorities, policy settings, social and cultural values), in addition to biophysical landscapes (Bushell, 2003). Worboys *et al*. (2005) have developed seven guiding principles that they believe should be applied in relation to the management of tourism and recreation within protected areas (summarised in Table 2.1). For the purpose of this review the various principles have been categorised as being related to either *site management* or *visitor management*, although some are arguably both. Although some of the principles are somewhat simplistic, they nevertheless highlight the importance of management considering both site and visitor parameters when managing protected areas for sustainable visitation.

Table 2.1 Principles for managing tourism and recreation within protected areas.

Principles for managing tourism and recreation within protected areas	
Site management principles	
1	The provision of appropriate visitor infrastructure and services should be made in accordance with ecologically sustainable visitor-use principles.
2	Planning tools such as the Recreation Opportunity Spectrum (ROS) are essential to the effective management of visitor opportunities. Protected area mangers should ensure that a spectrum of recreation settings is available within a region.
3	Every natural environment has its own special characteristics that must be taken into account when siting and designing visitor facilities and services.
Visitor management principles	
4	Continued growth in visitation to protected areas will require the careful management of visitors if they are to remain sustainable.
5	The encouragement and management of appropriate use involves providing a range of opportunities for visitors to interact with the natural and cultural features of protected areas, whenever this is compatible with the goal of conserving natural and cultural heritage values. Effective management demands accurate research.
6	The setting of limits is an essential tool in sustainable visitor-use management at visitor destinations.
7	Protected area managers should ensure that visitors, as much as possible, have rewarding and enjoyable experiences in protected areas.

(Source: Adapted from Worboys *et al*. 2005. p.463.)

2.2.3 Integrated protected area visitor planning frameworks

Planning is the process of setting goals (desired future conditions) and developing the actions (specific details of what will be done) necessary to achieve them (McCool and Patterson, 2000; Newsome *et al*. 2002). Although planning can be undertaken at various spatial scales (national and regional land use planning, protected area management planning, site planning), or for various purposes (fire planning, species recovery planning, organisational planning), it is invariably concerned with future courses of action (Worboys *et al*. 2005). The current review primarily focuses on planning that is undertaken to manage visitor use within natural protected areas, which typically represents one component of protected area management plans. Protected area management plans usually involve consideration of various issues including flora and fauna conservation, protection of landscape quality and aesthetics, protection of water quality, visitor use management, management of threatening processes (such as fire, weeds, feral animals), adjacent land use management, and the management of other authorised uses such as concessions and leases (Hendee *et al*. 1990; Anderson *et al*.1998; Hammitt and Cole, 1998; Worboys *et al*. 2005). Despite the considerable effort that has been invested developing various visitor planning frameworks, they have been used infrequently in management planning for protected areas (Newsome *et al*. 2002; Moore *et al*. 2003). This lack of implementation reflects a combination of a lack of resources (insufficient biophysical and social data, funding shortages), confusion in relation to the purpose of each framework and which is the most appropriate to utilise, and a lack of commitment among decision makers (Newsome *et al*. 2002; Moore *et al*. 2003). Implementation has also been thwarted by the fact that most of the planning frameworks require agreement amongst stakeholders about decisions (Newsome *et al*. 2002).

In general integrated planning approaches have been developed to both reduce adverse biophysical impacts and improve the quality of recreational experiences associated with visitor use of protected areas. Many adverse biophysical and psychosocial impacts can be prevented, or at least minimised, with effective integrated planning and management of visitation (Worboys *et al*. 2005). The concept of recreational carrying capacity, and three of the principal integrated visitor planning frameworks (Recreational Opportunity Spectrum, Limits of Acceptable Change and Visitor Impact Management) that have been found to be of assistance to protected area managers are now examined. Although a number of other planning frameworks exist (refer to Chapter 4 in Newsome *et al*. 2002 for a comprehensive review), only the well known ‘classical’ and time honored approaches are reviewed here.

Recreational carrying capacity

In response to increasing visitation levels and concern about the associated impacts, a number of attempts have been made to define numerical carrying capacities for individual protected areas. While various efforts have been made to apply the carrying capacity concept to the management of recreation within natural areas, biophysical and psychosocial impacts are not necessarily a reflection of visitation levels (Hammitt and Cole, 1998). Carrying capacity can be defined as the maximum level of use that an area can sustain (Stankey *et al*. 1990), and has two components, an ecological capacity (assessed in terms of the carrying capacity of biophysical components such as soil, vegetation, water, and wildlife), and an experiential carrying capacity (assessed in terms of the social environment influencing the recreational experiences of users) (Morin *et al*. 1997). While the carrying capacity concept has valuable agricultural application, it has generally failed to provide managers of natural areas with practical use limits. This is partly due to the fact that many biophysical impacts occur under relatively low use levels (Cole, 1985), or are a consequence of inappropriate visitor behaviour which results in adverse impacts beyond those which would occur if visitors exercised appropriate behaviour (Hammitt and Cole, 1998). Many biophysical impacts are the result of poorly informed and even illegal behaviour rather than a consequence of too many people at the same recreational site, meaning the relationship between use levels and impacts is not simple and linear (Cole *et al*. 1987; McCool and Patterson, 2000). Similarly, the recreational carrying capacity approach has failed to acknowledge that different types of visitor experiences and use have different experiential carrying capacities, wherein one visitor may perceive a destination to be overcrowded, while another perceives the same site to be underutilised (McCool and Patterson, 2000; Stankey *et al*. 1990). The carrying capacity concept has also failed to acknowledge that all recreational use has some impact, and the real question for management to address is how much impact or change is acceptable both in terms of the biophysical and psychosocial environments (Wight, 1998; McCool and Patterson, 2000)?

The practical limitations of recreational carrying capacity have seen a change in planning emphasis towards attempting to define the extent of impact that will be acceptable to land managers, or the types of experiences that need to be available to visitors. Given these limitations the traditional focus on visitor numbers and maximum use levels as assessed by recreational carrying capacity is progressively being replaced by a new paradigm that places greater emphasis upon maintaining resource quality at acceptable standards as defined by preset indicators (Shelby and Heberlein, 1984; McCool and Patterson, 2000). Nevertheless, it has been argued that the recreational carrying capacity concept still has merit although use limits need to be determined via other management frameworks such as Limits of Acceptable Change (LAC) or Visitor Impact Management (VIM) so that standards define the minimum acceptable condition of each indicator (Manning, 2000).

Recreational Opportunity Spectrum (ROS)

One of the first recreational planning frameworks to be utilised by protected area managers was the Recreational Opportunity Spectrum or ROS, which was developed in the 1970s in the United States (Clark and Stankey, 1979; Stankey *et al*. 1990). ROS allocates outdoor experiences along a primitive – urban continuum, and has a number of opportunity classes or zones with different levels of use (Virden and Knopf, 1989; Newsome *et al*. 2002). ROS was originally developed in response to conflict within recreational settings, and seeks to provide visitors with a spectrum of potential recreational activities, while segregating incompatible activities (Hammitt and Schneider, 2000). The architects of ROS (Clark and Stankey, 1979) believed that adverse biophysical impacts could be reduced by assigning high impact recreational activities to resilient sites, while low impact activities were allocated to less resilient locations (Newsome *et al*. 2002). ROS is most effective when used as a local or regional planning tool to provide a diversity of recreational opportunities (Newsome *et al*. 2002). However, ROS also complements the Limits of Acceptable Change planning framework because it provides a process for identifying and delineating opportunity classes with different levels of recreational use (Morin *et al*. 1997).

The greatest weakness of the ROS planning process is the difficulty associated with determining the level of demand for recreational opportunities, and reaching consensus about opportunity classes which sometimes results in a lack of implementation (Newsome *et al*. 2002). Another criticism that has been leveled at the ROS planning process is that it fails to adequately cater for the diversity of non-activity based opportunities such as experiences that are sought from many recreational sites, and might be more appropriate if transformed into an Experience Opportunity Spectrum (Bentrupperbäumer and Reser, 2002).

Limits of Acceptable Change (LAC)

The Limits of Acceptable Change or LAC planning framework attempts to determine the extent of change in wilderness values that is acceptable and will be tolerated by management and visitors using measurable resource standards. Stankey *et al*. (1985) proposed the LAC model as an alternative to recreational carrying capacity. Rather than seeking to identify how much use is too much, LAC attempts to determine how much change is acceptable (Stankey *et al*. 1985). Once this is known, managers can concentrate on strategies to preserve desired ecological and social conditions, rather than focusing upon limiting visitor numbers (Prosser, 1986). The LAC approach assists managers to determine what environmental and social conditions are acceptable, and helps identify the management actions required to protect or achieve those conditions (Morin *et al*. 1997; Newsome *et al*. 2002). Prosser (1986) summarises the LAC approach to recreation planning as having four main stages. Initially managers need to specify realistic biophysical and social conditions that they would regard as acceptable for a range of opportunity classes in addition to setting measurable impact indicators. The second stage involves managers analysing the correlation between existing conditions and those that have been identified as being acceptable in stage one. Next, managers need to identify the actions required to achieve the desired acceptable conditions. The final stage entails managers implementing the identified actions and monitoring conditions for change (Prosser, 1986). The public participate in LAC both through provision of expertise and by providing their opinions about the standards for acceptable impacts (Morin *et al*. 1997).

Potential weaknesses of the LAC framework include the fact that managers must make largely arbitrary decisions about the extent of change that will be deemed acceptable (Parsons, 1985; Wight, 1998), so the approach does not specifically take the ‘user perspective’ into consideration. Effective implementation of LAC requires the selection of appropriate indicators and a good understanding of the desired conditions within the area in question (Prosser, 1986). In some instances managers may deliberately set lower standards than are necessary to maintain the long-term integrity of a site in order to both attract visitation to the area and to ensure that their benchmarks are met (Wight, 1998). The LAC approach has also been criticised for not considering the cumulative impacts of visitation in surrounding areas, and for failing to consider whether tourism and recreation represent the wisest use of the environmental resources of an area (Wight, 1998).

Visitor Impact Management (VIM)

Visitor Impact Management or VIM is another alternative to the original carrying capacity concept, and like LAC, it uses standards and indicators to keep visitor impacts within acceptable limits. The VIM planning framework utilises information obtained from both scientific and subjective visitor evaluations of impacts, when developing guidelines for management of natural areas (Graefe *et al.* 1990). VIM is designed to be easier to use than LAC, as the model primarily focuses upon visitor impacts rather than wider impacts associated with opportunity classes (Newsome *et al*. 2002). There are eight steps in the VIM model (Graefe *et al.* 1990), which can be summarised as follows. Managers initially review existing data, management objectives and policies, before selecting key impact indicators and establishing standards for indicators. At this point managers compare the established standards with existing conditions and if the desired standards are exceeded, take action to identify probable causes of impact and possible management strategies. The final stage involves managers taking action to implement their desired actions (Graefe *et al*. 1990). The explicit monitoring loop contained within the VIM framework helps managers identify discrepancies between actual conditions and their desirable state as articulated by the organisation's objectives, and might for example include the discrepancy that arises between a desired state of having no litter and an actual state of litter being present at a tourist site (Davidson, 2004). Like LAC, VIM recognises that factors other than use levels are responsible for impacts, although VIM attempts to identify the actual cause of the impacts (Morin *et al*. 1997). As with LAC, VIM benefits from the prior completion of a park management plan, because there needs to be an understanding of the objectives that management is trying to achieve (Morin *et al*. 1997).

While VIM seeks to identify unacceptable impacts from the perspective of visitors and attempts to use this knowledge in conjunction with scientific information (Newsome *et* *al*. 2002), the model fails to adequately investigate the nature of the encounter between visitors and the setting (Reser and Bentrupperbäumer, 2005). Although VIM entails field assessments of social impact indicators and emphasises that interrelationships exist between impacting processes and visitor experiences, it fails to adequately address the actual nature and quality of individual experiences, and the interdependent nature of biophysical and psychosocial impacts (Reser and Bentrupperbäumer, 2005). Another substantial weakness of VIM is its lack of suitability for large areas of land with multiple opportunity classes or zones (Newsome *et al*. 2002), and the fact that the model works best with simple and routine issues (Davidson, 2004). Although the VIM process was adopted with some success by the Jenolan Caves Reserve Trust (Wight, 1998; Davidson, 2004), a team of experts in cave and visitor management investigating the environmental and social carrying capacity of the reserve found that the model was incapable of generating an acceptable upper limit of visitor use (Wight, 1998). They also concluded that implementation of the VIM framework suffered from a lack of suitable environmental and social data (Wight, 1998).

Limitations of traditional integrated protected area visitor planning frameworks

Although traditional frameworks such as the Recreation Opportunity Spectrum (ROS), Limits of Acceptable Change (LAC), and Visitor Impact Management (VIM) approaches have made a useful contribution to the management and monitoring of some protected areas, their overall uptake and implementation has been reasonably limited to date (McArthur, 2000; Newsome *et al*. 2002; Ward *et al*. 2002). The failure to implement traditional visitor planning frameworks has typically resulted from a lack of commitment by decision makers, a lack of resources (biophysical and social data, money etc.), confusion about their purpose and applicability, or a lack of agreement among stakeholders about decisions which is often required prior to implementation (Newsome *et al*. 2002; Moore *et al*. 2003). Implementation of most of the planning frameworks is also often problematic given that managers are frequently reluctant to set standards (Moore *et al*. 2003), and the fact that any standards that are adopted are usually arbitrary due to a lack of biophysical and social data (Wight, 1998). In a number of instances visitor planning frameworks have not been implemented due to a lack of support from the local tourism industry and the broader community, which is often critical to them obtaining the economic and political support necessary to both implement management decisions and maintain monitoring programs (McArthur, 2000). To date most planning frameworks have failed to adequately address the needs of both tourism operators and environmental managers (Ward *et al*. 2002). The failure of the various planning frameworks to obtain adequate support for implementation has been partly attributed to their inherent culture of not sufficiently involving stakeholders (McArthur, 2000). In the absence of sufficient stakeholder involvement, understanding and support for decisions, it is likely that outcomes generated by the various frameworks will be challenged and potentially overturned, potentially leading to the abandonment of the model itself (McArthur, 2000).

As a consequence of limitations with the traditional integrated protected area visitor planning frameworks, and in light of the particular research questions that form the basis of the present study, the various planning approaches have not been applied in the current research. Rather this research has chosen to apply a more 'experience-based' or 'visitor-centered' approach to visitor management via the use of a human-environment transactional model that places greater emphasis upon 'users' perspectives' of recreational settings and enables the positive impacts of visitation to be considered. It can be argued that human-environment transactional models have a number of advantages over traditional visitor planning frameworks. Traditional planning and management frameworks have been largely influenced by biophysical and conservation considerations, and have predominantly used techniques drawn from the natural sciences (McArthur, 2000; Reser and Bentrupperbäumer, 2005).

A particular failing of traditional approaches is that they do not adequately investigate the nature of encounters that take place between individuals and the environment within a protected area, which is arguably most important to management (Reser and Bentrupperbäumer, 2005). Traditional visitor planning frameworks tend to only emphasise the 'negative impacts' of visitation upon the environment, and generally fail to take into account the 'positive impacts' of visitation both for people and the setting (Reser and Bentrupperbäumer, 2005). In contrast transactional models provide greater acknowledgement that the 'environment' also includes the human dimension, and that 'impact' includes impacts upon visitor experience (Reser and Bentrupperbäumer, 2005). Transactional models therefore appear to be more 'visitor centered' and attribute greater importance to the experiences of visitors than traditional approaches. They also provide greater scope for use of human judgments about the current condition and welfare of particular recreational settings than do traditional integrated visitor planning frameworks.

2.2.4 Protected area management techniques and strategies

Visitor management within protected areas typically involves the implementation of various techniques and strategies, with subsequent monitoring of the effectiveness of management actions, although the latter is considered to be beyond the scope of the current review. Protected area managers often utilise a diverse range of operational or ‘on-the-ground’ techniques and strategies to actively ‘manage’ visitor activity. These protected area management techniques and strategies can be categorised in various ways. Ryan (1991) differentiates between macro-techniques (regional or zonal scale) and micro-techniques (site level) on the basis of the spatial scale at which they are applied. Distinctions can also be made between management actions on the basis of whether they involve the use of direct or indirect management interventions (Newsome *et al*. 2002; Fennell, 2003), or whether they relate to site or visitor management (Buckley, 1998; Hammitt and Cole, 1998; Newsome *et al*. 2002; Fennell, 2003; Turton, 2005). Figure 2.1 demonstrates the broad distinctions that exist between *direct* and *indirect* management, and between *site* and *visitor* management, many of which are considered in this research.

<table>
<tr><td rowspan="2">Indirect management</td><td>Locate facilities on impact resistant sites
Develop an appropriate site layout
Design appropriate facilities
Construct appropriate facilities
Manage and maintain visitor facilities
Periodic maintenance of broader site (weeds etc.)</td><td>Site management</td></tr>
<tr><td>Provide interpretation resources
Establish signage
Provide educational opportunities
Undertake site and experience promotion
Introduce user pays systems / Fees
Promote alternative destinations</td><td rowspan="2">Visitor management</td></tr>
<tr><td>Direct management</td><td>Regulation of visitor use and behaviour

• Regulate the total numbers of visitors
• Regulate the period of use (seasonal closures)
• Regulate the possible size of groups
• Regulate the permitted length of stay
• Restrict the activities that can be undertaken
• Enforce protected area regulations</td></tr>
</table>

Figure 2.1 Management of visitors to protected areas: classification of approaches. (Sources: Derived from Graefe *et al*. 1990; Hammitt and Cole, 1998; Newsome *et al*. 2002).

Direct and indirect management techniques

Direct management techniques tend to restrict individual choice (for example, restricting total visitor numbers at a site or regulating the number of members in each group), while *indirect management* techniques primarily focus upon influencing visitor behaviour (for example, the provision of interpretation and signage, or the introduction of fees) and provide individuals with greater freedom of choice (Newsome *et al*. 2002; Fennell, 2003). *Indirect management* techniques can also involve actual site modifications to minimise biophysical and social impacts associated with inappropriate site layout, design and construction (Graefe *et al*. 1990). Managers can engage in direct enforcement of regulations by providing on-site personnel to sanction visitors who engage in noncompliant behaviour (Graefe *et al*. 1990; Anderson *et al*. 1998). However, as enforcement of regulations represents an additional impost upon managers (Buckley and Pannell, 1990), they need to remain cognisant of the costs and benefits of such an approach when compared with more passive or indirect techniques to modify visitor impacts.

Site management techniques

Site management often seeks to indirectly manage visitors and biophysical impacts by directing and/or concentrating visitor use using tactics such as the installation of physical barriers, provision of facilities, and closing access to areas (Ryan, 1991; Anderson *et al*. 1998). *Site management* primarily seeks to reduce visitor impacts through actions undertaken at the site where use occurs and typically involves locating use on durable parts of the landscape, and designing and managing facilities in a manner that minimises the potential for impacts, often via site hardening and shielding at high use sites (Newsome *et al*. 2002). Site hardening and shielding usually includes initiatives such as the construction of boardwalks, the artificial surfacing of walking tracks with durable materials such as gravel and paving, enhanced drainage, the installation of handrails, fencing and bollards to exclude visitors from sensitive or degraded sites, the strategic planting of vegetation to define pedestrian and vehicular access, and locating picnic tables on concrete slabs to avoid the proliferation of areas of bare soil (Buckley and Pannell, 1990; Anderson *et al*. 1998; Buckley, 1998; Turton, 2005). Impacts along walking tracks can also be reduced by locating trails and facilities on resistant or resilient sites (Leung and Marion, 1996), and the installation of rope borders to reduce problems with trail proliferation (Farrell and Marion, 2001). Intensive site management practices such as hardening and shielding are generally not suitable for low use recreation sites such as long-distance walking tracks due to both cost considerations and the fact that this is aesthetically inappropriate within remote wilderness settings (Turton, 2005; Turton and Stork, 2006).

From an environmental psychology perspective site layout and design of the built environment can have an important influence upon visitors' responses to the setting, particularly in terms of their experience and behaviour (Veitch and Arkkelin, 1995; Bell *et al*. 2001). Effective site design and planning should seek to achieve a high degree of 'congruence' or 'fit' between users and a recreational setting so that the behavioural objectives of visitors are facilitated rather than frustrated (Bentrupperbäumer and Reser, 2002). Likewise effective site planning should seek to promote 'legibility' so that visitors can easily obtain an understanding of the layout and components of a site, rather than experiencing confusion (Bell *et al*. 2001). Appropriate design and construction of the built environment can be used to direct vehicular and pedestrian flows, minimise biophysical impacts, enhance interpretation of exhibits and signage, promote awareness of the need for sensitive behaviour at fragile sites, enhance wayfinding and site legibility, and discourage vandalism (Bentrupperbäumer and Reser, 2002). GIS (Geographic Information Systems) has been used for time-space analysis of visitor behaviour within recreational settings as a way of enhancing the layout of infrastructure to both assist activity management and protect the environment (Farsari and Prastacos, 2004). This system of data collection of human movement throughout a setting is relatively new. While it is limited in the information it can provide, nevertheless managers can utilise data obtained from GIS analysis of visitors' movements within a recreational setting to enhance the layout of pathways so that users are provided with the shortest route between frequently used facilities or are provided with routes that combine passing through key points at a site (Farsari and Prastacos, 2004). It is likely that such an approach to the layout of pathways at a site would reduce the incidence of biophysical impacts as visitors would be less likely take short-cuts. Although some recreational sites do have well designed built environments it would appear that many planners and managers have a poor understanding of the ways in which the design, layout and construction of infrastructure and facilities within a setting influence the experiences and behaviour of visitors (Bentrupperbäumer and Reser, 2002).

Visitor management techniques

Visitor management seeks to *directly* manage visitors by regulating the number, grouping, type, timing and distribution of use, as well as *indirectly* managing visitor behaviour via the provision of interpretation, education and direct communication (Ryan, 1991; Newsome *et al*. 2002). Managers can use a range of rationing techniques to allocate visitor access to protected areas including forward reservations, queuing (first come is first served), lotteries, make use of eligibility or merit systems, and introduce fees and charges (Ryan, 1991; Anderson *et al*. 1998). For example, in the Sequoia and Kings Canyon National Parks in the southern Sierra Nevada, California, mangers utilise a daily trailhead quota as the basis of use capacity (Parsons, 1985). Management strategies to regulate visitor access may also include zoning, limiting the size of groups, limiting the length of stay, restricting or prohibiting various equipment and modes of travel, establishing seasonal or temporal limitations upon access, and dispersing or concentrating visitors within a protected area (Ryan, 1991; Buckley, 1998; Hammitt and Cole, 1998). Promoting or enforcing the use of tour guides and prescribing low impact behaviors and practices in ecologically sensitive areas have also been very effective at reducing visitor impacts (Farrell and Marion, 2001).

Traditional protected area management strategies have tended to focus more upon sites and less upon the visitor, and often use a range of site management strategies as outlined previously that aim to make recreational areas more resistant to visitor impacts, although this often changes the nature of the visitor experience and can also compromise heritage values (McArthur, 1994; Worboys *et al*. 2005). However, protected area managers are becoming increasingly aware of the importance visitor education and interpretation programs can play in enhancing the quality of visitor experiences, whilst reducing visitor impacts upon the natural environment (McArthur, 1994; Sun and Walsh, 1998; Worboys *et al*. 2005). Managers regularly use interpretation to promote more caring attitudes among visitors towards the natural environment (Orams, 1995; Pearce and Moscardo, 1998), while fostering support for the existence of conservation reserves (Wearing and Larsen, 1996; Chin *et al*. 2000). Interpretation can help to encourage positive visitor behaviour although they must be given both the motivation and opportunity to act (Orams, 1995). Research has demonstrated that when interpretive material is provided to visitors entering natural areas in the United States, it can potentially reduce visitor impacts by 50 percent (Chin *et al*. 2000 citing Oliver *et al*. 1985), while visitor surveys within Warren National Park in Western Australia indicate that 90 percent of respondents would support additional efforts by management to educate users about minimal impact use and camping techniques to reduce impacts (Smith and Newsome, 2002). A number of interpretation programs, such as the ‘Walk Softly’ program in Tasmania, have been demonstrated to be effective at modifying visitor behaviour and have reduced the need for additional site management interventions (McArthur, 1994). Interpretation has similarly been credited with reducing the extent of graffiti and vandalism of stones on Easter Island despite an increase in visitor numbers over the decade 1987-1997 (Mason, 2005). Within the Wet Tropics region, all hikers undertaking the Thorsborne Trail on Hinchinbrook Island are required to watch ‘Without a Trace’, a fifteen minute video promoting minimal impact camping and hiking. While both the quantity and quality of visitor education programs around the world have increased substantially in the past decade (Cole, 2000), the full potential of such programs is yet to be realised (McArthur, 1994).

Appropriate site and experience marketing has been found to increase visitor satisfaction (Ryan, 1991; McArthur, 1994), thereby making the task of visitor management easier (Mason, 2005). As a result of numerous examples of inappropriate marketing, protected area managers are increasingly working with the tourism industry to ensure that marketing of both visitor experiences and sites is appropriate (Ryan, 1991; McArthur, 1994). A basic premise of market-oriented management is that mangers have an understanding of who their visitors are, and what types of experiences they seek (Gardner, 1994). Inappropriate marketing can result in unrealistic visitor expectations, and poor quality experiences, with resultant adverse consequences for recreation sites. However, if resource managers and tourism industry representatives work cooperatively to determine the type of visitor experiences a site is capable of providing, and to whom, marketing can be used to better meet the needs of both parties, as well as ensuring that visitors have realistic expectations from the start (McArthur, 1994). Such an approach can reduce the need for construction of additional visitor infrastructure and restrictions upon access.

2.2.5 Protected area management techniques for the Wet Tropics region

The primary management goal for the Wet Tropics of Queensland World Heritage Area is to provide for the implementation of Australia's international duty to *protect*, *conserve*, *present*, *rehabilitate* and *transmit* to future generations the Wet Tropics of Queensland World Heritage Area within the meaning provided by the World Heritage Convention (*Wet Tropics World Heritage Protection and Management Act, 1993*). This goal necessitates that the Wet Tropics Management Authority simultaneously protect, conserve and rehabilitate the attributes of the Wet Tropics World Heritage Area, whilst also presenting the area to visitors (Wet Tropics Management Authority, 2004a). In order to meet these international obligations under the World Heritage Convention protected area managers have utilised an array of *site* and *visitor management* techniques.

Site management in the Wet Tropics

The most appropriate *site management* strategy for addressing the ecological impacts associated with high visitor numbers within tropical rainforest environments in the Wet Tropics region has been to concentrate visitors' activities within a limited number of sites rather than allowing impacts to become dispersed across a high number of sites (Bentrupperbäumer and Reser, 2000). Within these high use sites visitors are further concentrated to limited areas, which are protected using a combination of site hardening and shielding techniques such as boardwalks, gravel or bitumen paths and mechanically compacted track surfaces (Turton, 2005). The site area that is available for visitor use is also often limited and defined by vehicle bollards, pedestrian fences and barriers, and strategic planting of vegetation. The Wet Tropics Management Authority (1992) has published a series of building and design guidelines for structures within the Wet Tropics World Heritage Area covering a range of aspects including site layout, building design (scale and form), materials, colours, vegetation plantings, construction of walking tracks and access roads. Although the purpose of the guidelines was primarily to enhance the appropriateness of infrastructure developed within the Wet Tropics region so that structures enhanced rather than eroded World Heritage values (Wet Tropics Management Authority, 1992), the design and construction of the built environment is also an important influence upon human behaviour (Bell *et al*. 2001).

While high use visitor sites can incur a range of localised impacts and ultimately represent 'sacrificial sites', low intensity dispersed recreational activities such as long-distance walking may pose a more significant threat to World Heritage attributes due to the very fact that impacts are dispersed and widespread as opposed to being localised and generally confined (Turton, 2005). For example, long-distance walkers within the Wet Tropics region can act as a conduit for the spread of weeds, feral animals and soil pathogens such as *Phytophthora cinnamomi* (Wet Tropics Management Authority, 2004a), and can result in the creation of social trails if hikers depart from the designated trail (Butler, 2002). The threat posed by *Phytophthora* within the Wet Tropics region has led Turton (2005) to recommend vehicle operators remove soil from tyres and mud flaps, while long-distance walkers should be encouraged to clean soil from hiking boots and tent pegs before traversing areas susceptible to dieback. The retention of overhead canopy cover along walking tracks, and at camping and picnic areas, has previously been demonstrated to be an effective site management technique to combat soil erosion, nutrient loss and weed establishment within tropical rainforest environments (Smith and Turton, 1995; Turton *et al*. 2000a; Turton, 2005). Canopy cover above walking tracks and roads also helps to reduce a range of linear barrier effects upon both arboreal and ground dwelling fauna, in addition to mimimising road kills (Goosem, 1997; Goosem and Turton, 1998, 2000).

Visitor management in the Wet Tropics

Protected area managers within the Wet Tropics region utilise a range of *visitor management* techniques to both maintain the quality of visitor experiences and prevent or reduce biophysical impacts. In particular, managers often utilise a range of *direct management* techniques to regulate visitor access including rotation of camping areas, zoning, limiting the size of groups, establishing seasonal or temporal limitations upon access, and dispersing or concentrating visitors within protected areas (Turton, 2005). For example, a limit of six in each group, and a maximum of 40 hikers at any one time apply on the Thorsborne Trail on Hinchinbrook Island National Park (Queensland Parks and Wildlife Service, 1999). The temporary or permanent closure of recreational sites to visitors can also help to reduce seasonal impacts and facilitate site recovery. Research conducted at rainforest campsites (for example Noah Beach) in the Wet Tropics region has demonstrated that the closure of campsites facilitates rapid rates of recovery for soil and organic litter cover, suggesting that high-use campsites should be rotated on a regular basis (Smith and Turton, 1995). As a consequence of the increased threat of widespread impacts associated with dispersed recreational activities such as off-road driving and long-distance walking, the wet season closure of these low use intensity sites has been recommended as a strategy to both reduce soil erosion (Goosem and Turton, 1998; Talbot *et al*. 2003; Turton, 2005), and assist to prevent the spread of soil borne pathogens such as *Phytophthora cinnamomi* (Worboys and Gadek, 2004). Similarly, the seasonal closure of some swimming holes during the dry season has also been suggested as a tactic to help prevent the introduction of water borne pathogens during the period when rainfall is lowest (Turton, 2005).

A lot of emphasis has also been placed on utilising various information dissemination strategies to *indirectly manage* visitors in the Wet Tropics World Heritage Area.

Protected area managers have typically sought to disseminate information and interpretative messages to visitors using *formal information sources* such as regional visitor information centres and the internet (Bentrupperbäumer and Reser, 2002). Since previous research has demonstrated that most visitors tend to rely upon *informal information sources* (for example, word of mouth / local knowledge), current information dissemination priorities appear to be misdirected (Bentrupperbäumer and Reser, 2002). It should also be noted that *formal information sources* such as visitor information centres are large consumers of both human and financial resources.

2.3 PEOPLE – ENVIRONMENT INTERACTIONS

It can be argued that a consideration of people-environment (or human-environment) interactions constitutes a shifting paradigm in natural resource management. Various academics maintain that the past decade has witnessed a paradigm shift in terms of the way that managerial philosophy and policies are being directed towards public land management, especially within the United States (Williams and Vaske, 2003; Kyle *et al*. 2004a). Whilst the traditional management paradigm considered natural areas purely from the perspective of the value of their ‘resources’ (timber, wildlife, minerals, recreational opportunities etc.), the current paradigm seeks to preserve and protect resources by placing greater emphasis upon visitor management, with managers seeking to understand “the subjective, emotional, and symbolic meanings associated with natural places and the personal bonds or attachments people form with specific places or landscapes” (Williams and Vaske, 2003. p.1). One positive outcome which has resulted from this paradigm shift is that managers are now better equipped to manage natural areas in line with the divergent meanings that different stakeholder groups ascribe to them (Kyle *et al*. 2004a).

In response to growing Western urbanisation humans have increasingly sought to obtain encounters with the natural environment or what has been termed ‘green experiences’ (McAndrew, 1993). Analysis of the relevant literature suggests that this paradigm shift has contributed to more research effort being directed towards exploration of the interactions that take place between humans and their surrounding environments, although it is still limited in both scope and extent. Such research has typically attempted to explain the nature, quality and consequences of visitor experiences within natural areas, the transactions that take place between people and the natural environment, in addition to exploring concepts such as place attachment, perceptions of wilderness, and the notion of sustainability. For the purpose of this research the experience of visitors using long-distance walking tracks was considered to be largely determined by the two-way interactions that take place between an individual and the biophysical and psychosocial settings in which their recreation occurs. Consequently, a human-environment transactional model was utilised to conceptualise and operationalise the various interactions which take place between visitors and the natural, built, and social environments they encountered during their respective long-distance walks.

2.3.1 Human-environment transactional models

People-setting or human-environment interactions, including those that take place between humans and recreational settings such as long-distance walking tracks, can be conceptualised using a human-environment transactional model. Human-environment interactions are characterised by ‘dynamic reciprocity’ or ‘mutual causation’, with simultaneous exchanges occurring between the person and environment and vice versa with influences upon both (Bonnes and Secchiaroli, 1995). Scherl (1991) suggests the best way to understand the contribution the environment makes to an individual’s recreational experience, and the link between experiences, benefits and the environment is to treat the individual as one component of an environmental transaction. Figure 2.2 is an example of a human-environment transactional model developed by Bentrupperbäumer and Reser (2000, 2002), which is particularly applicable to recreational settings. This model attempts to diagrammatically present the various environments and reciprocal transactions that take place between a visitor and a recreational setting. As depicted in the model, recreational sites consist of both a biophysical and a psychosocial setting, with each consisting of two environmental domains or layers. Transactions between visitors and a recreational site have the potential to generate both positive and negative biophysical and social impacts at the site, in addition to positive and negative psychological impacts for the individual user (Bentrupperbäumer and Reser, 2000). The bi-directional or reciprocal nature of impacts means that the influence of the recreational setting upon individual experience is just as important to consider as the environmental impacts that result from recreational activity (Reser and Bentrupperbäumer, 2001).

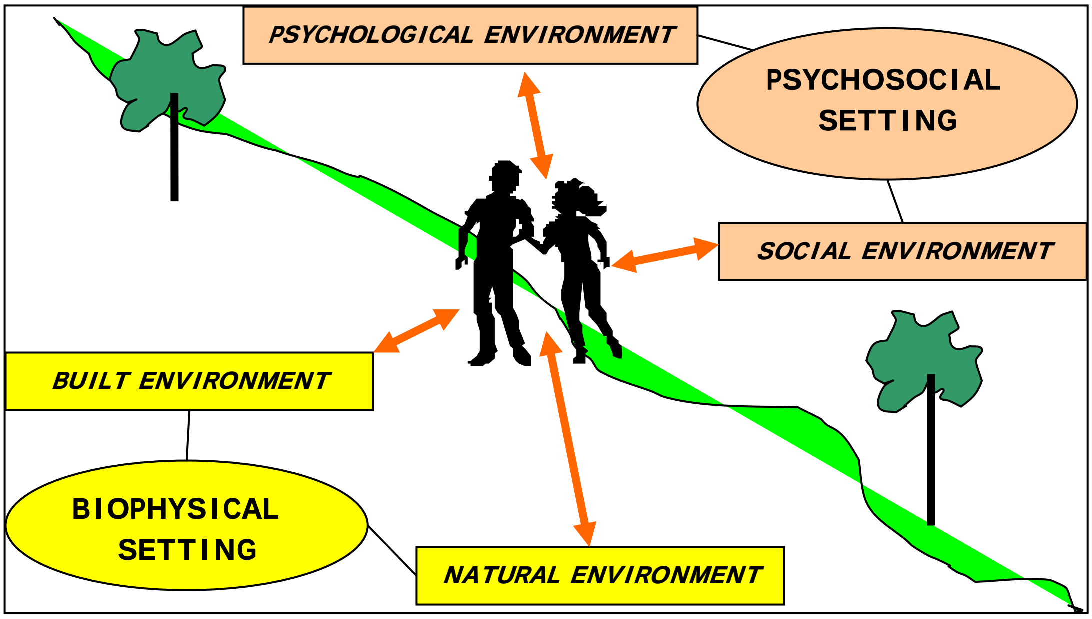

Figure 2.2 Human-environment transactional model.
(Source: Derived from Bentrupperbäumer and Reser, 2000, 2002.)

Assessments of both the biophysical impacts (impacts upon the environment) that occur within an outdoor recreation setting and the psychological impacts (impacts upon people) that take place for individual users require the use of different methodological approaches. Many biophysical impacts within a setting are the manifestation of human behaviour or human behavioural responses to the environment (Bentrupperbäumer and Reser, 2000). Since it is often neither feasible or ethically appropriate to unobtrusively observe human behaviour within outdoor recreation settings, particularly on remote sections of long-distance walking tracks, it becomes necessary to obtain insights about how these environments have been used by people on the basis of the physical traces that visitors leave behind (McAndrew, 1993). Physical traces such as erosion, litter, and environmental damage represent forms of 'fossilised behaviour' and can provide assistance when attempting to reconstruct and understand the human behaviour that has occurred within a setting (McAndrew, 1993). While many biophysical impacts represent the manifestation of human behavioural responses to a recreation setting, psychosocial impacts represent psychological responses to a setting and are typically assessed via self report questionnaires (Bentrupperbäumer and Reser, 2000).

Research has shown that visitor experiences, visitor satisfaction and visitor behaviour are linked (Bentrupperbäumer and Reser, 2000, 2002; Reser and Bentrupperbäumer, 2005). Despite the fact that the quality of visitor experiences within natural landscapes has recently become an integral component of research into visitor satisfaction (Chhetri *et al*. 2004), management agencies appear to have been reasonably slow to accept that this can have an important influence upon their behaviour. Furthermore, visitor perceptions of the natural, built and social environments encountered at a site has important implications for the quality of their recreational experience and ultimately can be reflected in their behaviour towards the physical setting and other visitors. Human behaviour is largely a consequence of the interactions that occur between a complex array of factors whilst at a recreation site, which in turn tend to be influenced by their quality of experience and satisfaction levels (Kuss *et al*. 1990).

McArthur (1994) is critical of current natural and cultural heritage management strategies for an excessive focus upon heritage attributes rather than focusing upon the visitor experience and suggests management should attempt to maximise the quality of visitor experiences in order to minimise visitor impacts. For example, if a visitor perceives the biophysical setting to be unattractive and the visitor facilities to be in poor condition, this is unlikely to engender respect and caring behaviour towards the natural and built environments, or indeed towards other users. On the contrary, such dissatisfaction can result in inappropriate behaviour that leads to additional negative setting impacts and accelerates the deterioration of the site. Similarly, if a visitor perceives the social environment to be disturbing due to the number or behaviour of other visitors, this can translate into conflict between users, diminished experiences and ultimately adverse implications for the biophysical setting. When the biophysical and psychosocial settings engender positive visitor experiences, site users are more likely to behave in a manner that is both respectful of the biophysical setting and tolerant of other visitors, with positive consequences for the long-term sustainability of the recreational site (Bentrupperbäumer and Reser, 2000, 2002; Reser and Bentrupperbäumer, 2005). Hence the challenge for managers is to design and provide positive experiences for visitors that engender sensitive and ecologically responsible behaviour that will mitigate impacts upon the natural environment (Reser and Bentrupperbäumer, 2001). Such an approach is particularly relevant when managing long-distance walking tracks since extensive *site management* is generally either impractical or aesthetically inappropriate (Turton and Stork, 2006), and hence greater emphasis may need to be placed upon *visitor management*.

Human-environment transactional models have previously been used in a variety of theoretical and applied research contexts, although implementation of these models requires the acceptance of various assumptions. A central assumption of transactional frameworks is that all people-setting interactions generate reciprocal impacts for both people and the setting that are ongoing over time (Hartig and Evans, 1993; Reser and Bentrupperbäumer, 2000). Just as the presence and behaviour of visitors can impact upon the natural, built, and social environments that comprise a recreational setting (Bentrupperbäumer and Reser, 2000), the setting can have reciprocal positive or negative impacts upon the experiences and resultant behaviour of visitors (Reser and Bentrupperbäumer, 2000). The important point to stress is that these transactions are interactive and that all leisure environments affect human behaviour in some way (Pigram, 1993). Their interdependence therefore needs to be understood if recreation sites are to be effectively managed to deliver satisfying recreational experiences for visitors and minimise biophysical disturbance.

Another important assumption of the model is that the internal human ‘psychological environment’ or ‘psychological domain’ comprises an integral component of the recreation setting (Bentrupperbäumer and Reser, 2002). Therefore, human response to all components of the recreational setting, and in particular the experience visitors have can comprise a valid impact indicator or early warning system for management. This notion has necessitated that the concept of impact be extended to include the reciprocal impacts that flow between a visitor’s psychological environment and the natural, built and social environments (Bentrupperbäumer and Reser, 2002). To this end transactional models have been successfully utilised as the theoretical framework for previous work within the disciplines of environmental psychology (Reser and Scherl, 1988; Reser and Bentrupperbäumer, 2000; Werner and Altman, 2000), and environment-behaviour research (Wapner *et al*. 2000). Such research typically seeks to explain how humans relate to and use, influence and are influenced by their natural, built and social surrounds (Werner and Altman, 2000). Transactional models have also been utilised as the conceptual framework for applied investigations of the impacts of visitation and use within the Wet Tropics World Heritage Area of Queensland (Bentrupperbäumer and Reser, 2000, 2002), and have been adopted to provide the theoretical framework for the current examination of visitor impacts and experiences on long-distance walking tracks.

While substantial research has been conducted into the impacts of visitors upon the natural environment, the reciprocal impacts of the natural environment upon recreational users has been largely ignored, despite the undoubted benefits that management could derive from better understanding the psychosocial experiences of visitors. Various fields of psychology have for decades regarded the environment as a source of stimulation that draws both positive and negative responses from individuals, resulting in changed behaviour and modified world views (Magnusson and Törestad, 1992; Bechtel, 1997). Nevertheless, most research that has been conducted to date in relation to visitor experiences is generally directed towards studying satisfaction levels and collecting demographic information via what is largely termed market research (Pearce and Moscardo, 1994, 1998; Hunter and Green, 1995; Moscardo, 1996; Driml, 1997; Law, 2000; Millward Brown Australia, 2000; Morgans, 2000), while the psychosocial impacts of the recreational experience upon visitors are largely overlooked (Reser and Bentrupperbäumer, 2001, 2005).

From a human-environment transactional perspective, protected area managers are missing out on an opportunity to obtain valuable information about the reciprocal impacts of the environment upon humans, and of the quality of visitor transactions with the environment (Reser and Bentrupperbäumer, 2001, 2005). Such information could be used to assist with visitor management and to effect behaviour change through the development of more targeted interpretive materials, enhanced presentation of recreational sites, better layout and design of settings, and a considered distribution of numbers accessing the setting at any one time. The provision of positive visitor experiences can also enhance overall community satisfaction with protected area management and ultimately increase community support for the preservation of natural areas (Gardner, 1994; McArthur, 1994). Unfortunately, the overriding problem within Australian protected areas is that very few park managers incorporate strategic visitor monitoring into their visitor management, often because they have little understanding of how to maximise the quality of visitor experiences (Gardner, 1994). Scope undoubtedly exists for more research in this area.

2.3.2 Experiencing wilderness

For many visitors, part of the attraction of undertaking a long-distance walk is to be surrounded by and experience wilderness. Wilderness is a culturally defined, predominantly urban concept that has little basis in science and exists only in western imaginations and perceptions (Gomez-Pompa and Kaus, 1992). Australia's natural areas are cultural landscapes, having been influenced and modified by Aboriginal people for thousands of years (Worboys *et al*. 2005). Science has repeatedly demonstrated that virtually every landscape on earth, including the humid tropics, has been inhabited, modified or managed by humans in the past, and consequently the notion of there being areas of pristine ecosystems untouched by humans is flawed (Gomez-Pompa and Kaus, 1992; Holdgate and Philips, 1999). Tropical forests are therefore anthropogenic artifacts that perform important functions as species habitat and human resource reservoirs of medicines, food, fiber, fuel and resins (Hecht and Cockburn, 1990). It could even be argued that whole areas of tropical rainforest, particularly in Asia and Central and South America, represent human artifacts, as the tree species now dominant have been protected or planted by past civilizations which have practiced shifting agriculture (Gomez-Pompa and Kaus, 1992).

In western society, areas perceived as wilderness are valued for their intrinsic worth, as places where nature is revered and where the image of wilderness as an area empty of people can be preserved (Nash, 1967). Such a perception continues to influence the thinking and legislation of western policy makers, as evidenced by the *1964 United States Wilderness Act* which defines wilderness as a place 'where man himself [sic] is a visitor who does not remain' (Nash, 1967; Stankey, 1989). In contrast to the wilderness perceptions of many western urbanites, rural people and particularly indigenous people in the tropics perceive these same areas as their homes and they base their natural resource management and land use practices upon their own world view (Gomez-Pompa and Kaus, 1992). For example, the developing tourism industry on Cape York Peninsula in Far North Queensland originally attempted to portray the region as a virgin wilderness effectively denying the existence and activities of local residents (Strang, 1996). The tourism industry's vision of Cape York as an 'empty bushland' was both confusing and insulting to pastoralists and indigenous people who perceive themselves as an integral part of that landscape (Strang, 1996). Consequently, tour operators offering safari tours on Cape York now actively promote interaction with the resident cattle producers and Aboriginal people living there as being part of the 'wilderness experience' (Strang, 1996).

2.3.3 Personal benefits resulting from people-environment interactions

Research has consistently demonstrated that humans derive a range of personal benefits from spending periods of time in natural environments, which range from park lands to wilderness areas. The personal benefits that may accrue from visiting natural areas can include physical health, therapeutic, educational, spiritual, aesthetic, developmental, social and symbolic benefits, in addition to opportunities to experience self-sufficiency (Driver *et al*. 1987; Scherl, 1991). Visits to natural areas are also believed to have a restorative influence by being both stress reducing (Fisher *et al*. 1984; Parsons, 1991; Ulrich *et al*. 1991; Ulrich, 1993), and attention restoring with a range of associated physiological and psychological benefits (Kaplan and Kaplan, 1989; Veitch and Arkkelin, 1995). This restorative capacity can also result in improved human concentration, more positive self-esteem, body image and outlook on life, and enhanced problem solving skills (Hartig and Evans, 1993). Time spent in nature or even views of natural settings are also known to generate a range of health benefits including assisting people to recover more quickly from illness and surgery (Ulrich, 1993; Bechtel, 1997). For example, the quality of the view from a hospital window has been found to influence the rehabilitation of ill patients (Verderber, 1986). Similar results were reported by Ulrich (1984), who demonstrated that the content of a view from a hospital can influence the recovery of patients after surgery, with views of nature promoting faster recovery.

Recreation conducted within remote wilderness areas, such as long-distance walking, offers particular challenges and conditions that appear to generate benefits. As a consequence of remoteness and relatively low numbers of visitors, wilderness areas frequently require recreationists to possess a degree of self-sufficiency, subsistence skills, and physical fitness (Scherl, 1989). Scherl maintains that one of the principal benefits of spending time in wilderness areas is the opportunity to experience individual transactions with the environment, and thereby obtain self-relevant feedback. Because wilderness areas are non-responsive to individual-wilderness interactions, the focus shifts from how the environment is responding to what the individual is doing, thereby generating self-relevant feedback (Scherl, 1989). Extended wilderness visits have been found to generate a range of benefits including personal insights, greater self-awareness, the development of concern for others, and new orientations to life (Talbot and Kaplan, 1986). Some of the other benefits of time spent in wilderness areas include improved self-confidence and sense of control over one's life, and opportunities for learning/personal growth and self-expression (Scherl, 1989).

Participation in long-distance walking within wilderness areas can arguably be included within the category of risk recreation given the remoteness of the destinations involved and the degree of self-sufficiency and survival skills required. Such recreational activities may enable some individuals to develop or reinforce a desired self-image including being regarded by others as 'adventurous' or 'self-sufficient' (Scherl, 1989). This recreational segment continues to experience growth in numbers as participants seek to obtain feelings of competency in a natural environment containing elements of either real or perceived risk (Ewert and Hollenhurst, 1989; Pigram, 1993). The growth in wilderness recreation may also be a response to the increasingly frenetic pace of life as humans seek to 'escape' from the stress and pressure of their everyday routines (Bechtel, 1997). Sources of stress can include noisy and bustling urban surroundings, vast quantities of information and sensory stimulation, and ever more pressures upon available time. Consequently a combination of push–pull forces operate to motivate visits to remote natural areas as humans are pushed from urban areas by stressful lifestyles, while being simultaneously pulled to wilderness areas by the opportunity to experience alternative surroundings that compensate for their urban deprivation (Pigram, 1993). A description of the potential personal benefits that humans can obtain from spending time in wilderness areas are summarised in Table 2.2.

Table 2.2 Personal benefits derived from time spent in wilderness areas.

Potential benefits	Description of the potential benefits
Developmental	Opportunities for changes in users' self-concepts, self-esteem or acquisition of skills.
Therapeutic/healing	Opportunities to cope with a wide variety of mental and physical stresses by experiencing peace and tranquility and a 'biological fit' (in wilderness we encounter natural rather than artificial stimuli that are more compatible with our ancestral roots).
Physical health	Opportunities for frequently extended and aerobic activities in an environment free of pollutants. These opportunities can also enhance quality of life.
Clear-unambiguous feedback	Opportunities to be involved in activities that generate feedback about oneself that is concrete, clear and inherently reinforcing.
Self-sufficiency	Opportunities to come into close contact with one's emotions and fears, and to control these feelings.
Spiritual	Opportunities for spiritually uplifting experiences and for a feeling of unity with the universe.
Aesthetic/creative	Opportunities to appreciate and enjoy nature.
Educational	Opportunities to explore and learn about nature.
Social identity	Opportunities to spend time with family and friends, to develop cohesiveness and solidarity.
Symbolic	Opportunities to bequest wilderness areas to future generations (many people attribute high importance to this purpose).

(Source: Derived from Scherl, 1991. p.16.)

2.3.4 Theoretical explanations for people-environment benefits

There are a number of theoretical explanations as to why humans derive psychological and physiological benefits from encounters with the natural environment, and in particular wilderness areas. The majority of explanations that have been postulated suggest that benefits accrue from obtaining experiences that are not readily available within everyday built and social environments (Hartig and Evans, 1993). Four theoretical perspectives are considered to be relevant to the current research as a way of explaining why people seek out natural environments and their responses to them once encountered. These are presented in chronological order and are briefly summarised below.

Stress Reduction Theory (Ulrich, 1979)

This theory was first proposed by Ulrich (1979) in an attempt to explain how exposure to natural landscapes influenced psychological and physiological well-being. The theory suggested that humans can obtain benefits such as stress reduction from both *actual* and *vicarious* encounters with natural landscapes (Ulrich, 1979, 1984). Whilst benefits can result from visiting or viewing actual landscapes, people can also obtain a vicarious experience through viewing posters, photographs, paintings and documentaries that depict wilderness or natural settings without needing to visit them in person (Ulrich, 1979, 1984; Ulrich *et al*. 1991). In order to test the theory Ulrich (1979) conducted an experiment with 46 mildly stressed students who had just completed a one hour examination at the University of Delaware. Students were divided into two equal sized groups with one group being shown 50 colour slides of 'unspectacular' natural landscapes dominated by green vegetation whilst the second group was shown 50 colour slides of urban landscapes that were devoid of nature (Ulrich, 1979). The experiment demonstrated that exposure to slides depicting nature were more likely to promote positive feelings such as friendliness and playfulness, whilst exposure to slides depicting urban scenes were more likely to work against emotional well-being by promoting negative feelings such as sadness, anger and aggression (Ulrich, 1979). Results were found to be consistent regardless of student's gender and whether they had grown up in rural or urban environments (Ulrich, 1979).

The Biophilia Hypothesis (Wilson, 1984)

The 'biophilia hypothesis' proposes that as a consequence of our human evolution within natural environments, people are genetically programmed to prefer natural over urban landscapes as these are the landscapes that are linked to survival (Wilson, 1984, 1993; Kellert, 1993; Bechtel, 1997). Human preferences for natural areas over modified environments can be interpreted as having some benefit because this environmental preference reflects a positive emotional state (Wilson, 1984, 1993; Hartig and Evans, 1993). Although these evolutionary explanations have limited significance for biological survival today, they nevertheless help to explain hedonistic human behaviour that includes seeking aesthetic satisfaction and freedom from anxiety within natural environments (Hartig and Evans, 1993).

Direct Feedback Theory (Reser and Scherl, 1988)

This theory suggests that the person-environment transactions that take place during wilderness experiences provide individuals with clear and unambiguous feedback from an impartial and indifferent environment (Reser and Scherl, 1988). This contrasts with the ambiguous and indirect feedback that humans commonly receive from their physical and social surroundings in everyday life that often results in people not knowing if they have done something well (Reser and Scherl, 1988). Because attention demands are lower in wilderness areas in comparison to human-made-landscapes, people have more time and resources for a sustained inward focus as resources are directed to the self (Reser and Scherl, 1988). Wilderness visits offer individuals the opportunity to exercise inner self-control in their transactions with the environment because they have no capacity for external control over their surroundings (Scherl, 1988, 1989). For example, an individual may experience feelings of fear and panic upon encountering situations beyond their control, such as being physically exhausted but still needing to continue walking to reach a safe camping site, but they may gain confidence and strength from controlling their emotions and coping with the situation (Scherl, 1989). The theory has been tested via research conducted with participants from three adult Outward Bound programmes in Australia using the repertory grid technique to establish the principal domains that individuals used to construe a structured wilderness experience (Scherl, 1988). The research sought to better understand participants' Outward Bound experiences from the perspectives of the individuals involved (Scherl, 1988). Results suggested that three aspects of wilderness experiences predominated being 'emotional responses and level of arousal', 'distinctions between self and group', and a recognition that 'either physical or mental effort was part of the experience (Scherl, 1988).

Attention Restoration Theory (Kaplan and Kaplan, 1989)

This theoretical perspective maintains that spending time in natural environments performs a restorative function for mentally fatigued humans (Kaplan and Kaplan, 1989). The theory suggests that natural environments function as restorative environments because they enable involuntary attention to predominate, which frees up energy that can be directed to the self. When a person is mentally fatigued, they may suffer mental inertia and have difficulty focusing; consequently it requires substantial effort to retain interest and direct their attention to something they perceive as uninteresting (Kaplan and Kaplan, 1989). Conversely, when something is regarded as interesting, it requires very little effort to maintain involuntary attention (Kaplan and Kaplan, 1989). The theory maintains that the type of environment preferred by an individual is the type most likely to function as a restorative environment (Kaplan and Kaplan, 1989). The theory has been tested using various rating scales to rank the restorative value of environments, with results consistently demonstrating that natural environments are more likely to perform a restorative function than urban environments (Laumann *et al*. 2001).

2.3.5 Constraints upon visitor behaviour

While a number of theories have been developed to explain the various benefits that humans derive from encounters with the natural environment, there are also those which have been developed to help explain why people sometimes have negative experiences within these settings. One such theory is the 'behaviour constraint model of environmental stimulation' or 'behaviour constraint theory' (Stokols, 1979; Bell *et al*. 2001) which argues that undesirable environmental stimulation such as stressful situations can constrain usual human behaviour (Stokols, 1979). The behaviour constraint model has three stages, 'loss of perceived control' over a situation, 'psychological reactance', and 'learned helplessness' (Veitch and Arkkelin, 1995; Bell *et al*. 2001). Loss of perceived control can arise when individuals encounter events they perceive to be beyond their control such as being in an exposed location during severe weather conditions or being in an extremely crowded situation (Bell *et al*. 2001). Once individuals perceive that environmental events are beyond their control and anticipate that this is likely to constrain their behaviour, they may initially experience discomfort before attempting to reassert control over the situation via a phenomenon known as psychological reactance (Veitch and Arkkelin, 1995; Bell *et al*. 2001). If efforts to reassert control over a situation are repeatedly unsuccessful this can result in learned helplessness whereby individuals cease trying to change a situation as they learn their efforts have no effect upon the outcome (Seligman, 1975; Hartig and Evans, 1993). Consequently individuals 'learn' that they are 'helpless' (Bell *et al*. 2001). One type of response that can constrain behaviour is fear.

Fear as a behavioural and experiential constraint

Although humans primarily derive psychological benefits from encounters with the natural environment, such interactions can also generate negative emotions, in particular fear. Any recreational or physical activity can lead to fear for one's physical and psychological safety, with fear having the potential to either constrain or prohibit participation and enjoyment associated with an activity (Henderson and Bialeschki, 1993). Within a long-distance walking context hikers' behaviour may be constrained by fear of 'undesirable' stimulation such as potential encounters with dangerous wildlife (crocodiles, snakes and spiders), tropical storms, becoming lost, or getting injured. If an individual is conscious of fear during a leisure activity this will restrict their ability to experience a total sense of freedom and therefore detracts from their enjoyment, requiring instead a great deal of energy to negotiate or overcome their fears (Henderson and Bialeschki, 1993). Many females are socialised to be wary or to avoid participating in physical activities on their own (Henderson and Bialeschki, 1993). Recreational activities such as long-distance hiking and camping in remote locations may put individuals, particularly females, in a vulnerable situation in which they might experience various fears.

Coble *et al*. (2003) conducted an interesting study in relation to levels of fear among unaccompanied hikers in wilderness areas in the United States. Their study was conducted in West Virginia during 1999 and involved researchers interviewing equal numbers of male and female hikers to identify the types of fears they experienced while hiking alone in wilderness areas, and examined how men and women responded to their fears. Five main types of fear were identified, including fear of becoming lost, fear of being harmed by another person, fear of being injured or having a life threatening emergency such as dehydration or hypothermia, fear of dogs and wild animals, and fear of the theft or vandalism of possessions left in one's vehicle. Study results indicated that the most commonly expressed fear for both genders was the fear of being harmed by another person, specifically a male. All fears were experienced by both genders with the exception of fear of theft or vandalism of possessions, which was only mentioned as a concern by males. Participants in the study adopted various strategies to negotiate their fears including avoiding any perceived threats (such as hiding in the bush when encountering other hikers or wild animals), modifying their participation in solo hiking so that they were usually accompanied by another person, using aids or protective devices (such as carrying maps and compasses to avoid becoming lost, carrying pepper spray, keys or a hiking stick for personal protection, carrying a first aid kit and extra supplies in case they were injured or became lost, and increasing their individual knowledge and skills by learning self defence and navigational techniques. Other hikers interviewed adopted a psychological approach to dealing with any perceived threats whereby they tended to focus on the positive aspects of the surrounding environment to nullify the impact of any perceived fears, exercised heightened awareness when meeting other walkers, and tried to maintain a positive belief about human nature and the possible motivations for other visitors to be in a wilderness area. The results of this study indicate that the experience of fear and the various strategies that people employ to negotiate their fears can both constrain and adversely impact upon the quality of a solo hiking experience, through diminishing potential psychological benefits such as freedom of choice, personal control and autonomy (Coble *et al*. 2003).

2.3.6 People in space and time

All human-environment interactions have both a spatial and temporal dimension that provides structure and meaning to this relationship within recreational settings (Aitken, 1991; Bechtel, 1997). Visitors generally experience both spatial variability (heterogeneous landscape configurations associated with movement through space) and temporal variability (changes within the setting associated with the passage of time). As a consequence of spatial variability in the landscape, recreational experiences are not evenly distributed across recreational settings due to the concentration of human use both within and between sites, and over time (Graefe, 1987). Previous research suggests that the spatial and temporal sequence in which hikers encounter environmental phenomena can influence their perceptions of variety, novelty and surprise, when appraising their overall experience of the landscape (Hull and Stewart, 1995). Satisfaction levels can also vary in response to movement through different types of environments or landscapes (Hull and Stewart, 1995; Chhetri *et al*. 2004).

One theoretical perspective that has been proposed to explain variation in human responses to changing landscapes is the ‘landscape preference theory’ (Kaplan and

Kaplan, 1989). Landscape preference theory proposes that humans tend to prefer certain types of landscapes over others as a consequence of our evolution (Kaplan and Kaplan, 1989). This has been tested in a number of studies which have consistently demonstrated that humans prefer savannah type or more open landscapes, to more cluttered or complex natural landscapes (Appleton, 1975; Balling and Falk, 1982; Hartig and Evans, 1993). Consequently, humans are less likely to prefer vegetation types with a dense understorey because this habitat type has an obstructed view that promotes a sense of lurking danger and restricted movement, or a limited capacity to escape (Kaplan and Kaplan, 1989; Pigram, 1993). Humans also tend to prefer landscapes with water and trees over those that lack these features (Kahn, 1999). Human preference for particular landscapes would appear to indicate that they offer safety, or some habitat advantage over other environments (Kaplan and Kaplan, 1989; Kellert, 1993).

Long-distance walking necessarily entails spatial variation in the natural, built, and social environments encountered as a hiker moves throughout the recreational setting. Movement within a recreational setting frequently brings walkers into contact with various components of the physical setting (natural and built environments), in addition to possible contact with other visitors (the social environment). It is highly likely that the diversity of human-environment interactions with continually changing natural scenery, track conditions and individual encounters with environmental phenomena contribute substantially to the appeal of long-distance walking. Table 2.3 outlines potential spatial and temporal variations in interactions with various environments that can occur as hikers traverse a long-distance walking track.

Table 2.3 Potential spatial and temporal variations in interactions with the various environments during a long-distance walk.

Impact domains	Spatial continuum	Temporal continuum
Natural environment	- landscape heterogeneity - flora and fauna encounters - distribution of biophysical impacts along track	- diurnal and seasonal variations in weather conditions - ongoing natural processes (periodic flowering plants etc.)
Built environment	- spatial distribution of visitor infrastructure nodes (toilets, campgrounds, lookouts etc.) - variable track conditions	- the frequency of encounters with visitor infrastructure when hiking (signage, track markers, boardwalks, lookouts etc.)
Social environment	- spatial distribution of other hikers within activity nodes (campgrounds, trailheads, swimming holes etc.) and along the trail - location where encounters occur	- the frequency of encounters with other hikers/groups - the duration of encounters with other hikers/groups
Psychological environment	- perceived attractiveness of environments encountered - landscape preferences - sequence of encounters	- during (the actual experience occurring in real-time)
		- before (planning/prior travel) - after (reflections/memories) - impact of previous experience - impact of prior expectations

All recreational experiences also occur within a temporal framework that can be considered as having at least five phases, being anticipation, travel to, participation in the actual activity, travel from, and recollection (Clawson and Knetsch, 1966). These five phases can be further compacted into three, representing the different stages of an experience being ‘pre-travel processes’, ‘on-site experiences’ and ‘post travel processes’ (Vittersø *et al*. 2000), or effectively ‘before’, ‘during’ and ‘after’ stages. In the ‘before stage’, prospective visitors develop prior expectations and build a sense of anticipation drawing upon their previous experiences in combination with their own unique attitudes, values and world views. The ‘before stage’ may involve a degree of prior preparation including information gathering and analysis, the purchase of provisions and equipment, securing regulatory permits, and organising trip logistics. The actual recreation experience is represented by the ‘during stage’, that period of time spent participating in the chosen recreational activity within a recreation setting and influenced by the spatial and temporal context as outlined in Table 2.3. The ‘during stage' frequently brings recreationists into contact with one another, or into contact with the natural and built environments that exist at the recreation site. Participants are continually appraising their surroundings, perceiving external stimuli, and evaluating their experience throughout the 'during stage'. The 'after stage' commences at the point when the actual recreational experience finishes, and is frequently characterised by recollections on the experience, flashbacks and memories, processing of stimuli absorbed, and the formation of altered perceptions. If it can be assumed that satisfaction equals enjoyment minus expectations (Eagles and McCool, 2002), it is important that enjoyment derived from the 'during' and 'after' stages of a recreation experience exceeds the prior expectations that have been built up in the 'before' stage or a negative experience will result. Research has demonstrated that traveling to and from a site and reminiscing about experiences are often very important parts of a recreational experience (McAndrew, 1993).

A temporal dimension to visitor experiences can also exist in terms of the time of year that visitation occurs, with participants likely to obtain a very different recreational experience depending upon seasonal factors (summer/winter or wet season/dry season), or times of high use intensity such as school holidays and weekends. Long-distance walking also involves a temporal component whereby the perceived attractiveness of the recreational setting can change over time in response to variability in the natural, built and social environments within the recreation setting, or transformation of the psychological domain of the recreational user. This variability can occur both within the context of one recreational experience or over the duration of repeat visits to the same location (Table 2.3).

2.4 BIOPHYSICAL IMPACTS OF VISITATION AND USE

Visitor use of walking tracks and related infrastructure such as carparks, lookouts and campsites in tropical rainforests has the potential to cause adverse biophysical impacts upon the various components of the natural environment, specifically soil, vegetation, water and wildlife. These impacts are not evenly distributed throughout the landscape but vary over space and time in response to the type and intensity of visitor usage, and in association with spatial and temporal variation in the ecological and physical parameters. This section of the review examines literature pertaining to the biophysical impacts of visitation (recreation and tourism) upon the various components of the natural environment. Wherever possible, the results of research conducted within tropical rainforest environments are reported and critiqued.

2.4.1 Resistance and resilience

Biophysical impacts are an inevitable consequence of visitor use of recreational sites, although the extent of impact is often a result of the resistance and resilience characteristics of ecosystem components or site conditions (Pomeroy and Service, 1986; Pimm, 1988, 1991; Liddle, 1997; Hammitt and Cole, 1998). Resistance is best conceptualised as the ability of an ecosystem to withstand impact, while resilience represents the capacity of an ecosystem to recover from impacts once they cease (Holling, 1973; Cole, 1988; Fisher and Grimm, 1991; Hammitt and Cole, 1998; Odum and Barrett, 2005). The varied ecological characteristics of different ecosystems mean that different environments (and species) can vary substantially in their capacity to both resist and recover from either natural phenomena (for example, cyclones, droughts, fires), or impacts associated with human activity (Pimm, 1991; Liddle, 1997; Odum and Barrett, 2005). In addition to climatic variables, soils, vegetation type, and slope all contribute to the resistance and resilience of recreational sites (Liddle and Greig-Smith, 1975; Liddle, 1988; Cole and Trull, 1992; Cole and Bayfield, 1993). There is also some evidence to suggest that resilience of recreational sites increases in conjunction with increasing elevation (Arrowsmith and Inbakaran, 2002), although many mountain ecosystems are considered to be fragile environments (Harrison and Price, 1996). Table 2.4 presents examples of ecosystems with varying levels of resistance and resilience to trampling.

Table 2.4 Ecosystems with varying resistance and resilience to trampling.

	Low resilience	***High resilience***
High resistance	Some heath communities Some desert communities	Grasslands Tropical savanna
Low resistance	Alpine shrublands Lichens and some forbs	Tropical rainforests

(Source: Derived from Sun and Liddle, 1993a, 1993b, 1993c; Liddle, 1997; Hammitt and Cole, 1998; Whinam and Chilcott, 1999).

Within the context of visitation associated with tourism and recreation, tropical rainforest is an environment that displays low resistance; hence it is relatively fragile and incurs a range of biophysical impacts under relatively low use levels (Sun and Liddle, 1993a, 1993b; Talbot *et al*. 2003). On the other hand tropical rainforest displays high resilience meaning that it is capable of rapid recovery once visitation pressures are removed (Day and Turton, 2000a; Turton, 2005). The high resilience of tropical rainforests is most likely a consequence of climatic variables including high temperatures and abundant moisture availability that is conducive to rapid plant growth (Whitmore, 1990). Since previous research has found that soil fertility can also assist plant recovery after trampling (Sun, 1991), this may also aid tropical rainforest resilience in locations where soil conditions are favourable. In contrast, alpine environments possess both low resistance and low resilience, meaning that impacts occur quickly, and once in existence, the ecosystem requires a long period of time to fully recover (Hammitt and Cole, 1998; Whinam and Chilcott, 1999). Grasslands are an example of an ecosystem which possesses both relatively high resistance and high resilience resulting in a high level of durability (Sun and Liddle, 1991, 1993d; Hammitt and Cole, 1998). The particular characteristics that contribute to tropical rainforests possessing low resistance but high resilience to trampling will be discussed in more detail in subsequent sections but are briefly summarised in Table 2.5.

Table 2.5 Resistance and resilience characteristics attributed to tropical rainforest.

Low resistance	High resilience
- vegetation and soils are easily impacted under relatively low levels of use - moist friable soils are easily compacted throughout much of the year - leaves are often delicate and broad and are easily damaged by trampling - most species have upright growth forms - some species have brittle stems	- vegetation recovery is rapid once trampling pressure is removed - plants are vegetatively active all year round and grow rapidly - abundant moisture and temperatures exist throughout much of the year - plants are adapted to capitalise on periodic disturbance events such as tropical cyclones and tree falls

(Source: Derived from Kuss, 1986a; Boucher *et al*. 1991; Day and Turton, 2000a, 2000b; Talbot *et al*. 2003; Turton, 2005).

2.4.2 Extent and timing of recreational activities

Regardless of ecosystem type, some biophysical impacts are virtually unavoidable within the tread zone of a walking track, which effectively represents a 'sacrifice' zone where some impacts are tolerated and indeed expected by management (Bratton *et al*. 1979; Cole, 1983, 1985; Cole *et al*. 1987; Hammitt and Cole, 1998; Turton, 2005). In addition to the resistance and resilience of ecosystem parameters at a recreation site, the amount of resultant biophysical impact is largely a product of the extent and timing of visitation (Liddle, 1997; Hammitt and Cole, 1998). Within a recreational context, the extent of environmental impact that an ecosystem sustains is in part a consequence of the amount of visitor use, the type of recreational activities, and the season in which visitation takes place (Cole, 1987; Newsome *et al*. 2002), in addition to site layout and design, including the provision of infrastructure (Worboys *et al*. 2005; Turton, 2005). Research has consistently demonstrated that biophysical impacts are not necessarily a consequence of high visitation levels, since a curvilinear relationship exists between level of use and the resultant intensity of impact (Hammitt and Cole, 1998). Consequently, a substantial extent of biophysical impact can occur under relatively low levels of human use, with subsequent increases in visitation often resulting in minimal additional adverse impact (Hammitt and Cole, 1998). The relationship between level of impact, level of use and high and low resilience is demonstrated in Figure 2.3.

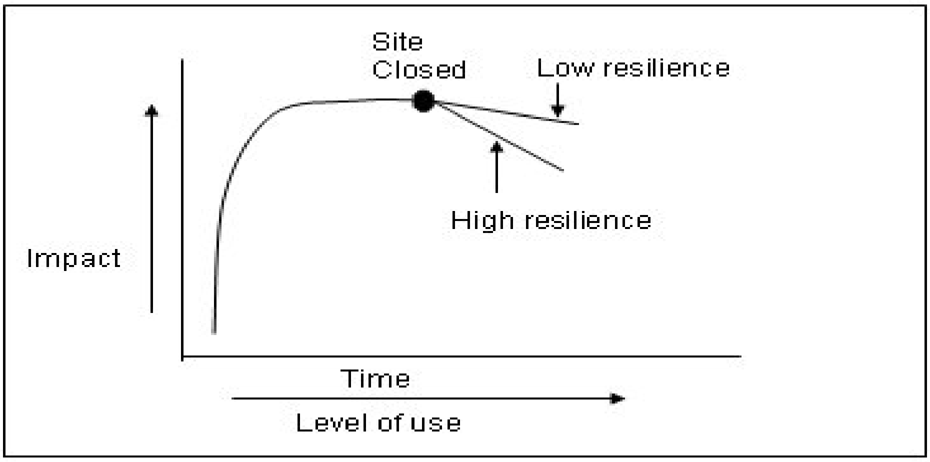

Figure 2.3 Curvilinear relationship between level of use, impact and recovery rates of natural sites exposed to trampling.
(Source: Adapted from Cole, 1982).

A controlled trampling experiment conducted on the Atherton Tablelands in North Queensland demonstrated this curvilinear relationship between level of use and impact whereby even relatively low intensity trampling produced substantial damage to tropical rainforest soils (Talbot, 2001). Results from the experiment demonstrated that only 75 passes were required to substantially reduce the permeability of both basalt and rhyolite soils (Talbot, 2001; Talbot *et al*. 2003). The season in which visitation occurs can also have an important bearing upon the extent and severity of biophysical impacts as ecosystem resistance fluctuates in response to various environmental parameters including soil moisture content, leaf litter depth and canopy cover (Weaver *et al*. 1979; Liddle, 1997; Hammitt and Cole, 1998). This is exemplified by ecosystems that possess soils that are particularly prone to compaction when they have a high moisture content, or vegetation that is especially susceptible to trampling when suffering from moisture stress (Weaver *et al*. 1979; Kuss, 1986a; Cole and Marion, 1988; Liddle, 1997). In many ecosystems recreational activities contribute to the introduction of weeds and pathogens, or the disturbance of endangered species, which can all represent far more significant ecological impacts than localised trampling resulting from human visitation (Buckley and King, 2003; Turton, 2005).

2.4.3 Impacts associated with inappropriate activities and behaviour

The type of recreational activities that visitors participate in at a recreational site can have an important bearing upon the ensuing impacts (Weaver and Dale, 1978; Weaver *et al*. 1979; Liddle, 1997; Day and Turton, 2000a). Trampling experiments have demonstrated that use of a walking track by hikers is unlikely to generate biophysical impacts of a magnitude and scale that could be expected if horse riders, motor bike riders and other off-road vehicles were permitted to utilise the same track (Weaver and Dale, 1978; Liddle, 1997; Hammitt and Cole, 1998). A trampling experiment was conducted within a grassy meadow and a forest understorey in the temperate zone to compare the impacts of walkers, horses and motor bikes upon vegetation cover (Weaver and Dale, 1978). Results revealed that horse riders had the greatest adverse impact upon vegetation cover on flat surfaces within the grassy meadow while motor bikes caused the most damage on sloping (15˚) surfaces (Weaver and Dale, 1978). Comparisons within the forest understorey found that motor bikes and horses were equally damaging, completely removing all ground cover after 200 passes while it took 1,000 passes by walkers to completely eliminate all vegetation (Weaver and Dale, 1978). These results were not surprising given the fact that ground pressure exerted by a horse's hooves when carrying a mounted rider can be as much as 27 times that of a hiker's shoes (Liddle, 1997), while many motor bikes have rubber tyres that have been designed to enhance surface grip.

Inappropriate behaviour and use by a small number of visitors can often amplify biophysical impacts beyond that which could be reasonably expected to result from a much larger number of visitors. Turton *et al*. (2000b) attributed some of the most severe biophysical impacts at recreation sites within the Wet Tropics World Heritage Area to inappropriate behaviour and use by small numbers of local residents. An example of improper behaviour exacerbating impacts is provided by Butler (2002) who compared biophysical impacts associated with both designated walking tracks and undesignated tracks or social trails within the Wet Tropics World Heritage Area. Butler found that hikers who short-cut by using undesignated walking tracks were more likely to generate a range of soil and vegetation related impacts that would not have eventuated had they utilised the official or designated walking track. Since social trails were generally located on steeper slopes than was the case for designated walking tracks, they tended to have a higher prevalence of soil erosion and exposed tree roots than occurred on official walking tracks (Butler, 2002). The formation of undesignated walking tracks in formerly trackless areas has similarly been identified as an important source of biophysical impact associated with inappropriate visitor behaviour within the Tasmanian Wilderness World Heritage Area (Parks and Wildlife Service, 1998).

2.4.4 Potential impacts of visitation upon soil

Previous research has demonstrated that recreational use of natural areas result in a spectrum of changes to soil properties, although soils vary widely in their susceptibility to impacts (Parks and Wildlife Service, 1998). Various authors (e.g. Kuss, 1986a, 1986b; Liddle, 1997; Hammitt and Cole, 1998) report that trampling is the major recreational source of soil related impact. Soil impacts associated with trampling include increased soil bulk density and penetration resistance (compaction), reductions in leaf litter and humus content, smearing, modified soil structure which results in reduced permeability and increased surface runoff, and increased rates of erosion (Cole and Schreiner, 1981; Kuss and Graefe, 1985; Garland, 1990; de Gouvenain 1996; Marion and Cole, 1996; Liddle, 1997). The impacts upon soil due to trampling also have implications for nutrient cycling, soil fauna and soil temperatures (de Gouvenain, 1996; Liddle, 1997; Hammitt and Cole, 1998). An indication of the extent of soil impact associated with trampling can be obtained from measurements of the depth of litter and organic material, water infiltration rates, bulk density, depth of trail tread (excavation), resistance to penetration, number of exposed tree roots, area of exposed mineral soil, and the number and species of soil fauna (Manning, 1979). Although there has been less research conducted in relation to the impact of trampling on soils located within wet tropical environments compared with other environments (Boucher *et al*. 1991; Sun and Liddle, 1993a), the research conducted to date confirms many of the generalised findings reported from temperate areas (Jim, 1987; Boucher *et al*. 1991; Talbot, 2001; Talbot *et al*. 2003). Table 2.6 summarises some of the potential adverse ecological consequences that can result from human impacts upon soil.

Table 2.6 Potential adverse ecological consequences associated with soil trampling.

Soil impacts	What happens?	Potential negative ecological consequences
Soil compaction	- soils are progressively compacted by recreational activities (e.g. hiking) - soil particle size is reduced - reduced water infiltration - reduced soil aeration - increased soil temperatures - reduced soil moisture holding capacity	- reduced soil stability leading to erosion - negative impacts upon vegetation (reduced plant vigor, plant deaths) - displacement of soil fauna
Soil erosion	- organic litter and mineral soil are transported away by wind and water movement - funneling and accelerated surface water runoff - increased sediment discharge into streams - loss of soil nutrients - exposure of plant roots	- negative impacts upon water quality - negative impacts upon vegetation (reduced plant vigor, plant deaths) - negative implications for soil stability resulting in landslides and tree falls etc. - displacement of soil fauna

(Source: Derived from: Kuss, 1986a, 1986b; Cole and Marion, 1988; Garland, 1990; Congdon and Herbohn, 1993; Graham, 1994; Liddle, 1997; Hammitt and Cole, 1998).

Soil compaction

Recreational use of long-distance walking tracks within tropical rainforests has the potential to cause soil compaction, both along trails and in areas associated with related activities such as overnight camping, wildlife viewing and use of informal bush toilets. Soil compaction is generally evidenced by increases in soil bulk density and penetration resistance, in addition to reductions in soil water infiltration and pore size, with variables such as soil texture, porosity, moisture content, and use intensity controlling the degree to which soils are compacted (see Table 2.6) (Kuss, 1986a). Trampling related compaction of soils in tropical areas has been recorded by a number of researchers (Frenkel, 1972; Jim, 1987; Jusoff, 1989; Sun and Liddle, 1993b; Graham, 1994; Wallin and Harden, 1996; Karger, 1997; Turton *et al*. 2000a; Sutherland *et al*. 2001; Talbot, 2001; Butler, 2002). Soil compaction is a potentially serious problem within tropical rainforest soils because it reduces plant root penetration (Graham, 1994), soil aeration (Jim, 1987; Jusoff, 1989; Sutherland *et al*. 2001) and water infiltration rates (Jim, 1987; Jusoff, 1989; Wallin and Harden, 1996; Sutherland *et al*. 2001; Talbot, 2001). Impeded root penetration and soil aeration diminish the capacity of vegetation to establish on trampled areas, while reductions in infiltration rates result in increased surface runoff, both of which have negative implications for soil stability. It should be noted that the presence of vegetation within the tread zone on long-distance walking tracks is generally considered undesirable.

Soil erosion and sedimentation

Soil erosion and sedimentation are often a highly visible impact associated with concentrated recreational use of walking tracks, campgrounds, lookouts and carparks within natural areas. Erosion is generally regarded as one of the most serious recreational impacts on hiking trails because it is often permanent or at least costly to mitigate, and once initiated it frequently continues to occur even if visitor use is reduced or terminated (Bratton *et al*. 1979; Wallin and Harden, 1996; Hammitt and Cole, 1998; Turton *et al*. 2000a). Soil erosion can also have serious ecological consequences for vegetation communities, and ultimately for fauna (Hammitt and Cole, 1998). Erosion often commences with the scuffing away and pulverisation of leaf litter and organic matter on the soil surface (see Table 2.6). Once soil litter is pulverised by trampling it is easily transported away by wind or water, exposing the mineral soil (Manning, 1979). Kuss (1986b) has also noted that soil adhesion to hiking boots, and subsequently soil relocation, increases under moist conditions, although it decreases under very wet conditions. Laboratory experiments by Quinn *et al*. (1980) demonstrated that while the heel of a hiking boot is responsible for the majority of trampling related soil compaction, the shearing action by the toe of the boot during each step is responsible for much of the trail related soil erosion. Although the type of footwear worn by hikers does not influence the extent of trampling impact that results, hikers who carry backpacks tend to cause more impact than those without packs (Parks and Wildlife Service, 1998). This is most likely a consequence of the increased weight in backpacks exacerbating both heel compaction and toe shearing (refer Quinn *et al*. 1980).

The magnitude of erosion problems along any given walking track is generally related to site specific factors, although the intensity of visitor use is undoubtedly a contributing influence. Site factors that are known to be important determinants of erosion potential within the temperate zone include slope, the extent of vegetation and organic matter cover, soil type and depth, and soil moisture content (Bratton *et al*. 1979; Cole, 1981, 1983; Tinsley and Fish, 1985; Kuss, 1986b), while overhead canopy cover can be considered critical to prevent erosion within tropical rainforest environments (Turton, 2005). Quinn *et al*. (1980) conducted laboratory experiments to assess the mechanical processes involved in trampling and attempted to quantify run-off and soil erosion associated with artificial rainfall. Their results demonstrated that soil erosion increases in conjunction with increased trampling intensity and slope steepness and that the protective value of surface vegetation cover on soil may be overestimated because soil deformation and smearing commence while vegetation cover is still intact. Some evidence of the contribution of use intensity to soil erosion along rainforest walking tracks is provided by Ravinski (1991), who conducted research within national parks in Costa Rica. Annual visitor numbers to selected national parks in Costa Rica have increased from 300 in 1973 to 15,000 in 1989, with a substantial corresponding increase in soil erosion (Ravinski, 1991). Nevertheless, it has been suggested that limited soil compaction, in combination with the incorporation of organic matter into the soil by moderate hiking use may actually assist to stabilise a section of track rather than increase erosion potential, although this remains untested in tropical rainforests (Kuss, 1986b).

The high rainfall associated with tropical rainforests means that surface water runoff is able to transport substantial quantities of suspended sediment to rainforest watercourses and means that management of runoff is critical to controlling soil erosion from walking tracks. Wallin and Harden (1996) used simulated rainfall experiments to compare surface water runoff and soil erosion associated with walking tracks and adjacent undisturbed tropical rainforest areas in Costa Rica and Ecuador. Their results demonstrated that overland flow generated from walking tracks is up to 40 times greater than that originating within undisturbed forest. They estimate that 15 mm of rain falling within 30 minutes on a 100 m section of trail could transport as much as 17.4 kg of sediment directly into streams at Jatun Sacha in Ecuador, assuming that all dislodged soil particles were transported to a watercourse. A similar rainfall event on a 100 m section of trail comprised of alluvial soils at La Selva in Costa Rica could be expected to deposit up to 19.1 kg of sediment into streams (Wallin and Harden, 1996).

Similar observations of soil erosion associated with surface water runoff have been reported from the temperate zone by Cole (1983) who conducted systematic sampling of soil erosion along tracks in the Big Creek catchment within the Selway-Bitterroot Wilderness in Montana. Cole found that the vast majority of erosion and incision problems occurred on slopes of greater than 20 percent and most could be solved via the use of water bars or the excavation of ditches transecting the trail to control surface runoff. Garland (1990) trialed various techniques for assessing erosion risk associated with mountain footpaths in the Drakensberg Mountains in South Africa and also reported that the quantity of surface water runoff is critical to erosion as it is the principal means of relocating dislodged soil particles. Further evidence of the erosive capacity of uncontrolled surface water runoff was supplied by Sutherland *et al*. (2001) who recorded the extent of erosion on side-slopes adjacent to the Hawai'iloa Ridge Trail in Hawaii. Tinsley and Fish (1985) investigated trail erosion in the Guadalupe Mountains National Park in Texas, United States and found that quantities of erosion and deposition were influenced by the pattern, frequency and intensity of precipitation occurring in the park. Within the Wet Tropics region, the ecological consequences of increased sediment entering rainforest streams as a result of recreational trampling are likely to also include adverse impacts for some aquatic fauna and possible negative outcomes for the adjacent Great Barrier Reef.

Soil organic matter

The combination of moisture availability and trampling related destruction of surface organic material on tropical rainforest walking tracks has implications for the soil profile. Since trampling results in accelerated decomposition of surface organic material (Manning, 1979; Hammitt and Cole, 1998), it is generally hypothesised that trampled soils will possess reduced soil organic matter within the soil profile, although the relationship between trampling and soil organic matter is not well understood (Cole, 1987; Sun and Liddle, 1993a). Incorporation of organic material into the soil profile occurs primarily via diffusion and mass flow with both processes influenced by soil compaction and moisture availability (Liddle, 1997). Talbot *et al.* (2003) presented the results of a controlled trampling experiment conducted in wet tropical rainforest on the Atherton Tablelands in North Queensland. They found that surface organic litter decreased slightly in conjunction with increased trampling intensity up to 200 passes, but underwent a substantial reduction by the completion of 500 passes (Talbot *et al*. 2003). Cole (1987) has previously argued that trampling induced destruction of organic material is a problem on hiking trails because it increases the exposure of mineral soil to compaction and potentially soil erosion. Although litter decomposition is known to occur rapidly in warm moist environments such as tropical rainforests (Cornu *et al*. 1997; Moorhead *et al*. 1999), litterfall rates are known to be substantially higher in tropical rainforests in comparison with temperate forests (Cornu *et al*. 1997). Consequently, both decomposition and replenishment of surface organic material are likely to occur rapidly along tropical rainforest tracks, with decomposition hastened by trampling.

Soil nutrients

The accelerated breakdown of surface organic matter provoked by trampling appears to assist in maintaining soil nutrient levels along rainforest walking tracks and offsets reductions in nutrient cycling associated with trampling induced compaction. Given that water is generally abundant within most tropical rainforest soils, it could be argued that nutrients released from the breakdown of surface organic material on rainforest tracks will be rapidly assimilated into the soil profile. Karger (1997) investigated the impact of trampling upon soils along rainforest walking tracks at Mossman Gorge in the Daintree National Park, North Queensland. Despite the fact that soil nutrient cycling is often limited by compaction (Kuss, 1986b; Liddle, 1997; Hammitt and Cole, 1998), Karger recorded only minimal differences in soil nitrogen and phosphorous concentrations between compacted walking tracks and the untrampled soils of the adjacent understory. Her results seem to suggest that at least in the short term, soil nutrient levels along compacted rainforest trails can be sustained by the continual rapid assimilation of nutrients from trampled organic litter. It should be noted that Karger's research was conducted during the dry season, a period when litter decay and nutrient leaching is slowest (Cornu *et al*. 1997). As a consequence, her results may not account for seasonal variations associated with increased rainfall during the wet season.

Spatial variations in visitation impacts upon soil

There is substantial spatial variation in the distribution and magnitude of soil impacts as a consequence of recreational trampling, with the extent of impact being primarily related to spatial variation in environmental conditions. Some soil types are highly resistant to trampling while others are fragile and more easily damaged (Liddle, 1997; Hammitt and Cole, 1998; Newsome *et al*. 2002). Soil impacts vary greatly over space as a consequence of variations in soil type, geology (soil parent material), soil texture and consistency, slope, extent of canopy cover, drainage, and variations in the type and intensity of visitor use (Tinsley and Fish, 1985; Kuss, 1986a). Talbot (2001) conducted a controlled trampling experiment on two tropical rainforest soils on the Atherton Tablelands in North Queensland and demonstrated that substantial variability exists between the responses of different soil types to trampling, for example basaltic soils were more susceptible to trampling than rhyolitic soils. Research conducted by Obua and Harding (1997) along walking tracks within moist evergreen forest in Kibale National Park in Uganda demonstrated considerable spatial variation in trampling impacts, with soil erosion and root exposure significantly correlated with slope and vegetation cover. Sun and Walsh (1998) maintain that spatial variation in the resistance of soils to withstand human trampling should be a factor when selecting the location of walking track infrastructure.

Temporal variations in visitation impacts upon soil

Trampling impacts upon tropical rainforest soils vary over time as a consequence of changes in visitor numbers and types of activity, seasonal variations in climatic parameters (wet/dry seasons), and the possibility of intensive rainfall events and cataclysmic tropical cyclones. Research conducted by Boucher *et al*. (1991) within lowland tropical rainforest in Costa Rica demonstrated that an asymptotic relationship exists between impact and time, whereby the majority of trampling related soil damage results from initial site use, with subsequent use causing minimal additional impact. Boucher *et al*. found no statistically significant differences in soil attributes (moisture content, wet and dry weights) between soils from trails used for varying periods of time, although trail use was estimated to be only about 100 passes per year.

The timing of recreational activity, including weather conditions during the period of visitor use affects the magnitude of trampling impacts upon tropical rainforest soils. Overall, visitor impacts at high use recreation sites within the Wet Tropics region are greatest during the wet season when ecosystem resistance is lowest (Turton and Stork, 2006), and erosive potential is greatest (Turton *et al*. 2000a). Nevertheless, research has demonstrated that tropical rainforest soils are more prone to compaction by trampling during the dry season, even though soils possess lower moisture content (Turton *et al*. 2000a). The increased soil compaction recorded during the dry season is believed to be partly a consequence of high clay content soils hardening during the drier months (Turton, 2005), although it may also be related to higher visitation levels during this season. It should be noted that results reported from temperate environments show the reverse with soils generally being more compactable during wet conditions (Kuss, 1986a; Liddle, 1997; Hammitt and Cole, 1998). Within the Wet Tropics region of North Queensland, the vast majority of walking track usage occurs during the dry season, which generally extends from May until December, when potential for soil compaction is greatest but potential for soil erosion is generally lowest. Fortunately, Cornu *et al*. (1997) report that tropical rainforest organic litter decays more slowly during the dry season due to the reduced water availability, resulting in mineral soil being afforded more protection from trampling and raindrop impact by surface organic material than would be the case if the highest trampling intensity occurred during wet conditions.

2.4.5 Potential impacts of visitation upon vegetation

Extensive research conducted within a wide diversity of vegetation types has demonstrated that trampling can adversely impact upon vegetation both directly through physical damage to plants and indirectly via modification of the soil environment upon which plants depend (Frenkel, 1972; Cole, 1985, 1987, 1988; Calais and Kirkpatrick, 1986; Kuss, 1986b; Liddle and Thyer, 1986; Jim, 1987; Boucher *et al*. 1991; Kuss and Hall, 1991; Sun and Liddle, 1991). Direct impacts of trampling upon vegetation can include damage to foliage, stems, shoots and exposed surface roots resulting in reduced photosynthetic capacity, water loss and increased energy requirements to repair damaged plant components (Kuss, 1986b; Sun and Liddle, 1993a). Indirect consequences of trampling can include physiological stress associated with transformation of the soil habitat that can reduce plant root penetration, aeration, nutrient absorption, and moisture uptake (Kuss, 1986b; Sun and Liddle, 1993a). Trampling frequently results in a range of modified plant growth responses including reduced height and biomass (Kuss and Graefe, 1985; Sun and Liddle, 1993a), reductions in leaf length, width and thickness (Sun and Liddle, 1993b), and inhibited flowering and reduced seed or fruit production (Kuss and Graefe, 1985). Table 2.7 summarises some of the potential adverse ecological consequences that can result from human trampling of vegetation.

Table 2.7 Potential adverse ecological consequences of vegetation trampling.

Vegetation impacts	What happens?	Potential negative ecological consequences
Direct impacts of visitation upon vegetation	- physical trampling of biomass (foliage) - physical damage to branches and trunks (nails, carvings, ring barking etc.) - physical trampling of seedlings	- reduced photosynthetic capacity and increased energy requirements to repair damaged components - reduced plant vigor - death of damaged plants - increased seedling mortality
Indirect impacts of visitation upon vegetation	- modification of the soil environment (soil compaction, soil erosion, reduced soil moisture etc.) - spread of soil borne pathogens on hiking boots (e.g. Phytophthora)	- reduced plant root penetration and growth - reduced plant regeneration - reduced plant vigor - disease and dieback - death of plants - displacement of fauna

(Source: Derived from: Kuss and Graefe, 1985; Liddle and Thyer, 1986; Kuss and Hall, 1991; Liddle, 1997; Hammitt and Cole, 1998; Gadek and Worboys, 2002).

Visitors to tropical rainforest areas may also contribute to rainforest dieback via the spread or activation of a root rotting fungus, *Phytophthora cinnamomi* which kills susceptible plant species (Gadek and Worboys, 2002). The fungus occurs in soil throughout the Wet Tropics region and can be spread to new locations by soil, and surface or subsurface water movement (Gadek and Worboys, 2002). *Phytophthora cinnamomi* was first detected in tropical rainforests in North Queensland by Brown (1976) over 25 years ago. More recently, Gadek *et al*. (2001) have used a combination of remote sensing and geographic information systems (GIS) to assess the current extent of rainforest canopy dieback associated with *Phytophthora cinnamomi* within the Wet Tropics World Heritage Area. As they report a significant correlation between the distribution of *Phytophthora cinnamomi* in mapped dieback polygons and the location of roads and tracks in the Tully Falls-Koombooloomba area, future use and maintenance of long-distance walking tracks has the potential to spread or activate *Phytophthora cinnamomi* spores, with resultant rainforest patch deaths, to areas that are currently unaffected (Gadek and Worboys, 2002). The Wet Tropics Conservation Strategy specifically identifies long-distance walkers as a concern because they climb mountains directly from the lowlands and have the potential to carry the pathogen to unique mountaintop ecosystems that are currently uninfected (Wet Tropics Management Authority, 2004a). Protected area managers for the Wet Tropics World Heritage Area have already implemented a number of measures to prevent the spread of *Phytophthora cinnamomi* to the Misty Mountains Trails, which include the wet season closure of access roads and walking tracks, and the production of a brochure to educate hikers to wash their boots and equipment before and after walking in susceptible locations to prevent the spread of the pathogen (Wet Tropics Management Authority, 2004a).

Influence of plant morphological characteristics for resistance and resilience

Vegetation types and individual plant species are known to respond differently to trampling depending on their resistance and resilience characteristics (Kuss and Graefe, 1985; Sun and Liddle, 1993a; de Gouvenain, 1996). Cole (1988) has speculated that vegetation resistance, or the ability of vegetation to withstand impact, is largely a product of individual plant characteristics, while vegetation resilience or the ability of vegetation to recover from impact, is more a product of environmental and site conditions. This is supported by Kuss and Graefe (1985) who maintain that plant morphology (life form, growth form, species), adaptive strategies, habitat influences, community interactions, and stage of succession, are all strong influences upon plant resistance and resilience. Other influences upon vegetation response to trampling include environment and stress factors such as the type, duration, and frequency of recreational activity, and the season of use (Kuss, 1986b). Within temperate environments, trampling resistant plants tend to be woody with sclerophyllous leaves, and possess the ability to survive in droughty conditions (Kuss and Graefe, 1985). Plants with high trampling resistance regularly possess flexible stems and to a lesser degree high leaf strength (Sun and Liddle (1993b, 1993c), or can be characterised as having tufted, bunched, or low spreading growth forms such as grasses (Kuss and

Graefe, 1985). Cole (1988) compared disturbance and recovery of trampled montane grassland and forests in Montana and found that grasses were three times more resistant to trampling than woody vegetation. Table 2.8 summarises various plant morphological characteristics that are believed to contribute to both high or low resistance and resilience.

Table 2.8 Plant morphological features that influence resistance and resilience.

Resistance	Resilience
High resistance - highly flexible stems - high leaf strength - woody or sclerophyllous leaves - small thin leaves - low overall height - tussock or bunched growth forms - abundant thorns, prickles etc. - high density of stems - large number of leaves	*High resilience (e.g. tropical rainforest)* - fibrous dispersed roots - regeneration buds are below ground (rhizomes, bulbs etc.) - rapid growth rates - vegetatively active all year round - adapted to disturbance events (cyclones, fire, trampling etc).
Low resistance (e.g. tropical rainforest) - soft delicate leaves - long wide leaves - brittle, inflexible woody stems - upright growth forms - long petioles (leaf stalks) - small number of leaves	*Low resilience* - single tap roots - slow growth rates - regeneration buds are above ground - short growing season - vulnerable to disturbance events (cyclones, fire, trampling etc.)

(Source: Derived from: Cole, 1978, 1985, 1987, 1988; Kuss and Graefe, 1985; Cole and Marion, 1988; Boucher *et al*. 1991; Sun and Liddle, 1993a, 1993b, 1993c; 1993d; Liddle, 1997; Hammitt and Cole, 1998; Talbot *et al*. 2003).

Humid tropical forests appear to exemplify a low resistance environment (Table 2.4; 2.8). Plants with characteristics like those found within tropical rainforests are likely to possess low resistance to trampling because they generally grow on moist easily compacted soils, are vegetatively active year round and produce soft delicate foliage that is susceptible to damage (Kuss and Graefe, 1985; Kuss, 1986b; Cole and Marion, 1988). This has been confirmed by Boucher *et al*. (1991) using the field survey method in Costa Rica and subsequently by Talbot *et al*. (2003) using experimental trampling on the Atherton Tablelands in North Queensland. Both studies report that even low numbers of visitor passes will cause substantial damage to tropical rainforest vegetation. Boucher *et al*. (1991) demonstrated that a curvilinear relationship existed between damage to trailside plants and quantity of use, with as little as 100 trail passes per year substantially reducing vegetation ground cover. Talbot *et al*. (2003) found that reductions in ground cover were most noticeable after 25 passes and 200 passes on basalt soils, and progressive reductions in ground cover up to 200 passes on rhyolite soils.

Although tropical rainforest vegetation exhibits low resistance to trampling, it also appears to possess high resilience, and is therefore generally capable of rapid recovery after disturbance ceases (Table 2.4; 2.8). Using field survey methods, Boucher *et al*. (1991) found substantial vegetation recovery along a disused trail in Costa Rica that had been abandoned for only 32 months. They also found that seedlings, herbs, and platanillos that prefer the enhanced light conditions within canopy gaps, actually grew better on the abandoned sections of trail compared to areas of undisturbed forest as reflected in higher species diversity. To date there does not appear to have been an attempt to quantify resilience, or to develop estimations of potential ecological carrying capacity using the experimental trampling methodology within tropical rainforest environments. Nevertheless, Boucher *et al*. (1991) advocate trialing periodic track rotation in order to create a mosaic of used and recovering track sections in order to capitalise on the perceived resilience of tropical rainforest to rapidly reestablish on disturbed areas. This is unlikely to be considered a realistic option within the Wet Tropics region due to cost considerations associated with provision of new track infrastructure, and concern about the risk of further spreading soil based pathogens via hiking boots.

Spatial variations in visitation impacts upon vegetation

Trampling impacts upon vegetation within humid tropical forests are primarily confined to the rainforest understorey where the vast majority of human activity occurs. Since impacts upon vegetation tend to decrease with increasing distance from the impact zone, trampling effects are usually most prevalent within the tread zone of walking tracks and within the centre of campgrounds. Day and Turton (2000b) investigated ecological impacts associated with recreational use of mountain bike and walking tracks in tropical rainforest on Saddle Mountain near Cairns in North Queensland. Their results indicated that biophysical impacts decreased with distance from the centre of the track, with vegetation cover, litter cover, litter depth, seedling density, and diversity index all increasing with increased distance from the track centre. They concluded that trampling impact upon vegetation extended, on average, some 1.2 metres from the track centre (Day and Turton, 2000b). Spatial variations in visitor impacts have also been recorded between day-use and camping areas located within different vegetation types within the Wet Tropics region. Turton *et al*. (2000b) compared visitor impacts associated with day-use and campgrounds located within littoral forest, wet sclerophyll and tropical rainforest communities and found that littoral forest was least resistant to impacts, while wet sclerophyll was most resistant to impacts. Anecdotal evidence suggested that both littoral forest and rainforest were likely to be most resilient to impacts (Turton *et al*. 2000b).

Temporal variations in visitation impacts upon vegetation

The impacts of visitation upon vegetation have previously been found to vary in response to changing seasonality. Many forbs possess low resistance early in their growing season, while shrubs are often least resistant late in their growing season when branches and stems tend to be more brittle (Hammitt and Cole, 1998). Research conducted at high use recreation sites within the Wet Tropics region has demonstrated that visitor impacts upon vegetation tend to be greatest during the wet season when ecosystem resistance is lowest (Turton and Stork, 2006). This is exemplified by research conducted on short-distance walking tracks which has demonstrated that seedling density was highest during the wet season, possibly reflecting increased fruiting activity (Smith and Turton, 1995; Turton *et al*. 2000a). Over time vegetation disturbance associated with human trampling in tropical rainforests may benefit some opportunistic plant species and aid establishment of weeds along track edges, through enhanced light availability and elimination of competition.

Track width is known to often increase with time as a consequence of vegetation damage on the lower or downhill side of walking tracks aligned across slopes (Burden and Randerson, 1972), usually as a result of hikers avoiding muddy sections of trail (Wallin and Harden, 1996; Parks and Wildlife Service, 1998). Track widths of up to 3.86 metres have been recorded in tropical rainforest within Manuel Antonio National Park in Costa Rica (Farrell and Marion, 2001). Increases in track width within tropical rainforest environments are likely to increase light availability to the track edge and nearby understorey, although actual light environments will be influenced by a combination of factors including track width, slope, aspect, latitude, daily and seasonal variations in the position of the sun, height of the surrounding forest, and sky conditions (Whitmore, 1975; Denslow, 1980; Canham, 1988; Turton, 1993; Young, 1994). Since light is known to be a limiting factor for understorey vegetation within tropical rainforests, any increase in light availability associated with track widening is likely to favour the establishment of fast growing pioneer species, including weeds, similar to those that colonise canopy gaps (Chazdon, 1986; Denslow, 1987).

2.4.6 Potential impacts of visitation upon water

Recreational use of walking tracks in tropical rainforest environments has the potential to negatively impact upon water quality in freshwater streams (Farrell and Marion, 2001; Wilson *et al*. 2004a; 2004b; Wet Tropics Management Authority, 2004a). As previously noted (Table 2.6), high rainfall can result in the movement of a substantial amount of sediment into watercourses. Since water is an enticement for recreational activity, water quality in natural areas can often be adversely impacted by inputs of sediment, nutrients and pathogens associated with visitor activity (Liddle, 1997; Farrell and Marion, 2001; Newsome *et al.* 2002). Table 2.9 summarises some of the potential adverse ecological consequences for water that can result from human visitation.

Table 2.9 Potential adverse ecological consequences of visitation upon water.

Water impacts	What happens?	Potential negative ecological consequences
Direct impacts of visitation upon water	- direct sedimentation effects - littering and pollution - inadequate disposal of human body waste - addition of nutrients (sunscreen, food scraps, detergent etc.)	- reduced water quality due to increased sediment loads - water pollution - introduction of diseases such as *giardia* - eutrophication
Indirect impacts of visitation upon water	- modification of the soil environment associated with riparian vegetation - increased compaction and erosion of stream banks	- reduced water quality due to increased sediment loads - reduced bank stability and increased risk of erosion

(Source: Derived from: Liddle, 1997; Hammitt and Cole, 1998; Climburg *et al*. 2000; Farrell and Marion, 2001; Newsome *et al.* 2002; Bridle and Kirkpatrick, 2003).

Both physical and biological pollution of water has been recorded in Costa Rica and Belize, in association with ecotourism (Farrell and Marion, 2001). A primary concern in relation to contamination of water is the possible human health problems resulting from the spread of disease causing pathogens such as bacteria, viruses, and protozoans (Climburg *et al*. 2000). Hawes (1996) has previously reported that littering and water pollution are common impacts associated with camping and long-distance walking in Tasmanian wilderness areas, while increased incidences of outbreaks of diseases such as *giardia* have been recorded within the Tasmania Wilderness World Heritage Area (Parks and Wildlife Service, 1998). Buckley and Pannell (1990) maintain that pollution from human waste is more likely to be a problem in areas with ‘highly oligotrophic waters such as those of montane or sandy freshwater streams’. Once they enter rainforest streams, nutrients and pathogens can be transported considerable distances, increasing the spatial scale of impact beyond the point source.

Very little research has been conducted to date in relation to the impacts of human toilet waste disposal in natural areas (Bridle and Kirkpatrick, 2003). Although the improper disposal of human faeces is recognised as a potential source of water contamination, the scattered disposal of urine in wilderness areas does not appear to be problematic (Bridle and Kirkpatrick, 2003). Experimental research conducted in relation to the rate of decay of buried bags of unused toilet paper, facial tissues and tampons within nine different environments typical of natural areas in Tasmania has demonstrated that mean annual rainfall was the single most important variable influencing decomposition rates (Bridle and Kirkpatrick, 2005). Although rates of decay were also influenced by temperatures and the extent of soil organic content, depth of burial of toilet waste did not appear to influence decomposition rates (Bridle and Kirkpatrick, 2005). Tampons were found to be considerably more resistant to decay than either toilet paper or facial tissues and should be disposed of outside of natural protected areas (Bridle and Kirkpatrick, 2005). It should be noted that the combination of high temperatures and abundant rainfall experienced within the Wet Tropics region are likely to accelerate the rate of decay of human toilet waste above that reported from temperate locations in Tasmania.

2.4.7 Potential impacts of visitation upon wildlife

Recreational use of walking tracks in tropical rainforests has the potential to negatively impact upon wildlife, both directly through physical disturbance and indirectly through the transformation of habitat parameters including soil, vegetation, and water upon which fauna depend. Stephenson (1993) highlighted the potential for adverse interactions to occur between tourism and wildlife in tropical rainforest, through research conducted within the Pèrinet Reserve in Madagascar. Stephenson witnessed direct interference with wildlife in the reserve, with tour guides regularly catching reptiles and small mammal species to display to tourists, and daily searches of the forest to provide tourists with viewings of the Indri (*Indri indri*), which is the largest primate in Madagascar. He also recorded evidence of tourists leaving defined paths to better view and photograph lemurs, which in addition to disturbing wildlife, resulted in the formation of additional trails through vegetation trampling (Stephenson, 1993). Table 2.10 summarises some of the potential adverse ecological consequences for wildlife that can result from visitation.

Human visitation within natural areas also has the potential to spread disease to wildlife. Visitation and in particular use of long-distance walking tracks has the potential to distribute spores of the frog chytrid fungus to upland and lowland streams in the Wet Tropics region, with adverse consequences for frog species (Wet Tropics Management Authority, 2004a). The frog chytrid fungus causes a disease (*Chytridiomycosis*) that is often fatal to stream dwelling frogs and is spread via both water and wet soil (Wet Tropics Management Authority, 2004a). Although the frog chytrid fungus was first discovered in 1999, it may have been responsible for a decline in frogs that has been apparent within the region dating back to the 1970s, with a number of species of upland frogs now either presumed extinct or classified as endangered (Wet Tropics Management Authority, 2004a). Measures to quarantine the spread of frog chytrid fungus would be similar to those proposed to prevent the spread of *Phytophthora cinnamomi* to uninfected areas of vegetation and might include the establishment of washdown facilities and the education of hikers to clean mud from boots and tent pegs (Wet Tropics Management Authority, 2004a).

Table 2.10 Potential adverse ecological consequences of visitation upon wildlife.

Wildlife impacts	What happens?	Potential negative ecological consequences
Direct impacts of visitation upon wildlife	- direct interference with wildlife (catching and handling animals etc.) - trampling of wildlife - feeding of wildlife	- displacement of wildlife - disruption to usual behaviour (e.g. breeding, foraging, predation) - wildlife mortality due to trampling or stress - wildlife habituation
Indirect impacts of visitation upon wildlife	- modification of soil habitat (e.g. compaction, erosion) - modification of vegetation (e.g. wildfires, vegetation damage, weed infestations) - introduction of feral animals and pathogens - reduced quality of freshwater sources - creation of linear barriers through social trails	- displacement of fauna as a consequence of habitat modifications - predation of wildlife due to introduction of feral animals (e.g. cats, dogs) - death of wildlife due to introduction of diseases (e.g. frog chytrid fungus) - disruption to wildlife movements

(Source: Derived from: Stephenson, 1993; Graham, 1994; Liddle, 1997; Hammitt and Cole, 1998; Goosem, 2000, 2002; Wet Tropics Management Authority, 2004a).

Goosem (1997; 2000; 2002) has investigated the impact of linear barriers, principally roads and powerline clearings, upon wildlife within tropical rainforests in North Queensland. To overcome the adverse impacts of linear barriers on wildlife, Goosem recommended maintaining canopy cover above linear features to reduce both edge and barrier effects for small mammals. Although Goosem conducted her research within road and powerline clearings, some of her findings are nevertheless capable of being extrapolated to other linear barriers, such as walking tracks. While the risk of vertebrates being trampled to death by humans walking on rainforest tracks is reasonably low in comparison to the risk of being struck by motor vehicles when crossing roads, environmental discontinuities associated with walking tracks may nevertheless function as linear barriers to smaller species, in addition to introducing a variety of edge effects into core wilderness areas. For these reasons, it would seem prudent that the width of walking tracks be kept to a minimum, and overhead canopy cover be retained wherever possible, in order to reduce the direct impacts of trampling upon wildlife.

The indirect impacts of trampling and visitation upon wildlife resulting from habitat modification are extremely difficult to assess due to the mobile nature of fauna and the diversity of environmental variables that influence wildlife distribution and behaviour. Nevertheless, Graham (1994) has previously examined the impact of trampling upon wildlife residing in soils beneath walking tracks, in comparison to untrampled areas of tropical rainforest using earthworms as a faunal indicator. Graham found that there were no significant differences in earthworm biomass and abundance between the two habitats although earthworms were generally more prevalent in untrampled areas. These results suggest that at least some soil fauna is capable of surviving beneath the layer of surface compaction that develops along rainforest walking tracks (Graham, 1994). Much more research is undoubtedly required to better understand the indirect impacts of recreation upon wildlife, particularly in tropical rainforest environments.

2.5 PSYCHOSOCIAL EXPERIENCES OF VISITORS

Various authors have previously identified a need for additional research into visitor use and experience within the tropical rainforests of this region, given the importance of this information for effective *visitor management* (Valentine and Cassells, 1991; Bentrupperbäumer and Reser, 2000; Wet Tropics Management Authority, 2001). Due to the limited research that has been conducted to date both within this geographical area and focusing upon the psychosocial experiences of long-distance walkers, the following review has been broadened to include literature that reports the experiences of recreationists other than long-distance walkers. Much of the literature referred to in the following review reports the experiences of visitors to protected areas in the temperate zone, particularly ‘backcountry’ or ‘wilderness areas’ within North America. Nevertheless, the findings summarised below are considered to have relevance to the experiences of long-distance walkers within tropical rainforest environments.

2.5.1 Psychosocial research for recreational management

The true value of psychosocial research conducted with visitors to natural protected areas is that it provides managers with information critical to developing and implementing strategies for sustainable access and use of these areas, as well as maximising the quality of their experience (Reser and Bentrupperbäumer, 2005). In order for protected area managers to balance competing demands to undertake both conservation work and visitor management, they require objective data about visitor use and requirements, and the resultant impact of visitation upon park resources (Bushell, 2003). Unfortunately the intuition of both managers and researchers about visitor needs are often different to those of actual visitors (Manning, 1986). Global experience suggests that most adverse impacts upon park resources associated with tourism and recreation are not the result of excessive visitor numbers, but rather are the result of inadequate *visitor* planning and management (Bushell, 2003; Eagles and McCool, 2002).

Psychosocial research can help managers work more effectively to increase support for resource management programs and policies, whilst also reducing controversy, conflict, and the need for restrictive rules and regulations relating to resource management (Jakes *et al*. 1998). As protected areas are generally established and managed for both recreation and conservation it is important that managers have a comprehensive understanding of the behavioural and psychological responses of recreationists who use an area. Social science research can inform protected area managers about the profile of visitors, their motivations for visiting a protected area, the activities that they participate in, and the factors that influence the quality of their experiences (Bentrupperbäumer and Reser, 2000). Once managers acquire information about visitor expectations, preferences and perceptions of the acceptability of impacts, this can be used to establish biophysical and social indicators for an area based upon standards that are acceptable to visitors (Stankey and Lucas, 1985).

Protected area managers need to cater for both a diversity of visitor experiences and understand the various human-environment transactions and how these influence visitor satisfaction and behaviour if they are to manage recreational settings within these landscapes effectively. Quality in outdoor recreation may be defined as visitors having a choice of recreational opportunities and therefore a diversity of experiences from which to choose (Scherl, 1991). Scherl suggests that effective recreation management means ensuring that there is both a spectrum of recreational opportunities available and that managers understand visitor experiences and preferences and how these are influenced by their management actions (Scherl, 1991). Managing the natural environment is about managing the impacts of human visitation and use (the consequences of human behaviour), which requires managers to understand and manage human behaviour (Reser and Bentrupperbäumer, 2005). Although protected area managers tend to be quite familiar with the potential impacts of visitation upon the natural environment at a setting, they are typically less familiar with the impacts of the natural setting upon the quality of experience, perceptions, and behaviour of visitors (Reser and Bentrupperbäumer, 2005). Thus effective planning, policy development and site management within a recreational context demands that land managers possess an understanding of visitor behaviour, if they are to provide satisfying leisure experiences in harmony with nature (Pigram, 1993).

Psychosocial studies also provide researchers and managers with an opportunity to test and refine theories about a range of aspects that relate to human behaviour, motivation and satisfactions within a recreational context. In practical terms, increased knowledge of these visitor responses can assist managers in predicting recreational behaviour (Pigram, 1993), and will assist in the design and production of more targeted interpretive materials aimed at educating visitors about appropriate behaviour (Scherl, 1991). This is considered especially important in light of research that suggests that inappropriate behaviour is influenced by the demographic characteristics of the visitors themselves. For example, research indicates that propensity to litter is in part influenced by their demographics, with young people more likely to litter than older people, men more likely to litter than women, rural people more likely to litter than urban people, and people on their own more likely to litter than those in groups (Cialdini *et al*. 1990). From an applied management perspective it is also important to know what aspects of a nature-based recreation experience result in visitor satisfaction or detract from it, so that future planning, design, management and monitoring take these issues into consideration. Such information is essential to ensure that recreational sites are meeting the needs of visitors.

An essential ingredient of recreation is that individuals have the opportunity to choose when and how to recreate, which contrasts with a work setting where others often have control over one's behaviour (Eagles and McCool, 2002). A sense of freedom, where the locus of control resides with the individual, is a fundamental motivation for many visitors to recreate in a natural setting (Eagles and McCool, 2002). Consequently, if visitors perceive management regulations at a recreation site to be unreasonably restrictive or unduly intrusive upon their activities and freedom, they are likely to resist compliance (Eagles and McCool, 2002). Conversely, visitors are far more likely to support the philosophy behind a site's management if they attain a satisfying and enriching experience (McArthur, 1994). Positive visitor experiences result in greater support for management objectives and ultimately make protected area management easier (McArthur, 1994). Management therefore has to endeavor to make optimal use of site design and utilise unobtrusive interventions in order to minimise the perceived restrictions upon individual freedom thereby encouraging positive human-environment interactions.

Protected area managers can also utilise knowledge obtained from psychosocial research as a management tool when managing visitor behaviour and numbers. For instance, if park managers experience problems with the over-use of an area, they can use information about visitors' motivations to visit the area to better redirect them to other locations that they would find equally attractive (Galloway, 2002). If managers are better informed about the various factors that impact upon visitor's quality of experience within a recreation setting and use this information effectively, this will translate into improved *site* and *visitor management*. Figure 2.4 provides a diagrammatic representation of many of the factors known to influence the quality of experience of recreationists in general, and therefore potentially long-distance walkers, with factors categorised according to various environments or domains as outlined in the human-environment transactional model (Figure 2.2).

Biophysical Setting	**Natural Environment** - appraisal of scenery - landscape attractiveness - weather conditions - wildlife encounters - perception of impacts - wilderness attributes	**Built Environment** - adequacy of facilities - standard of facility construction - standard of track maintenance - interpretation and education - management regime - presence of rangers - signage and wayfinding
	Quality of Experience	
Psychosocial Setting	**Social Environment** - recreational conflict - perceptions of crowding - inappropriate behaviour - size of groups encountered - location of encounters - the recreational activities and mode of travel of other visitors	**Psychological Environment** - personal characteristics of walkers (age, gender, education, physical fitness, place of residence etc.) - motivations for visiting - prior expectations - extent of previous experience - perceptions of physical difficulty - perceptions of value for money - behavioural constraints (e.g. fear) - satisfaction with experience

Figure 2.4 Factors known to influence the quality of experience of long-distance walkers within biophysical and psychosocial settings.

There is much debate about whether visitors are influenced more by biophysical or social parameters at a recreation site. The appearance and attractiveness of physical settings (natural and built environments) are undoubtedly important influences upon the quality of experiences that visitors obtain (Bentrupperbäumer and Reser, 2000). A number of visitor surveys have demonstrated that users of natural areas are more concerned about biophysical impacts such as soil erosion and damage to trees, than they are about social factors such as group size, and the number of encounters with other visitors on walking tracks (Roggenbuck *et al*. 1993; Morin *et al*. 1997; Smith and Newsome, 2002). However, other researchers have found the opposite effect to be true, with visitors being more concerned about social conditions such as conflict with other visitors, littering, crowding, and noise than they were about the condition of biophysical resources associated with campgrounds and walking tracks (Buckley and Pannell, 1990; Lucas, 1990; Hammitt and Cole, 1998).

Research conducted within the Wet Tropics region of North Queensland suggested that visitors were most concerned about the direct impacts of inappropriate visitor behaviour such as littering (Moscardo, 1997; Bentrupperbäumer and Reser, 2000). The differing assessments of the relative importance of biophysical and social factors as influences upon visitor experience and satisfaction are likely to be a reflection of the diversity of both the biophysical and social settings encountered at the time of the surveys, and the individual circumstances that they encountered at particular recreation sites. In any event, visitor appraisals of the natural, built and social environments provide critical information for natural resource managers (Reser and Bentrupperbäumer, 2005), and particularly given the fact that perceptions held by visitors and managers often diverge (Newsome *et al*. 2002). An understanding of the influence of biophysical and social settings on visitor response is particularly important given the known linkages between human experience and human behaviour (Reser and Bentrupperbäumer, 2005).

2.5.2 Characteristics of visitors to natural recreation areas

Visitors to wilderness areas

Previous research has demonstrated that a majority of wilderness visitors (predominantly long-distance walkers) tend to be young (McAndrew, 1993), well educated (Fisher *et al*. 1984; Lucas, 1990; Morin *et al*. 1997; Kearsley *et al*. 1998), and are often high income earners working in professional or technical vocations in larger cities (Fisher *et al*. 1984, McAndrew, 1993), who usually visit in small groups (McAndrew, 1993). Wilderness visitors are generally younger than the broader population (Lucas, 1990; Sop Shin and Jaakson, 1997; Chin *et al*. 2000), although research conducted within Nuyts Wilderness Area in Western Australia found that wilderness visitors were fairly evenly distributed across the 26-40 and 41-60 age groups (Morin *et al*. 1997). Young males typically comprise a high proportion of wilderness users as they tend to possess both the physical strength required for strenuous outdoor activities, and often have no dependants in comparison to older age groups (Sop Shin and Jaakson, 1997).

Research suggests that between 60-85 percent of visitors to different North American wilderness areas have attended a university or college, while between 20-40 percent have undertaken postgraduate study (Lucas, 1990). A similar trend has been confirmed among visitors to Nuyts Wilderness Area, where 70 percent of those surveyed had completed some form of tertiary education (Morin *et al*. 1997). Over 50 percent of visitors to Nuyts Wilderness Area were accompanied by one other person, while 64 percent resided in Perth (Morin *et al*. 1997). The vast majority of wilderness users in the United States live in urban centres close to the destinations they visit (Fisher *et al*. 1984), although visitors do also come from throughout the whole of the country (Lucas, 1990).

Case study: characteristics of long-distance walkers in New Zealand

This case study briefly summarises the results of a survey conducted with 970 backcountry users at 22 different sites in New Zealand during the 1995-96 hiking season that generated important information about the characteristics of visitors using long-distance walking tracks (Kearsley *et al.* 1998). Of the 970 surveys analysed, over half (55%) were completed by New Zealand residents while 45 percent were completed by international visitors, with males comprising 54 percent of the sample. Results indicated that just over half (51%) of all hikers who responded were aged 25-34. Respondents generally had high levels of education with 69 percent possessing a tertiary degree of which 21 percent had a postgraduate qualification. Comparisons of education data provided by hikers who resided in New Zealand with education data supplied by the New Zealand population during the 1996 Census revealed that long-distance walkers tended to be more highly educated than the wider population.

Hikers using long-distance walking tracks in New Zealand were highly experienced with 52 percent of respondents indicating they hiked at least three times each year, while a further 36 percent walked at least once every year (Kearsley *et al.* 1998). The high level of experience reported in this case study was contrary to results reported for the Heaphy Track (Cessford, 1997a) and the Tongariro Circuit Track (Cessford, 1997b) following surveys conducted with hikers during the period 1993-95. Cessford (1997a, 1997b) found that most respondents were largely unfamiliar with the Heaphy Track and the Tongariro Circuit Track, and were generally inexperienced in backcountry walking.

Survey results reported by Kearsley *et al.* (1998) suggested that New Zealand residents tended to utilise informal information sources (especially word of mouth), while international visitors were more likely to use guidebooks although informal information sources (word of mouth / people I have met while traveling) were next most important. The average group size was 3.6 people although this was slightly lower for international walkers (2.6) than for domestic hikers (4.4). Overall 31 percent of respondents indicated that they had walked with one other person while 16 percent of respondents had walked alone. The proportion of solo hikers was found to be substantially higher among international hikers (25%) than domestic hikers (8%) (Kearsley *et al.* 1998). The characteristics of hikers presented in this case study are believed to be representative of long-distance walkers to wilderness areas in other destinations including Europe, Canada and the United States.

Visitors to the Wet Tropics region

Although minimal research has been conducted in relation to the profile of visitors using long-distance walking tracks within the Wet Tropics region, substantial site-based research has been undertaken at a number of designated recreational sites within the Wet Tropics World Heritage Area, which incorporated day-use, camping and short-distance walking opportunities. While this research differs to that associated with long-distance walking tracks it nevertheless provides valuable information about the characteristics of visitors to the region. During 2001-02 an extensive visitor survey was conducted with 2,780 visitors to ten predominantly day-use sites within or adjacent to the Wet Tropics World Heritage Area (Bentrupperbäumer and Reser, 2002). The survey revealed that 34.0 percent of visitors to the ten Wet Tropics sites were local residents, a further 34.7 percent were domestic visitors from elsewhere in Australia and the remaining 31.3 percent were of international origin.

The average age of respondents was 36.3 years, although the majority of visitors were aged between 20 and 29 years with international visitors more likely to be younger than visitors residing in Australia. The sample comprised slightly more females than males, with female respondents generally younger than their male counterparts. Visitors were generally well educated with 40.9 percent of those surveyed having completed a university education, although the proportion of local residents who had completed a tertiary education was lower at 30.7 percent. The survey also revealed that most visitors had relied upon informal information sources (such as word of mouth / were repeat visitors) to locate sites (Bentrupperbäumer and Reser, 2002).

2.5.3 Psychological and behavioural responses

Psychological and behavioural responses to various environments or domains (natural, built, and social) encountered during the course of a recreational experience are inevitable, interlinked and informative.

2.5.3.1 Visitor interaction with the natural environment

A two-way interaction occurs between visitors and the natural environment at recreation sites that can generate either positive or negative psychological and behavioural responses. Although research has consistently demonstrated that people-natural environment interactions result in positive outcomes such as stress reduction, self-relevant feedback and attention restoration (Section 2.3.3 provides an expanded discussion), there may also be negative aspects to natural environment encounters (Hartig and Evans, 1993). In particular, contact with extreme and unusual natural environments, events such as natural disasters (floods, landslides etc.) and encounters with dangerous animals can all elicit negative responses (Hartig and Evans, 1993). In recreational research there is often a tendency to consider natural environment impacts associated with human visitation purely from the perspective of negative biophysical impacts upon the natural environment (Hartig and Evans, 1993; Bentrupperbäumer and Reser, 2002; Reser and Bentrupperbäumer, 2005). Unfortunately this perspective tends to ignore the many positive psychological and behavioural responses that can result when visitors engage with the various environments and natural domains within outdoor recreation areas (Hartig and Evans, 1993). The failure to place more emphasis upon the positive consequences of human interactions with the natural environment represents a lost opportunity for protected area managers (Bentrupperbäumer and Reser, 2002; Reser and Bentrupperbäumer, 2005).

Natural environment interactions can result in a range of positive psychological and behavioural responses for visitors that typically result in modified perceptions, enhanced quality of experiences, improved health, and altered behaviour. Specific positive psychological responses can include altered values and world views, modified priorities including new orientations to life, opportunities for learning and personal growth, and new insights and enhanced self-awareness (Talbot and Kaplan, 1986; Scherl, 1989; Pigram, 1993; Bentrupperbäumer and Reser, 2002). The restorative effects of time spent in natural areas can also result in improved concentration, enhanced self-esteem and body image, and improved problem solving skills (Kaplan and Kaplan, 1989; Hartig and Evans, 1993). Natural environment encounters within outdoor recreation settings can also result in positive behavioural responses as visitors obtain a greater appreciation of the role and importance of protected areas and behave in a more caring and respectful manner towards both the physical setting and other visitors (Pigram, 1993; Reser and Bentrupperbäumer, 2005). Surveys of visitors to ten sites within the Wet Tropics World Heritage Area demonstrated that appraisals of the natural environment were highly positive at most sites with respondents generally perceiving the natural environment to be in good condition, well managed and both appealing and interesting (Bentrupperbäumer and Reser, 2002).

Natural environments appear to differ in their capacity to generate positive psychological responses for different visitors (McAndrew, 1993; Pigram, 1993). As an example Sop Shin and Jaakson (1997) surveyed visitors to three provincial parks in Ontario, Canada about their perceptions of the natural environment and found that these varied greatly between individuals, and were influenced by factors such as prior experiences, personal values and beliefs, and individual emotions. Their results also suggested that there was a strong correlation between wilderness quality and visitor satisfaction at any recreational setting (Sop Shin and Jaakson, 1997). A clear link also appears to exist between the quality of the natural environment and visitor choice of destination to visit (Valentine, 1992; McAndrew, 1993).

Visitor responses to biophysical impacts

Research suggests that visitors to natural areas are becoming more knowledgeable about the environmental impacts that result from their use of recreational settings, which has potential implications for the way in which they respond to environmental damage at a site (Noe *et al*. 1997; Bryden, 2001; Butler, 2002; Dorwart *et al*. 2004). Visitors tend to respond to environmental damage/degradation in one of three ways, they may notice degradation but do not react in a negative manner, they notice it and do react negatively, or they remain oblivious to the existence of the impacts (Roggenbuck, 1992). When visitors notice environmental damage but are not bothered by it, presumably it is not an important influence upon the overall quality of their recreational experience, although tolerance for impacts has been shown to vary widely within different situations (Noe *et al*. 1997). Nevertheless, a number of researchers have demonstrated that visitor perceptions of environmental degradation generally decrease overall trip satisfaction (Martin *et al*. 1989; Buckley and Pannell, 1990; Leung and Marion, 2000; Farrell and Marion, 2001; Smith and Newsome, 2002; Lynn and Brown, 2003), which may result in inappropriate behaviour. Biophysical impacts caused by recreational activities are known to influence visitor behavior and respect for a site, quality of experience, and ultimately choices about length of stay and whether to return to a site (Martin *et al*. 1989; Kearsley *et al*. 1998; Bryden, 2001). If environmental conditions at a site deteriorate to such an extent that they are considered unacceptable to visitors, many may simply modify their behaviour within the setting or become displaced to other destinations (Kuss *et al*. 1990; Kearsley *et al*. 1998; Bryden, 2001; Farrell and Marion, 2001). Bryden (2001) found that more experienced, long-term users such as local residents were more likely to be displaced from recreational sites within Queensland's Wet Tropics region by environmental degradation, than were less experienced visitors.

Biophysical impacts that have been consistently identified as being of concern to visitors include litter (both a biophysical and a social impact), damage to trees (broken branches, nails, axe marks and carvings), vegetation trampling, inadequate disposal of human waste and soil erosion. Of those visitors who notice environmental impacts and are bothered by them, litter and vegetation damage are the most common concerns (Roggenbuck, 1992; Lynn and Brown, 2003; Dorwart *et al*. 2004). Visitors to Bako National Park in Malaysia indicated that litter, soil erosion and vegetation damage were the biophysical impacts of greatest concern (Chin *et al*. 2000), while visitors to Nuyts Wilderness Area in Western Australia specified damage to trees, litter, inadequate disposal of human waste, erosion on walking tracks, and vegetation loss as their principal concerns (Morin *et al*. 1997). Visitors to Nuyts Wilderness Area were more tolerant of bare ground and vegetation trampling in campgrounds than in other locations but were extremely intolerant of litter in all locations with approximately 50 percent of survey respondents only prepared to accept the presence of one piece of litter within the park (Morin *et al*. 1997).

Both management experience and research have demonstrated that the rapid removal of litter will discourage additional littering as people are less likely to litter in a clean area, in comparison to an area where litter already exists (Lucas, 1990; McAndrew, 1993; Anderson *et al*. 1998). Surveys conducted with visitors to Warren National Park in Western Australia demonstrated that most people were highly intolerant of damage to trees with 82 percent of respondents stating that they would only accept a few (0-5) damaged trees within an area. Other biophysical impacts of concern to visitors to Warren National Park included litter, vegetation loss, and erosion of the river bank at access points (Smith and Newsome, 2002). Evidence of human waste in wilderness areas negatively impacts upon visitor experiences when they encounter human feces and toilet paper in remote locations (Morin *et al*. 1997; Climburg *et al*. 2000). Another biophysical impact that negatively impacts upon visitor satisfactions levels is the presence of trees with severe root exposure (Leung and Marion, 2000). Visitors may potentially interpret the presence of biophysical impacts as an indication of poor management and can be left with the impression that management 'does not care' about the site (Bentrupperbäumer and Reser, 2002).

Visitor assessment of biophysical impacts

Visitor assessment of environmental impacts does not always correlate with physical measurements of impacts (Dorwart *et al*. 2004), and many visitors remain oblivious of their own adverse impacts upon recreational sites. Hillery *et al*. (2001) investigated the relationship between on-site measurements of biophysical impacts, and tourists' perceptions of those impacts at ten sites in Central Australia near Alice Springs. Their results indicated that tourists generally underestimated site impacts. In their study, the most common environmental impacts measured were informal trails, soil compaction and vegetation damage, while tourists identified exotic plants, feral animals, litter, and vandalism as the main environmental impacts (Hillery *et al*. 2001). Research reported by Marion and Lime (1986) suggested that visitors were generally aware of highly visible impacts such as littering, vandalism to trees and inadequate human waste disposal, but were much less likely to recognise their own less obvious impacts upon walking tracks such as soil compaction and vegetation trampling, ultimately underestimating the overall extent of impacts.

Butler (2002) compared visitor perceptions of biophysical impacts with actual on-ground measurements of impacts associated with undesignated walking tracks or social trails within the Wet Tropics region of North Queensland. Her results indicated that visitors generally overestimated the extent of environmental impact present, although she urges caution as biophysical impact sampling was only conducted on a few undesignated walking tracks, and may not have detected the full extent of environmental impacts (Butler, 2002). While it has previously been suggested that visitor perceptions of the condition of the natural environment can be utilised as ecological indicators (Graham and Hopkins, 1993), the inconclusive results presented above suggest caution will need to be exercised with this approach due to the incongruence between actual and perceived impacts. It can also be argued that it is unrealistic to expect visitors to be able to recognise impacts that are often diffuse and subtle such as soil compaction and vegetation trampling. In any event the nexus between visitor perceptions and visitor behaviour (Reser and Bentrupperbäumer, 2005), would suggest that visitor perceptions of biophysical impacts are as important as field based measurements of impacts, because negative visitor perceptions have the capacity to rapidly translate into negative visitor behaviour, with adverse consequences for recreational sites.

Similar discrepancies have been found to exist between how land managers and visitors perceive biophysical impacts at a site (Martin *et al*. 1989; Farrell *et al*. 2001; White *et al*. 2001). In one study comparisons were made of perceptions of environmental damage held by both land managers and wilderness visitors using slides depicting biophysical impacts of various types and severity (Martin *et al*. 1989). They assessed whether managers and visitors perceived campground impacts differently, the acceptability of the extent of impacts to both groups, and whether or not they perceived impacts differently depending upon their ‘perceptual zoning’ of an area. Their results indicated that managers were generally more sensitive to areas of bare ground, while visitors were generally more sensitive to tree damage and fire rings. Overall, visitors were found to be more likely than managers to perceive the extent of biophysical impacts at a site to be unacceptable. Visitors were more likely to regard impacts within core areas as unacceptable compared to impacts occurring in peripheral areas (Martin *et al*. 1989). Their study concluded that mangers should not assume that their own perceptions of resource degradation are the same as those held by visitors, which has implications for what indicators and standards are used within a monitoring system (Martin *et al*. 1989). Research has demonstrated that managers and visitors can evaluate the same biophysical impacts in either positive or negative ways. For example, whilst managers often perceive vegetation loss within a campground to be a negative consequence of visitation, campers frequently perceive areas devoid of vegetation as highly desirable (White *et al*. 2001).

2.5.3.2 Visitor interactions with the built environment

The built environment consists of site infrastructure including access roads, walking tracks, picnic and camping facilities such as toilets, rubbish bins, picnic tables, shelter sheds and water taps. It also includes the various forms of signage and interpretation and the management regime that exists within a recreational setting. Visitor interactions with the built environment can be both positive and negative with consequential impacts for both visitor experiences and site infrastructure (Hartig and Evans, 1993; Bentrupperbäumer and Reser, 2000, 2002). The built environment impacts upon visitor experiences and satisfaction levels as evidenced in visitor perceptions of the adequacy of site facilities, design, construction, and maintenance standards for park infrastructure, and the appropriateness of site management regimes (Bentrupperbäumer and Reser, 2000; Bell *et al*. 2001). Conversely, visitors impact upon the built environment via their participation in activities that contribute to the depreciation and damage of facilities, either through sustained usage or inappropriate behaviour such as vandalism (Bentrupperbäumer and Reser, 2000; Bell *et al*. 2001). Such negative behaviour towards infrastructure is likely to be exacerbated by the provision of visitor facilities that are poorly designed or constructed, and inadequately maintained.

Site facilities

The extent of availability of site facilities is a known influence on the nature and quality of visitor experiences at any given recreation site. Stankey (1973) conducted interviews with over 600 visitors to wilderness areas in the United States and developed a scheme for classifying visitors as either ‘purists’ or ‘nonpurists’ depending upon their level of desire for solitude and facilities, and the extent to which they were offended by signs of human disturbance such as litter and campground wear. Stankey maintained that while nonpurists desired visitor facilities, this was likely to be unacceptable to purists who would prefer an absence of facilities. Purist visitors also often favour a reduction in the number of trails and directional signage, and often reject the need for trails to be upgraded to a better standard (Stankey, 1973).

Many wilderness visitors favour the provision of facilities such as toilets, picnic tables, and water taps, and do not see this as conflicting with the wilderness values of a destination (Sop Shin and Jaakson, 1997). Surveys within both Nuyts Wilderness Area (Morin *et al*. (1997) and Warren National Park (Smith and Newsome, 2002) in Western Australia found that the majority of visitors supported the installation of additional directional signage along tracks to improve wayfinding. Morin *et al*. (1997) concluded that Australian wilderness users have a higher tolerance for directional signage than is the case for visitors to wilderness areas in the United States, an observation that they attribute to trails in the United States being well used and easy to locate, which is often not the case in many Australian wilderness areas. Research seems to indicate that the majority of visitors favour the establishment of site facilities that function to reduce human impacts upon the natural environment. Visitor surveys within Warren National Park indicated that 80 percent of respondents supported management constructing infrastructure such as stairs and boarding to protect fragile areas including riverbanks from erosion, while 65 percent of those surveyed supported improvements to the condition of walking trails along the river (Smith and Newsome, 2002).

Infrastructure layout, design, construction and maintenance

The layout, design and construction of visitor infrastructure can influence visitor experience and behaviour at any given recreation site. Appropriate layout of infrastructure within the setting can provide for privacy, reduce the sense of crowding, and enhance convenience for visitors, while good design can assist visitor access and comfort, help protect environmentally sensitive areas, enhance site aesthetics and improve the extent of congruence between visitor facilities and the environment (Bell *et al*. 2001; Bentrupperbäumer and Reser, 2002). Well designed visitor facilities should not only satisfy practical use and budgetary considerations, but also enhance the psychological and physical health of visitors who utilise the facilities (Cassidy, 1997). Consequently, infrastructure design needs to consider a range of factors including their physical shape and size, colour, temperature, air quality, noise levels, lighting, ease of access, privacy, and the personal space requirements of users (Bechtel, 1997; Cassidy, 1997; Bell *et al*. 2001). Similarly, visitor facilities should be constructed from appropriate materials and built to a standard that satisfies the reasonable expectations of users and ensures their physical safety (Bechtel, 1997; Cassidy, 1997; Bell *et al*. 2001). Hence it is important that facilities provided for visitors meet adequate layout, design and construction standards to ensure the overall wellbeing of the recreation site (Section 2.2.4 provides more information about the importance of site management within protected area settings).

Research suggests that poor standards of infrastructure maintenance (such as dirty picnic tables, overflowing rubbish bins, smelly toilets, overgrown lawns, graffiti, severely eroded walking tracks, damaged buildings or broken signage) can have negative implications for visitor perceptions of site management and can ultimately encourage inappropriate visitor behaviour (Bentrupperbäumer and Reser, 2002; Ward *et al*. 2002). If visitors develop a perception that managers are not sufficiently concerned about the welfare of the setting, this can also translate into irresponsible behaviour within the setting (Bentrupperbäumer and Reser, 2000). The 'broken window theory' argues that ignoring small problems such as shattered windows, litter, dirty footpaths, and graffiti within a community setting can create a perception of irreversible decline and neighborhood deterioration that can result in additional inappropriate behaviour and even criminal activity (Gladwell, 2000; Morin, 2005; Seattle Police Department, 2005).

Research undertaken within a recreation setting suggests that vandalism and littering are more common where such damage already exists. For example, Samdahl and Christensen (1985) studied vandalism of picnic tables within campgrounds in the United States and found that carving on timber picnic tables was more likely to occur when previous carvings already existed. Similarly, McAndrew (1993) reported that people seemed to be less inhibited about littering in an area where litter already exists.

2.5.3.3 Visitor interaction with the social environment

Visitors can have both positive and negative encounters with aspects of the social environment during the course of an outdoor recreation experience. Positive psychological responses can result as a consequence of opportunities to enhance social cohesion, strengthen relationships with friends and family members (either through spending time with them or without them), share experiences with others, meet new people, and socialise (McAndrew, 1993; Bechtel, 1997; Bell *et al*. 2001). Although solitude is an important component of an outdoor recreation experience for many visitors, others are excited by the opportunity to meet and socialise with new people (McAndrew, 1993). Negative interactions with the social environment typically results from recreational conflict that develops as a result of issues such as crowding, the size of other groups, inappropriate behaviour by other visitors, and conflicting modes of travel and/or activities (Bechtel, 1997; Roggenbuck, 1992; Hammitt and Schneider, 2000). Surveys conducted within the Wet Tropics World Heritage Area found that appraisals of the social environment were generally positive with most respondents being satisfied with the number and presence of other visitors, and believed their behaviour to be both environmentally responsible and appropriate, although lower satisfaction levels were recorded among international visitors (Bentrupperbäumer and Reser, 2002).

Recreational conflict

Visitor appraisal of the social environment at a recreational setting can influence their behaviour towards each other and the setting, their experience of the encounter, and their satisfaction with this activity. When visitors negatively appraise an aspect of the social environment at a site (such as crowding) this represents a form of recreational conflict. Owens (1985) defines recreational conflict as a negative experience that takes place when visitors compete for recreational resources, and do not derive their anticipated benefits. Recreational conflict therefore occurs when the behaviour of an individual or group is incompatible with the social, physical and psychological goals of other visitors resulting in either goal interference or contravention of values (Jacob and Schreyer, 1980; Roggenbuck, 1992; Hammitt and Schneider, 2000). Some authors maintain that some form of recreational conflict is inevitable within recreational settings, whether it be between different user groups (for example Spencer *et al*. 1999), or between land managers and visitors, and will only increase in the future as use levels increase (for example Hammitt and Schneider, 2000) and settings are inappropriately designed and laid out. Research has consistently demonstrated that various aspects of the social environment causes recreational conflict among visitors including perceptions of crowding (Schneider and Hammitt, 1995), the presence of large groups (Roggenbuck *et al*. 1993), inappropriate behaviour by other visitors (Hammitt and Schneider, 2000), and differing modes of travel and types of activities (Ramthun, 1995).

Crowding

Crowding is a negative subjective judgment (Stokols, 1976; Ditton *et al*. 1983; McAndrew, 1993) that is the result of a combination of both the environmental setting or site conditions (site organisation, physical constraints on desired activity, spatial density of humans), and an individual's perceptions as influenced by factors such as culture, level of previous experience, and prior expectations (Bechtel, 1997; Tarrant *et al*. 1997). While crowding is often defined as the experience of having too many people present in the one place (Stokols, 1976), a direct link between density (purely as numbers of people) and crowding has been consistently refuted (Ditton *et al*. 1983; Roggenbuck, 1992; Webb and Worchel, 1993). Perceptions of crowding occur when visitors believe they see more people than is appropriate for a recreational site, or than they are comfortable with (McAndrew, 1993), and are influenced by many factors including the number of people encountered, the behaviour of others, their own motivations and prior expectations, their attitudes and level of experience, and the types of areas and locations where encounters with others occur (Roggenbuck, 1992). Perceptions of crowding are more commonly associated with perceived intrusions into personal space whereby people feel disturbed by the unwanted interactions with others (Bechtel, 1997). Crowding tends to negatively influence a persons affective state and physiology, resulting in reduced performance and quality of experience, and can even contribute to increased levels of aggression (Fisher *et al*. 1984). When an individual experiences crowding this can also constrain their behaviour, including the types of activities that they undertake in a recreation setting (Ditton *et al*. 1983; Gramann and Burdge, 1984; Evans and Lepore, 1992).

Visitor perceptions of crowding during a recreational experience may be influenced by their *prior expectations* (McAndrew, 1993). Dissatisfaction with a recreational experience can arise when there is a discrepancy between the numbers of people a person expects to see (their prior expectations) and the number they actually see (Schreyer and Roggenbuck, 1978). This is supported by research conducted by Tarrant *et al*. (1997) who surveyed rafters, canoers and kayakers on the Nantahala River in the United States. Their results indicated that encounter preferences were strong predictors of perceptions of crowding (Tarrant *et al*. 1997). Similar results were obtained by Schreyer and Roggenbuck (1978), who surveyed whitewater recreationists at Dinosaur National Monument in the United States and found that individuals with prior expectations of obtaining opportunities for stress release, solitude and self awareness were more sensitive to feeling crowded, while those who were seeking fun and adventure were much more tolerant of the presence of other visitors. Roggenbuck (1992) maintains that one possible solution to visitor perceptions of crowding in recreation areas may be to provide more information about the actual levels of park use, and the potential for encounters with others. If visitors have more realistic prior expectations about the likelihood of encountering other people at a setting they may have greater tolerance to their presence, and a more satisfying recreational experience (Roggenbuck, 1992). This suggests that effective use of interpretation and appropriate information dissemination by management can help to create realistic prior expectations of the social environment, and thereby reduce recreational conflict due to crowding.

Previous experience can also influence visitor perceptions of crowding and subsequently satisfaction with a recreational experience (McAndrew, 1993). Individuals are known to regularly evaluate the social environment at a setting on the basis of their previous experience which evidently has a greater influence upon perceptions of crowding than actual numbers of encounters (Vaske *et al*. 1980; Ditton *et al*. 1983; Ramthun, 1995). Previous experience often complicates perceptions of crowding and typically influences visitor evaluations of appropriate setting densities towards levels that have previously been encountered (Kyle *et al.* 2004b). Research also indicates that when experienced users encounter inexperienced users, the more experienced users tend to have a lower tolerance of crowding (Vaske *et al*. 1980; Ditton *et al*. 1983). Similarly, experienced 'purist' users tend to have a preference for pristine and remote natural areas with limited numbers of encounters with individuals outside of their own group (Kyle *et al*. 2004a).

The *location* where encounters with other individuals and groups occur can also influence visitor perceptions of crowding. As a rule, encounters with other parties in peripheral areas such as trackheads and car parks are regarded as more acceptable than encounters that take place in core wilderness areas which visitors perceive to be more remote (Ditton *et al*. 1983; Roggenbuck, 1992; Tarrant *et al*. 1997). This is likely to be a product of visitors' prior expectations or perceptual distinctions concerning wilderness core areas (Roggenbuck, 1992). Visitors to North American wilderness areas are generally more accepting of encounters with groups along trails, than they are when the same group is encountered at a campground, or at a lookout (Roggenbuck *et al*. 1993). This was also confirmed to be the case within Nuyts Wilderness Area in Western Australia, where visitors were found to be more tolerant of encounters with other groups on trails than elsewhere, a result that the researchers attributed to the briefness of the encounter (Morin *et al*. 1997). Visitors to highly developed sites with intensive use are generally more tolerant of other users than is the case in wilderness areas (Gramann and Burdge, 1984), presumably because they anticipate the high likelihood of encounters with other users.

Other factors that research has shown to contribute to perceptions of crowding include evidence of environmental damage, noise and inappropriate behaviour by other visitors, and the degree of site specialisation required for a desired activity. Many authors report that visitor perceptions of environmental degradation can intensify their perceptions of crowding (Ditton *et al*. 1983; Martin *et al*. 1989; Kuss *et al*. 1990; Barron, 1995; Bentrupperbäumer and Reser, 2000). The high level of correlation between visitors' perceptions of environmental damage and their perceptions of crowding at a site has implications for managers who may have previously believed that the level of environmental degradation present at a site did not warrant their intervention. Sensitivity to crowding is also often exacerbated by noise (Kinnaird and O'Brien, 1996), or objectionable behaviour by other visitors such as vandalism or reckless actions (Gramann and Burdge, 1984; Chin *et al*. 2000). Perceptions of crowding also tend to increase when an individual or group perceives others to have goals or values that conflict with their own, with these often being exhibited within the various specialised activities that users choose to participate in during their visit to a recreational setting (Gramann and Burdge, 1984). Hammitt *et al*. (1984) found that the greater the degree of specialisation in the activity undertaken, the greater the potential for perceptions of crowding. For example, kayaking is more specialised than river tubing, so these users tend to require specific site conditions and often have well-defined prior expectations of site usage levels. While crowding represents one form of recreational conflict, there are many other situations that result in conflict between visitors.

Group size

The size of groups encountered along walking tracks and at campgrounds has consistently been identified as a factor that can negatively impact upon the quality of visitor experiences as it causes recreational conflict and exacerbates perceptions of crowding (Fisher *et al*. 1984; McNeely *et al*. 1991; Preece *et al*. 1995; Morin *et al*. 1997; Chin *et al*. 200). In particular, research has demonstrated that visitors are more tolerant of meeting multiple small groups than they are of meeting the same numbers of people in one large group (Tarrant *et al*. 1997). Surveys conducted within Nuyts Wilderness Area in Western Australia found that 33 percent of respondents were concerned about the size of groups that they had encountered (Morin *et al*. 1997), while wilderness users within the United States do not expect to see groups larger than six, and react negatively to encounters with larger groups (Roggenbuck *et al*. 1993). At many locations protected area managers generally have some degree of influence over the size of groups that frequent natural areas under their jurisdiction.

Inappropriate behaviour

Inappropriate behaviour, both towards the environment and other visitors, is a common source of recreational conflict that can detract from overall satisfaction levels, the quality of experience, and as stated repeatedly can have adverse impacts upon recreational sites (Hendee *et al*. 1990; Hammitt and Schneider, 2000). Such behaviour can include littering, noise (shouting, playing loud radios at night), reckless behaviour, camping too close to other visitors, feeding or approaching too close to wildlife, and criminal activities such as vandalism, theft, and poaching of plants and animals (Roggenbuck, 1992). Previous research has demonstrated that even small quantities of litter can arouse particularly strong negative responses among visitors and negatively impact upon the quality of their experiences (Martin *et al*. 1989; Morin *et al*. 1997; Kim and Shelby, 1998; Chin *et al*. 2000; Smith and Newsome, 2002). Conflict can also occur between visitors engaged in the same activity, as a consequence of different behavioural standards, such as the intensity at which they participate, or the extent to which they perceive each other as different (Kuss *et al*. 1990). Research conducted within the Daintree region of the Wet Tropics World Heritage Area confirmed that inappropriate behaviour by other visitors, such as littering, ignoring advisory signage, and damaging the natural environment, detracted from the enjoyment and satisfaction of many visitors (Barron, 1995).

Modes of travel and activities

Mode of travel and activity type can be a source of conflict between visitors to the same recreational site. Conflict can result from visitors' lack of willingness to accommodate activities and modes of transport different from their own (Beeton, 1999; Hammitt and Schneider, 2000), or from disruption to their recreational activity by noise or physical interference (Roggenbuck, 1992). As some activities have specific resource and space requirements, conflict can arise between visitors when they are prevented from engaging in their preferred activity (Roggenbuck, 1992; Hammitt and Schneider, 2000). Common examples of conflicts associated with incompatible activities and modes of transport reported from wilderness areas in the United States include those that occur between horseback riders and hikers, snowmobiles and cross-country skiers, canoeists and motorboats, and pedestrians and motorised vehicles (Roggenbuck, 1992). Attitudinal conflict has also been recorded between walkers and horseback riders in the Alpine National Park in Australia, even though some hikers did not actually encounter horseback riders (Beeton, 1999). Research has demonstrated that perceptions of conflict may not be equally shared by users who are engaged in different activities. Ramthun (1995) investigated conflicts that occurred between hikers and mountain bikers, and found perceptions of conflict to be asymmetrical, as 32.2 percent of hikers had experienced conflict with mountain bikers, but only 5.6 percent of bikers had experienced conflict with hikers. Ramthun also found that experienced hikers were more tolerant of track use by mountain bikers, than were less experienced hikers. This result was attributed to experienced hikers having clear expectations about what they would encounter on the track, and to other experienced hikers who may have been less tolerant of mountain bikes having been previously displaced to other locations (Ramthun, 1995).

Consequences of recreational conflict

In addition to reducing satisfaction and enjoyment among users, recreational conflict can ultimately result in visitor displacement or recreational succession as the character of the social environment within a site changes. Increased visitor numbers and changed activities can impact upon visitor satisfaction and result in visitor displacement as experienced visitors relocate (Buckley and Pannell, 1990; Shackley, 1996; Lindberg *et al*. 1998; Kearsley and Coughlan, 1999; Bryden, 2001). Hence, a nature based experience might be replaced by sporting activities or outdoor socialising (Shackley, 1996). Because experienced users tend to have lower levels of tolerance for crowding, they are more likely to be the ones who will be displaced by increased numbers of people visiting an area, or the onset of new activities (Vaske *et al*. 1980; Ditton *et al*. 1983; Bryden, 2001). Nevertheless, the very existence of experienced users at a destination indicates that there are either no serious conflict problems (Owens, 1985), or that experienced visitors are making behavioural adjustments, such as altering the timing or frequency at which they visit a site in order to minimise conflict and thereby avoid becoming displaced (Kuss *et al*. 1990).

Research in New Zealand (Kearsley *et al*. 1998; Kearsley and Coughlan, 1999) illustrates how recreational conflict, specifically crowding, can result in spatial and temporal displacement of backcountry visitors, or result in them adopting various behavioural and coping mechanisms, and is reported in some detail below. Surveys were completed by 970 visitors from 22 backcountry sites which revealed that approximately half (51%) felt that they had encountered more people than they had expected to meet during their walk. As a consequence, 15 percent were dissatisfied, 16 percent decided they would go somewhere else next time and a further 20 percent re-evaluated their perceptions of the track. The vast majority of respondents (81%) who experienced crowding indicated that this had occurred at huts. Many respondents indicated they used a variety of spatial and temporal behavioural coping mechanisms to avoid encounters with others which included leaving early, leaving late, camping (rather than using huts), targeting less crowded huts, walking quickly and hiking side tracks (intra-site displacement). Another segment of respondents indicated that they had used cognitive coping mechanisms such as mentally re-evaluating or repositioning their experience (product shift) in order to remain satisfied. Results also suggested that many respondents had already been displaced (inter-site displacement) from other tracks which they perceived to be more crowded (Kearsley *et al*. 1998; Kearsley and Coughlan, 1999).

2.5.3.4 Visitor perceptions of site management

An individual's perception of various aspects of site management can influence their behaviour and ultimately has implications for the long-term sustainability of recreation sites. Three aspects of recreational site management that have been demonstrated to be particularly important to visitors are management interventions that protect site attributes (Chin *et al*. 2000; Smith and Newsome, 2002), the provision of information and interpretation (Moscardo, 1996; Pearce and Moscardo, 1998), and the presence of uniformed park rangers within a setting (Fletcher, 1984; Swearingen and Johnson, 1995).

Interventions that protect site attributes

Visitors generally support management interventions that protect the natural attributes of an area, even if this imposes restrictions upon their own freedom and behaviour. Research conducted within Warren National Park in Western Australia indicated that a large proportion of visitors supported the introduction of a range of additional management interventions, some of which were likely to impact upon their own activities (Smith and Newsome, 2002). Interventions that were supported by visitors included discouraging use of overused areas (77%), temporarily closing access to certain areas of the park (66%), imposing limitations on group size (50%), and limiting the type and extent of use levels (48%), all of which assist to maintain the natural environment (Smith and Newsome, 2002). Similarly, visitors to Nuyts Wilderness Area in Western Australia supported management educating users about minimal impact use and camping techniques, rehabilitating degraded areas, limiting the number of people in each group, reducing visitor length of stay, discouraging use of overused areas, and increased enforcement by rangers (Morin *et al*. 1997). Visitor surveys within Bako National Park in Malaysia found that the majority of respondents supported management adopting a range of interventionist strategies, including limiting total visitor numbers, restricting access to parts of the park, and providing more enforcement staff (Chin *et al*. 2000).

Visitors are generally more supportive of management interventions when they can both understand the rationale behind any proposed changes, and view the resultant benefits, although their support for direct intervention is lower within wilderness areas than is the case within more highly visited areas (Anderson *et al*. 1998). Visitors also tend to prefer indirect tactics to direct tactics, and prefer interventions with which they are familiar to those that are new (Anderson *et al*. 1998). Morin *et al*. (1997) have suggested that management attention should primarily focus on those impacts that have been identified as being most important to visitors, although they caution that assessments will still need to be made about the ecological sustainability of impacts. When research indicates that visitors are generally supportive of a range of interventions, this provides managers with an opportunity to introduce management strategies without antagonising visitors.

Provision of information and interpretation

The provision of information and interpretation to visitors within protected areas can increase the quality of their experiences and appreciation of the natural environment (Moscardo, 1996; Chin *et al*. 2000). Good quality interpretation provides visitors with information about the destination that they are visiting, and explains concepts, meanings, and inter-relationships within the natural environment (McNeely and Thorsell, 1989; Pearce and Moscardo, 1998). Surveys of visitors using the Skyrail Rainforest Cableway near Cairns within the Wet Tropics region of North Queensland have demonstrated that interpretation is positively linked to visitor satisfaction and can potentially increase both expenditure and duration of stay at an attraction (Pearce and Moscardo, 1998). Previous research has also demonstrated that a majority of visitors to the Wet Tropics region associate negative impacts upon the natural environment with human-related activities, and would welcome information that assists them to reduce their own impacts upon the area (Bentrupperbäumer and Reser, 2000).

The presence of uniformed park rangers

The presence of uniformed park rangers within protected areas influences both visitor behaviour and quality of experience. Previous research indicates that most visitors appreciate the presence of uniformed rangers because of their role in providing information, increasing resource protection, enhancing visitor safety, and encouraging other users to obey park regulations (Fletcher, 1984; Swearingen and Johnson, 1995; Bentrupperbäumer and Reser, 2002). Research conducted by Swearingen and Johnson (1995) used a combination of visitor surveys and a behavioural experiment to investigate whether the presence of a uniformed park employee impacted upon visitor behaviour, attitudes, and quality of experience. For their experiment they selected a site where off-trail hiking was common, and then observed the behaviour of visitors depending on whether or not a uniformed ranger was present. They found that the presence of a uniformed employee was an effective deterrent to misbehaviour, and greatly reduced the incidence of non-compliance with park regulations. Their results indicated a 76 percent reduction in off-trail hiking when a uniformed ranger was present, compared to when there was no ranger present. The reduction in non-compliance occurred without direct intervention, and merely required the presence of the uniformed ranger. Their results also indicated that 37 percent of all survey respondents believed that an encounter with a uniformed ranger enhanced their enjoyment of the park, while only a minority (2.4%) of respondents believed this detracted from the enjoyment of their trip. In total, more than 97 percent of respondents were either positive or neutral in their attitudes towards the presence of uniformed rangers in parks, suggesting that previous research may have overstated visitor resistance to the presence of uniformed employees (Swearingen and Johnson, 1995). Similar results were obtained by Samdahl and Christensen (1985) who investigated vandalism of picnic tables within campgrounds and found that the presence of a uniformed ranger reduced the incidence of carving.

2.5.3.5 Psychological domain

In recent years increased research effort has been directed towards better understanding various aspects of the psychological domain associated with visitors undertaking outdoor recreation within natural protected areas. This is most likely a consequence of increased recognition of the contribution that such research can make to the management of natural protected areas and a growing awareness that negative visitor experiences can induce negative psychological and behavioural responses towards the setting (Vincent and Fazio, 1992; Reser and Bentrupperbäumer, 2000; 2005). Three aspects of the psychological domain that were considered to be particularly relevant to the current review and which have not yet been addressed are motivations, satisfaction and psychological preparedness.

Motivations

Motivations have previously been considered in detail within the context of various theoretical explanations of personal benefits associated with human-environment transactions (Section 2.3.3). Briefly summarised, both theory and research suggests that there are a variety of motivations driving people to seek outdoor recreation experiences within natural settings (Hartig and Evans, 1993; McAndrew, 1993; Bell *et al*. 2001). The allure of natural environments can be described in four ways being nature as a *restorer*, nature as a *competence builder*, nature as a *diversion*, and nature as a *symbol* of something else (McAndrew, 1993). Humans may be motivated to visit natural environments to obtain restorative benefits such as stress reduction and attention restoration because these environments offer more peaceful surroundings than usually exist in everyday life (Kaplan and Kaplan, 1989; Laumann *et al*. 2001). Secondly humans may be motivated to visit wilderness areas by a desire to feel more self reliant or self confident (Talbot and Kaplan, 1986; McAndrew, 1993). A third motivation for humans to visit natural areas is to obtain a different kind of sensory input to what is possible within urban environments, meaning that time spent in wilderness areas enables them to ‘get away from it all’ (McAndrew, 1993). To some people nature can also symbolise qualities and values that are important to them such as spirituality, continuity, mystery and the process of life itself (McAndrew, 1993; Bell *et al*. 2001).

A visitor survey conducted by Chin *et al*. (2000) in Bako National Park on the island of Borneo, Malaysia, found that important motivations for respondents to visit the area included being close to nature (78%), encountering wildlife (72%), viewing the scenery (71%), and learning about nature (70%). A similar survey conducted by Kinnaird and O’Brien (1996) within the Tangkoko DuaSadara Nature Reserve in Indonesia, revealed that wildlife viewing, particularly of primates, was the principal attraction enticing visitors to the area. They found that 57 percent of those surveyed stated that their primary motivation for visiting the reserve was to view a particular species of wildlife (Kinnaird and O’Brien, 1996). In contrast, many visitors to the Wet Tropics World Heritage Area perceive nature as an attractive backdrop to their social activities, rather than seeking out the natural values of the rainforest (Valentine and Cassells, 1991). This finding is supported by Pearce and Moscardo (1994), who conducted a survey of 549 visitors at Cardwell in North Queensland, and found that 66 percent of those surveyed look upon the Wet Tropics as a relaxing backdrop for a low activity kind of holiday, while an additional ten percent had little knowledge or interest in learning about the natural values of the rainforest. The remaining 24 percent of survey respondents were regarded as being appreciative of the natural values of the rainforests (Pearce and Moscardo, 1994). More recent research conducted within the Wet Tropics World Heritage Area found that *experiential* reasons (such as the opportunity to experience nature, view natural features and scenery, rest and relax, experience tranquility) were more important reasons for visiting than either *educational* or *activity-based* reasons (Bentrupperbäumer and Reser, 2002).

Survey research conducted with visitors using long-distance walking tracks in wilderness areas in New Zealand found that hikers had a diversity of motivations for visiting but primarily cited experiential-based reasons (for example to see scenic beauty and naturalness, to enjoy the outdoors, to encounter wilderness) for visiting (Kearsley *et al*. 1998; Kearsley, 2000). Activity-based motivations (such as to face the challenges of nature, to undertake physical exercise) were rated the next most important reasons to visit (Kearsley *et al*. 1998; Kearsley, 2000). Most hikers indicated that social-based reasons were not important motivations for their visit as they did not wish to meet new people or make friends during the course of their walk (Kearsley *et al*. 1998; Kearsley, 2000).

Satisfaction

Despite the inherent difficulties involved in accurately assessing visitor satisfaction (McAndrew, 1993), it remains an important theme in outdoor recreation research because it has long been used as the principal measure of quality in outdoor recreation (Manning, 1986). The focus on satisfaction within outdoor recreation research is also considered important due to the need for evaluative communication between visitors and management in the absence of clear feedback via 'price signals' which are commonly available to managers within the private sector (Manning, 1986). As recreation experiences provided by the public sector are traditionally either free or priced at nominal levels, this feedback mechanism is unavailable to public land managers (Manning, 1986). Most protected area managers also recognise the usefulness of visitors' opinions (Manning, 1986), which further vindicates some exploration of hikers' satisfaction with their long-distance walking experience.

Visitor satisfaction and the measurement of this complex concept remain the topic of much discussion in both the outdoor recreation and environmental psychology literature (Manning, 1986; Talbot and Kaplan, 1986; Graefe and Vaske, 1987; Walsh *et al*. 1992; Webb and Worchel, 1993; Manning *et al*. 1996; Cassidy, 1997; Moscardo, 1997; Bell *et al*. 2001). A central concern about the measurement of satisfaction relates to the validity of the construct, or determining what is actually being measured by researchers in their assessments (Vittersø *et al*. 2000). For example, dissatisfaction with an experience may be unrelated to visitors' evaluation of the physical setting at a recreation site, but rather a result of the undesirable behaviour of other visitors (Graefe and Vaske, 1987). Another concern with assessments of visitor satisfaction is that because visitors may have spent substantial quantities of time and money to organise a visit, they may be reluctant to admit that their trip has been a failure if their prior expectations have not been met (Vittersø *et al*. 2000). This can potentially cause visitors to use various cognitive dissonance strategies, such as overlooking discordant events, or suppressing negative feelings, in order to reduce the perceived inconsistencies between their prior expectations and the actual outcomes from their trip (Vittersø *et al*. 2000; Chhetri *et al*. 2004).

Previous research has found that visitor mood and satisfaction level tend to vary over both space and time throughout the duration of a recreational experience in response to heterogeneity in the setting conditions encountered (Hull and Stewart, 1995; Englin *et al*. 2006). This is particularly relevant within a long-distance walking track context where visitors are likely to encounter substantial spatial and temporal variation in situational variables including weather conditions, wildlife, topography, ecosystem types, and encounters with other visitors as they traverse a track. As it has previously been suggested that spatial and temporal variability in social and environmental conditions can potentially threaten the validity of assessments of satisfaction made using post-visit surveys (Kyle *et al*. 2004a), it was considered essential that the current research assess satisfaction within the setting where recreation was undertaken, preferably as close as possible to the conclusion of the experience, in order to enhance the validity of results.

Psychological preparedness

The quality of visitor experiences can also be influenced by factors beyond the control of land managers, but which managers can influence by providing appropriate information. If visitors have access to relevant information about various aspects associated with their recreational activities including likely weather conditions, insects, the nature of the terrain, and the level of physical exertion required, they are more likely to be psychologically prepared for the conditions they encounter. Weather conditions have an important influence upon human behaviour and satisfaction levels, with sunlight resulting in favourable moods and increased altruistic behaviour, while temperature extremes, rainfall, cloud, and wind tend to be negative influences (Fisher *et al*. 1984; McAndrew, 1993; Bell *et al*. 2001). Extremely hot temperatures tend to promote negative feelings as individuals become increasingly uncomfortable, and have been linked to increases in aggression and crime (McAndrew, 1993; Veitch and Arkkelin, 1995; Bell *et al*. 2001). Similarly many visitors have negative wilderness experiences because they do not enjoy encounters with insects, swamps and mud, or believed the hiking was too strenuous (Talbot and Kaplan, 1986). It is interesting to note that while people will often seek to avoid confusing paths with challenging slopes and rugged terrain in urban areas, in nature people tend to prefer challenging and diverse slopes within rugged wilderness areas (Chhetri *et al*. 2004).

2.6 CONCEPTUAL AND THEORETICAL ORIENTATION OF THE THESIS

As previously stated a human-environment transactional model developed by Bentrupperbäumer and Reser (2000, 2002) was utilised as the overarching theoretical and analytical framework. Effective use of the model requires the *simultaneous* assessment of biophysical impacts (impacts upon the environment) and psychosocial experiences (impacts upon people). Such an approach provides an opportunity to evaluate environmental conditions and visitor perceptions of the setting which represent equally valid sources of knowledge. An attempt has been made to diagrammatically present the conceptual and theoretical orientation of the thesis in three stages (Figure 2.5) to assist the reader to rapidly comprehend the overall formulation of the research.

Stage One – Disciplinary Foundations

The conceptual and theoretical orientation of the thesis reflects the varied disciplines upon which the research has drawn. The range of disciplines depicted in Figure 2.5 is both a reflection of the multidisciplinary nature of the study, and of the diverse yet complementary research work which has been previously undertaken concerning human-environment encounters, particularly in a recreational context.

Stage Two – Human-Environment Transactional Model

The second stage in Figure 2.5 depicts the integrated multidisciplinary nature of the human-environment transactional model used and emphasises that the research methodology enabled linkages to be established between the biophysical impact assessment and the psychosocial experience assessment. The green arrow indicates that linkages exist between the disciplinary foundations and the formulation of the methodology. The five rectangular boxes identify the key research avenues addressed within the thesis, two of which relate to the biophysical impact assessment and three to the psychosocial experience assessment.

Stage Three – Research Outcomes and Contributions to Knowledge

The final stage in Figure 2.5 and the presence of the red arrow are intended to illustrate how the research outcomes and theoretical implications of the research are a logical progression from the methodology and facilitate both scientific and applied management contributions to knowledge.

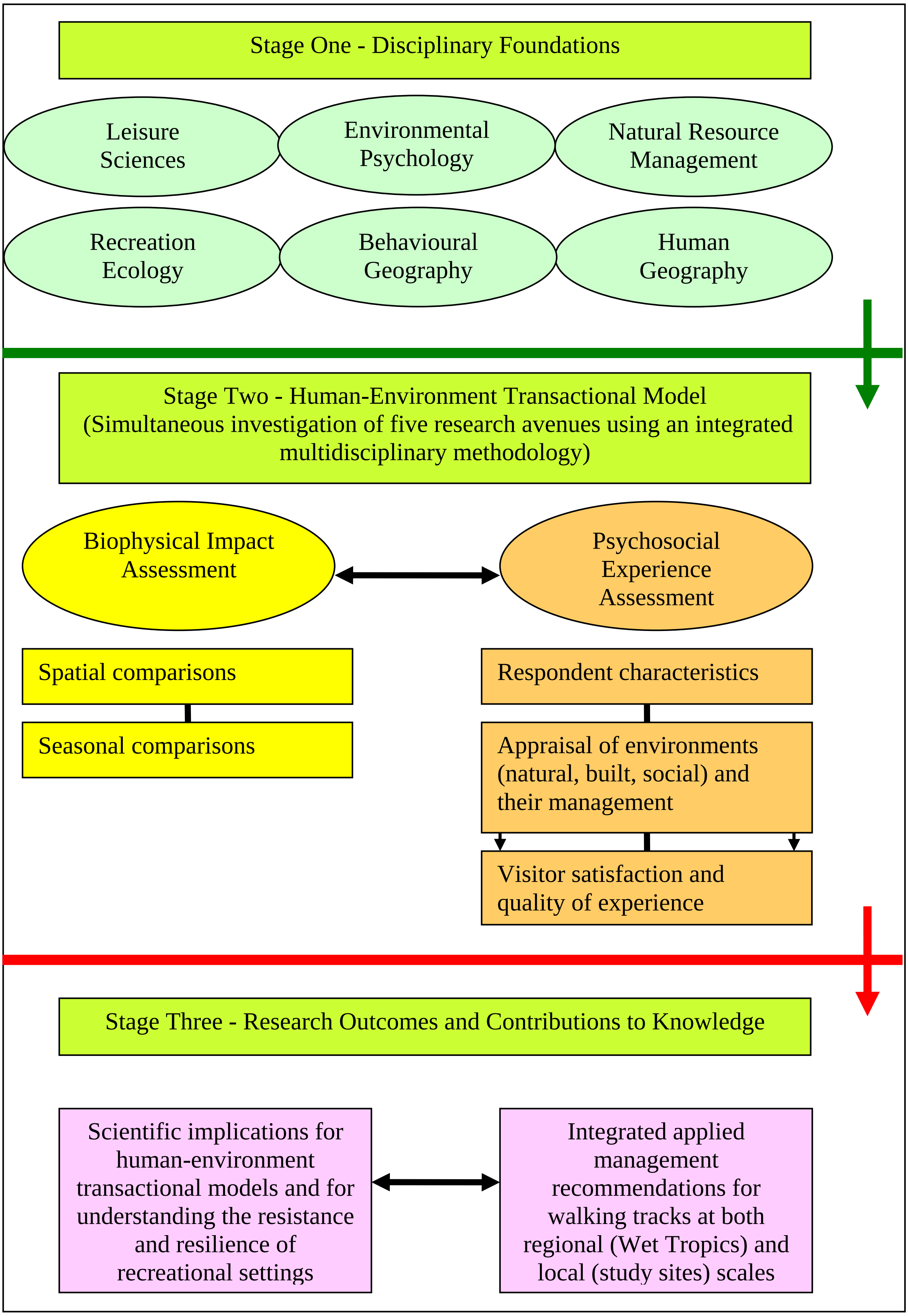

Figure 2.5 Conceptual and theoretical orientation of the research.

Conceptual and Theoretical Orientation of the Biophysical Impact Assessment

The conceptual and theoretical orientation of the biophysical impact assessment is presented in Figure 2.6. Ecological theory in the form of ecosystem 'resistance and resilience' was adopted as the theoretical framework for the biophysical impact assessment, and primarily sought to investigate the concept of 'impact on environment' via four methodological variables. Of these four variables, only 'impacts upon soil' and 'impacts upon vegetation' were systematically assessed in the field with their relative importance depicted via enlarged boxes in Figure 2.6. The construct of 'impact on environment' was assessed using both spatial and temporal (seasonal) comparisons of various environmental phenomena. A number of potential modifiers of 'impact on environment' were also identified which assisted in the formulation of the research design and in the interpretation of results.

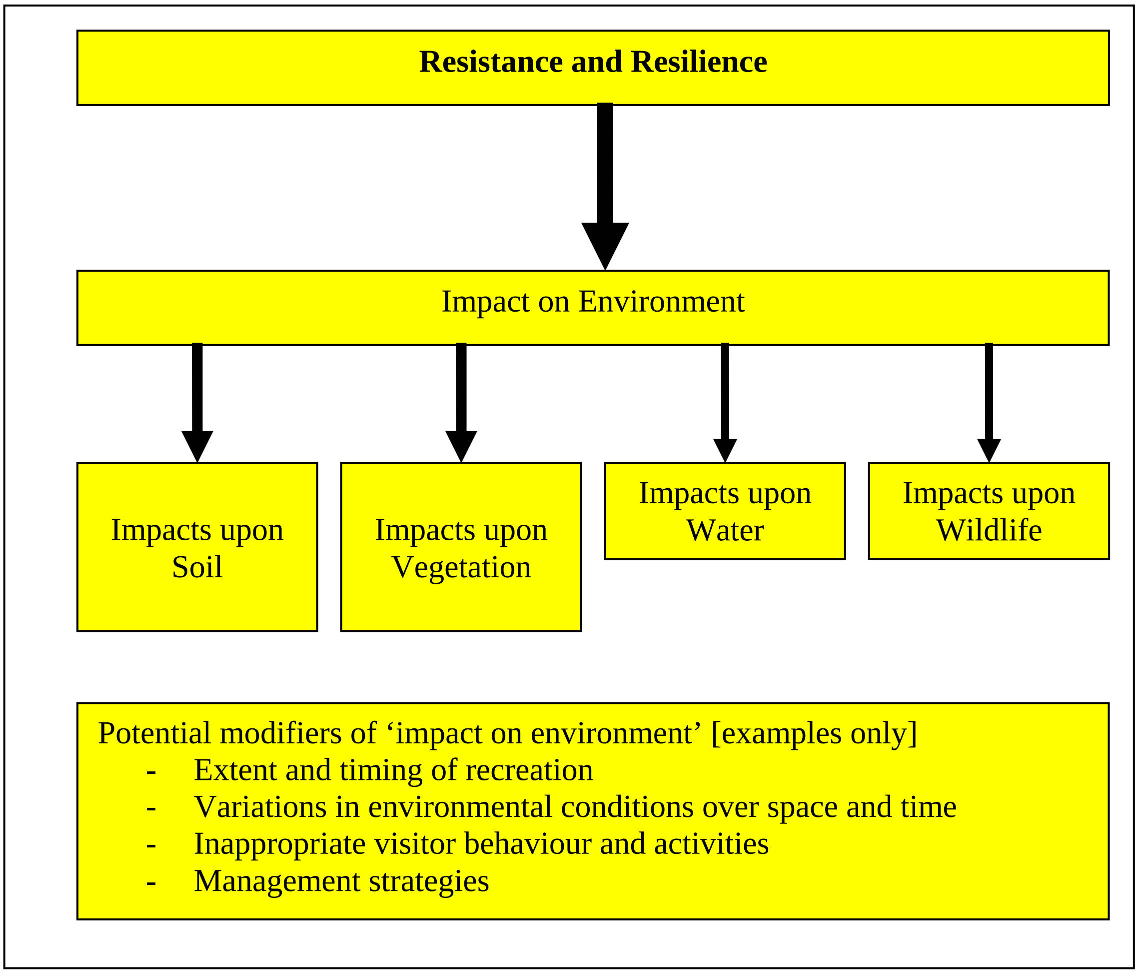

Figure 2.6 Conceptual and theoretical orientation of the biophysical impact assessment.

Conceptual and Theoretical Orientation of the Psychosocial Experience Assessment

'Psychosocial transaction' as one component of the human-environment transactional model was utilised as the conceptual and theoretical framework for the psychosocial experience assessment. The principal focus of this assessment was to examine the concept of 'impact on people', via an exploration of two related key variables, 'behaviour' and 'experience' (Figure 2.7). A number of potential modifiers of 'impact on people' were recognised which influenced the development of the research design and were relevant to the analysis.

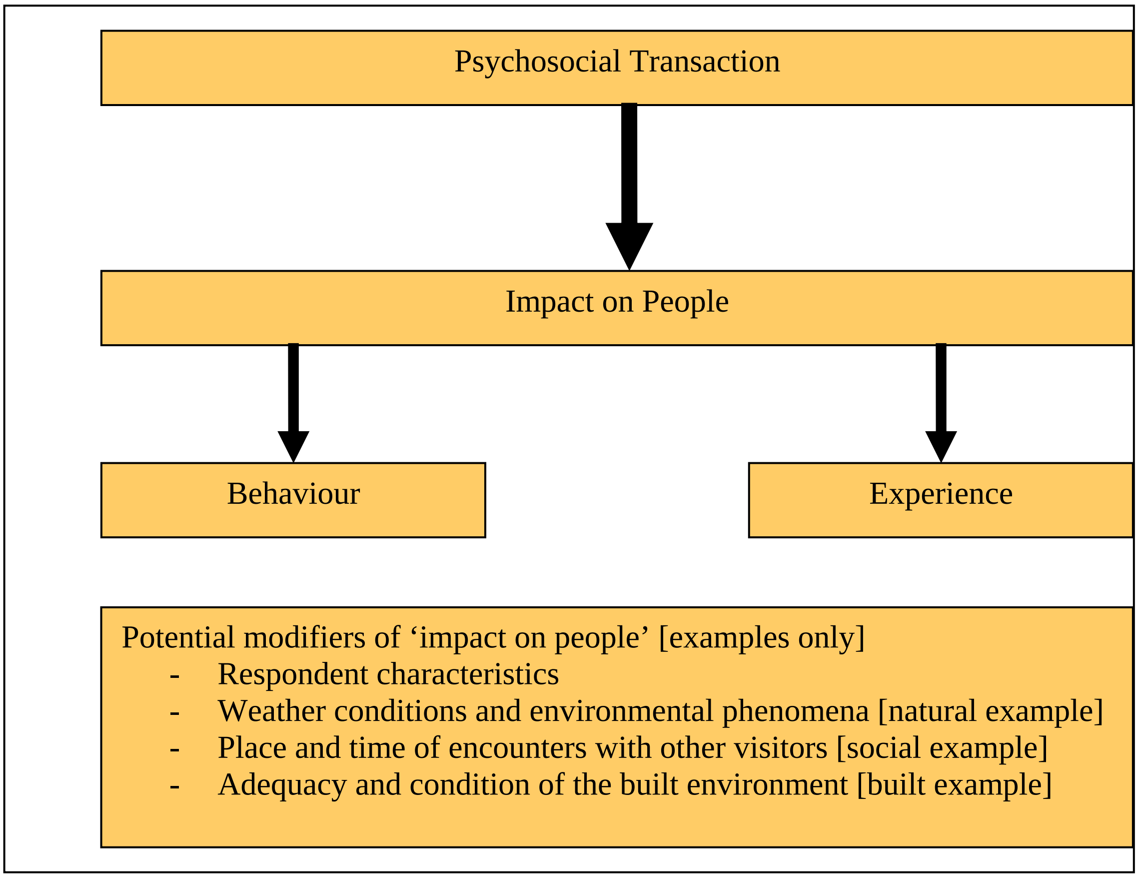

Figure 2.7 Conceptual and theoretical orientation of the psychosocial experience assessment.

2.7 SUMMARY

This chapter has provided an extensive overview of relevant literature pertaining to human-environment transactions, and has investigated a number of factors that influence both biophysical impacts and psychosocial experiences associated with visitor use of natural protected areas. It has demonstrated that effective protected area management is integral to the long-term sustainability of such areas when utilised for both conservation and recreation. The review has found that human-environment transactional models provide a suitable methodology with which to conceptualise the reciprocal relationships that take place between visitors and outdoor recreational settings. The chapter has confirmed that biophysical impacts associated with visitation remain relatively poorly understood within tropical rainforest environments. It has also established that appraisals of the natural, built, and social environments and the management of those environments are important influences upon the psychosocial experiences of visitors, and that this represents a largely neglected research avenue in relation to long-distance walkers.

CHAPTER 3 – THE STUDY LOCATION

3.1 INTRODUCTION

The chapter provides an introduction to the two study sites used for this research and is presented in three main sections as follows:

The Wet Tropics Region of North Queensland (Section 3.2)

The first section provides an overview of the Wet Tropics region of North Queensland where this research was undertaken. It includes a description of the regional climate, conservation and cultural heritage attributes, and various processes that threaten the World Heritage listed features of the region. This section also provides a summary of current tourism and recreation activity within the region and includes a review of present demand for long-distance walking activities, and long-distance walking track management within the region.

Mt Bartle Frere Track (Section 3.3)

This section provides an introduction to the Mt Bartle Frere Walking Track which is located within Wooroonooran National Park. The location, local weather conditions, soil, geology and landforms, floral and fauna, and cultural and historical attributes associated with the park are described in detail. The section concludes with a summary of existing management arrangements and visitation levels for this particular track.

Thorsborne Trail (Section 3.4)

The final section of this chapter provides an introduction to the Thorsborne Trail which is located within Hinchinbrook Island National Park. The description of the Thorsborne Trail uses the same format as that outlined above for the Mt Bartle Frere Track.

3.2 THE WET TROPICS REGION OF NORTH QUEENSLAND

The area referred to as the Wet Tropics region is located in the northeast coastal region of Queensland and extends for about 450 kilometres from approximately Townsville in the south to Cooktown in the north. Approximately 900,000 hectares has been included within the Wet Tropics World Heritage Area (Wet Tropics Management Authority, 1997). The location of both the Wet Tropics region and the Wet Tropics World Heritage Area are depicted in Figure 3.1, along with the approximate location of the two study sites. The Wet Tropics region contains a tiny proportion (0.01%) of the world's remaining tropical rainforests (Turton, 2005). In addition to rainforest the Wet Tropics region also contains examples of numerous other vegetation communities including mangrove forest, paperbark swamp, tall open forest, tall, medium and low woodland, and mixed rainforest with emergent sclerophyll trees (Australian Heritage Commission, 1986). The remaining tropical rainforest within the Wet Tropics region is effectively confined to three physiographic regions, the coastal plains, the coastal ranges and the Atherton Tableland. However, within these respective physiographic regions the present distribution of rainforest occurs across a diversity of elevations and soil types (Turton, 1991). The Wet Tropics region has been the focus of intense research effort over the past 20 years as evidenced by the publication of more than 1,000 scientific articles (Turton and Stork, 2006).

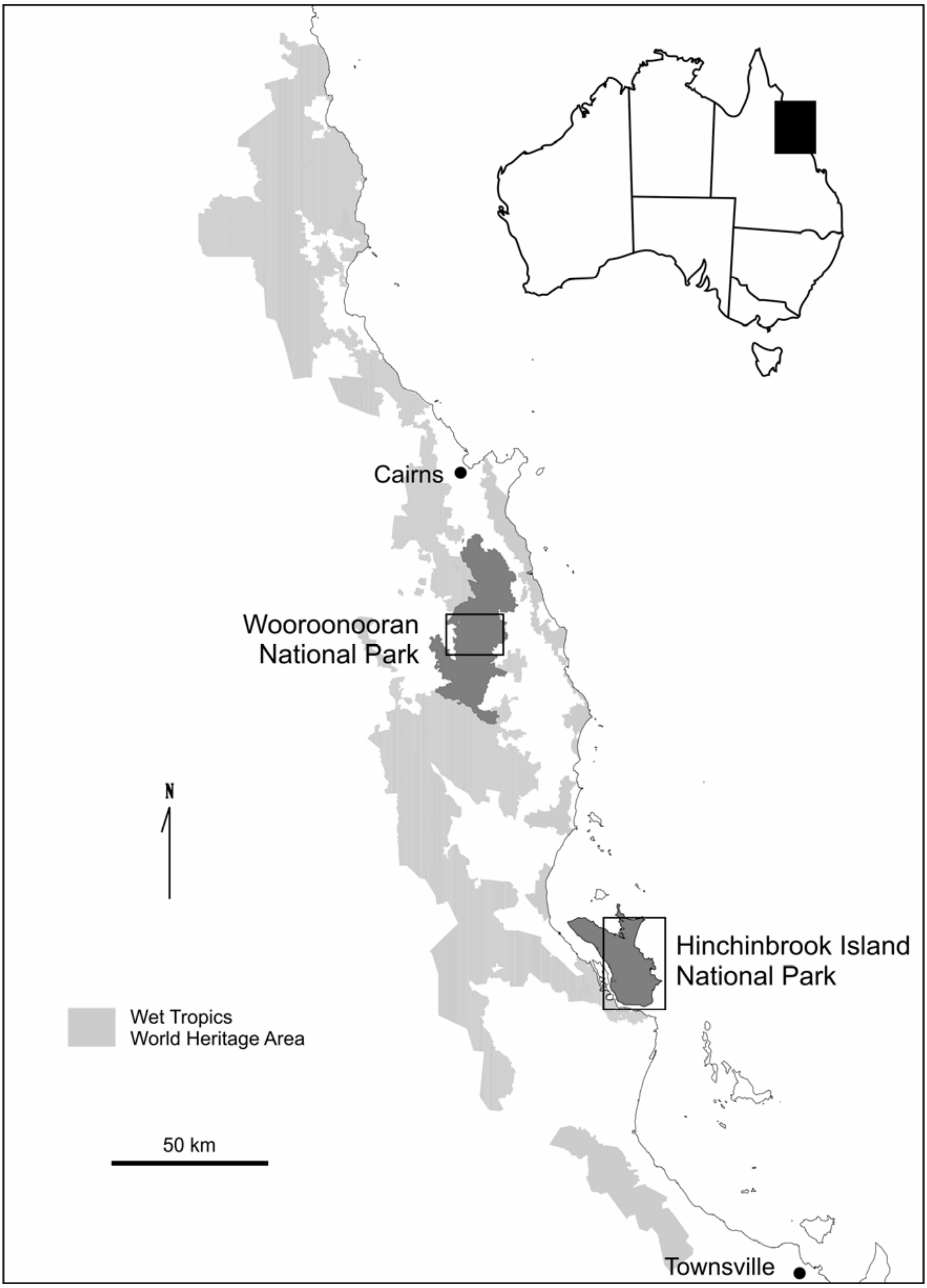

Figure 3.1 The Wet Tropics World Heritage Area depicting the location of study sites.

3.2.1 Regional climate

The climate of the Wet Tropics region is characterised by a predominance of easterly winds throughout the year, and largely conforms to the ‘Trade Wind Coast Climate’ category as defined by Gentilli (1972) in his survey of Australian climates. As a consequence of the synoptic climatology of the region in combination with the orographic uplift of the prevailing east to southeasterly winds by the coastal ranges, the Wet Tropics region experiences a high annual rainfall (Bonell, 1991). The Wet Tropics region has a mean annual rainfall of 1858 mm (SD $\pm$ 800 mm), although there is enormous spatial and seasonal variability across the area (Turton *et al.* 1999). The wettest regions within the Wet Tropics are located near Cape Tribulation and on the coastal fringe between Cairns and Tully, where annual mean rainfall consistently exceeds 3000 mm, increasing to as high as 9140 mm for Mt Bellenden Ker (Turton, 1991).

Rainfall within the Wet Tropics region is unevenly distributed throughout the year, resulting in distinct wet and dry seasons. During the summer months, circular disturbances such as tropical lows and cyclones in association with an unstable easterly wind stream to the south of the monsoon trough result in high seasonal rainfall totals (Bonell, 1991). In excess of 60 percent of annual precipitation usually falls during the four summer months between December and March (Turton *et al.* 1999). Mean rainfall during the wettest quarter (January - March) is 1092 mm (SD $\pm$ 397 mm) although this declines to 116 mm (SD $\pm$ 77 mm) during the driest quarter (July – September) as a consequence of the trade wind inversion (Turton *et al*. 1999). This seasonal variability in rainfall has important moisture availability implications for the region’s flora and fauna.

3.2.2 Conservation and cultural heritage attributes

The Wet Tropics of Queensland was inscribed on the World Heritage list as a natural heritage property on 9 December 1988 after satisfying all four criteria for listing as a natural heritage property (Wet Tropics Management Authority, 1996). To qualify for natural heritage listing a proposed site must satisfy at least one of the following criteria:

(1) be an outstanding example representing major stages of Earth's history, including the record of life, and significant ongoing geological processes in the development of landforms, or significant geomorphic or physiographic features; or
(2) be an outstanding example representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals; or
(3) contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance; or
(4) contain the most important significant habitats for in situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation.

(Source: Wet Tropics Management Authority, 1996. p.8.)

In October 2004 there were 788 properties inscribed on the World Heritage list with 611 listed for cultural heritage attributes and 154 listed for natural heritage attributes (United Nations Educational, Scientific and Cultural Organisation, 2004). Of the 154 properties that have been listed for natural heritage attributes, only 12 including the Wet Tropics of Queensland have satisfied all four criteria for natural listing (United Nations Educational, Scientific and Cultural Organisation, 2004). It should be noted that work is currently proceeding to enable renomination of the Wet Tropics of Queensland on the basis of cultural heritage attributes. As at October 2004, only 23 properties have successfully nominated to be placed on the World Heritage list for both natural and cultural heritage values (United Nations Educational, Scientific and Cultural Organisation, 2004).

The primary conservation significance of the Wet Tropics region is that it contains the largest continuous area of tropical rainforest in Australia (Australian Heritage Commission, 1986). The Wet Tropics region has great evolutionary significance in relation to the origin, evolution and dispersal of the angiosperms (Australian Heritage Commission, 1986). This has contributed to the Wet Tropics being regarded as one of the world's top biodiversity hotspots (Myers, 1988; Myers *et al*. 2000). The Wet Tropics region is floristically the most species diverse region in Australia and is home to over 2,840 species of vascular plants from 221 plant families (Wet Tropics Management Authority, 2003). Over 700 plant species only occur within the Wet Tropics region (Wet Tropics Management Authority, 2003). The relative importance of the Wet Tropics region to Australia's biodiversity is outlined in Table 3.1.

Table 3.1 Importance of the Wet Tropics region to Australia's biodiversity.

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please note that the reference for this table is available via the internet

(Source: Wet Tropics Management Authority, 2003. p.41.)

The Wet Tropics region also has a number of plant and animal species that are officially classified as rare or threatened (Table 3.2). In addition to flora and fauna, the Wet Tropics region also contains outstanding examples of geological and geomorphological processes, a living record of plant evolutionary stages, superlative natural scenery, unsurpassed wilderness values and a range of both indigenous and non-indigenous cultural heritage attributes (Wet Tropics Management Authority, 1997). The Wet

Tropics of Queensland is clearly of such conservation significance and universal natural heritage importance that its future protection and sound management is a global concern and justifies the focus of the current research project.

Table 3.2 Rare and threatened flora and fauna species in the Wet Tropics region.

Rare and threatened species of the Wet Tropics region	Flora species	Fauna species
Presumed extinct	17	0
Endangered	42	13
Vulnerable	54	18
Rare	238	51
Total	351	82

(Source: Wet Tropics Management Authority, 2003. pp: 45-46.)

The Wet Tropics region is also an important living cultural landscape which has cultural heritage value to both indigenous and non-indigenous people alike. There are approximately 18,000 Aboriginal people living in or near the Wet Tropics region and at least 16 Aboriginal language groups whose traditional lands incorporate part of the Wet Tropics region (Wet Tropics Management Authority, 1996). Furthermore, the area between Cooktown and Cardwell contains the only Australian Aboriginal rainforest culture still in existence with the surviving oral pre-history being the oldest known for any indigenous people without a written language (Wet Tropics Management Authority, 1996). Many of the walking tracks currently being used within the Wet Tropics region follow traditional rainforest Aboriginal routes that provided access to hunting and gathering areas, facilitated trade and ceremonial gatherings, and assisted to maintain kinship connections (Wet Tropics Management Authority, 2001). The Wet Tropics region also has considerable historical and social significance to various European, Chinese and other ethnic groups who began settling in the region almost 140 years ago to pioneer mining, logging, pastoralism and agriculture (Wet Tropics Management Authority, 1996), in addition to possessing aesthetic and recreational importance to current residents.

3.2.3 Threatening processes within the Wet Tropics region

Many of the conservation, cultural heritage and aesthetic attributes of the Wet Tropics region are vulnerable to a range of direct and underlying threatening processes. Direct threats can result in environmental change that reduces the capacity of ecosystems and species to survive and includes vegetation clearing and fragmentation, altered fire regimes, infestations by weeds, feral animals and pathogens, altered water flows, drainage of wetlands and climate change (Wet Tropics Management Authority, 2004a). Underlying or indirect threats can create demand for resources or act as vectors for direct threats and include regional population increase, demand for community infrastructure such as roads, water and electricity, urban development and pollution, agriculture and grazing, recreation and tourism (Wet Tropics Management Authority, 2004a). In June 1999 there were approximately 200,000 people living in the Wet Tropics region, with an annual population growth rate of 2.4 percent (Wet Tropics Management Authority, 2003). This suggests that indirect threats will continue to increase as demand for the construction of additional infrastructure and recreation opportunities within the Wet Tropics region continue to grow.

Nature-based tourism, which includes long-distance walking activities, can be regarded as another potential threat to the Wet Tropics region. At a global scale natural area tourism has increased at an unprecedented rate during the past decade and there is considerable evidence that some tropical rainforest destinations have been damaged by nature-based tourism (Turton and Stork, 2006). This is not surprising given that the nature-based tourism sector has increased from approximately two percent of all tourism in the late 1980s to about 20 percent by the late 1990s (Newsome *et al*. 2002). Long-distance walking is a popular way to experience core rainforest areas within the Wet Tropics region. Nevertheless, the construction of additional walking tracks can create linear barriers and corridors within previously intact rainforest areas and may further fragment core areas of the Wet Tropics region whilst providing a conduit for feral animals (Turton and Stork, 2006). Increased use of long-distance walking tracks can create demand for additional visitor facilities while hikers may function as vectors for the introduction and spread of weeds and pathogens such as *Phytophthora* within remote areas of the Wet Tropics region (Wet Tropics Management Authority, 2004a).

Visitor use of long-distance walking tracks and associated features such as swimming holes can result in direct impacts upon the environment through soil erosion, contamination of water supplies, vegetation damage, littering and illegal use of fire (Turton, 2005).

3.2.4 Tourism and recreation within the Wet Tropics region

The unique combination of natural and cultural heritage attributes present within the Wet Tropics region has in more recent times made the area an increasingly popular destination for visitors and local residents alike. Today tourism is extremely important to the economy and future prosperity of the Wet Tropics region. In economic terms it has been estimated that the contribution of tourism to the Wet Tropics region is in excess of $750 million annually (Driml, 1997). This is further evidenced by the fact that there are approximately 200 commercial tour operators utilising designated visitor sites within the Wet Tropics World Heritage Area (Bushell, 2003).

Total visitation to the World Heritage Area, counting both commercial tour passengers and independent travelers, is estimated to be in the order of 4.76 million visits per year (Wet Tropics Management Authority, 1997). Seasonal visitation to the World Heritage Area is reasonably evenly distributed throughout the year with approximately 2.4 million visits occurring during the dry season and 2.36 million visits taking place during the wet season (Wet Tropics Management Authority, 1997). It is estimated that there are about 4.65 million visits to the top 100 World Heritage listed sites identified in the Wet Tropics Nature Based Tourism Strategy (Bentrupperbäumer, 2003. pers. comm., 16 November). Of these, in the order of 3.5 million visits take place at the top 15 sites in the Wet Tropics World Heritage Area (Bentrupperbäumer, 2003. pers. comm., 16 November). Outdoor recreation by local residents within natural areas is a growing phenomenon throughout the developed world (Turton and Stork, 2006) and this trend is repeated in the Wet Tropics region where locals comprise approximately 40 percent of total visitation (Bentrupperbäumer and Reser, 2002).

3.2.5 Demand for long-distance walking within the Wet Tropics region

Although long-distance walking currently contributes only a small fraction of the total revenue generated by visitation to the Wet Tropics region, there is the potential for the economic importance of this activity to increase substantially in the future. Long-distance walking already makes a major economic contribution in other locations such as Tasmania, New Zealand, Europe, Canada and the United States. Some long-distance walks such as the Milford Track in New Zealand and the Overland Track in Tasmania have assumed ‘icon’ status and function to attract visitors to an area (Wet Tropics Management Authority, 2001). Some interest groups within the Wet Tropics region remain optimistic that the Misty Mountains Trails might assume similar iconic status in the future (Wet Tropics Management Authority, 2001).

Ongoing demand for long-distance bushwalking within the Wet Tropics region is directly dependant upon the availability of suitable walks for hikers to enjoy. Despite the fact that the Wet Tropics World Heritage Area covers approximately 900,000 hectares, walking activities are almost always associated with existing tracks or roads as a consequence of access difficulties associated with the thick vegetation and steep terrain that exists throughout much of the Wet Tropics region (Wet Tropics Management Authority, 2001). Indeed many of the natural features and attractions of the Wet Tropics region are only accessible by walking. At present the vast majority of walking activities within the Wet Tropics region takes place on short, well marked and intensively managed tracks (Wet Tropics Management Authority, 2001). This is evidenced by the fact that 25 short-distance walking tracks totaling a mere 40 km receive about 95 percent of the 1.5 million annual walks that take place in the Wet Tropics region (Wet Tropics Management Authority, 1997), confirming that long-distance walkers represent a small niche market relative to total numbers of walkers.

The visitor information section of the Wet Tropics Management Authority website provides listings of short, medium and long-distance walking tracks present within the Wet Tropics region that have been summarised in Table 3.3. Although the data in Table 3.3.indicates that only 15.2 percent of tracks in the region have been classified as long-distance tracks, they encompass over half the total distance of walking track length in the region. This suggests that although long-distance hikers have a limited number of walks to choose from, they nevertheless have access to a substantial proportion of the total walking track infrastructure present within the region. It should be noted that for the purposes of the Wet Tropics Management Authority website any walk of more than half a day in duration is classified as a long-distance walking track (Wet Tropics Management Authority, 2004b). This is substantially shorter than the definition adopted in the current research.

Table 3.3 Classification of walking tracks within the Wet Tropics region.

Track classification	Number of tracks	Percentage of total number of tracks (%)	Total track distance (km)	Percentage of total distance (%)
Short distance tracks	93	58.9	111.85	15.9
Medium distance tracks	41	25.9	222.4	31.6
Long distance tracks	24	15.2	368.7	52.5
Total	158	100	702.95	100

(Source: Wet Tropics Management Authority, 2004b).

The combination of access restrictions associated with the annual wet season, hot and humid weather conditions, steep topography, biting insects and the provision of minimal visitor infrastructure are likely to ensure that there will continue to be a limited market for long-distance walks that require overnight camping (Wet Tropics Management Authority, 2001). Nevertheless the popularity of the Thorsborne Trail on Hinchinbrook Island where demand for permits frequently exceeds supply (Cook and Harrison, 2002), indicates that latent demand clearly exists for more long-distance walks in remote areas of the Wet Tropics region (Wet Tropics Management Authority, 2001). There is also likely to be a need for additional overnight walks such as those on Mt Bartle Frere and the Goldfield Track which are ‘very well used’ by visitors each year (Wet Tropics Management Authority, 2001). This is further evidenced by the fact that demand for permits to complete the overnight walk up Mt Bowen on Hinchinbrook Island often exceeds availability, especially during the cooler months (Douglas, 2004. pers. comm., 23 June).

3.2.6 Management of long-distance walking within the Wet Tropics region

The management of long-distance walking tracks within the Wet Tropics region is subject to various international conventions, government legislation and policies. As both of the long-distance walking tracks being examined in this research project are World Heritage listed, their current and future management is subject to Australia's international obligations under the World Heritage Convention. The Mt. Bartle Frere Track in Wooroonooran National Park is contained within the Wet Tropics World Heritage Area while the Thorsborne Trail on Hinchinbrook Island forms part of the Great Barrier Reef World Heritage Area (Valentine, 1994). Under the World Heritage Convention, Australia has a responsibility to *protect, conserve, present, rehabilitate and transmit* World Heritage values to future generations (Wet Tropics Management Authority, 2000). To this end, walking has previously been identified as an excellent means of *presenting* World Heritage values to the visiting public (Wet Tropics Management Authority, 2001).

The management of all forms of tourism and recreation within the Wet Tropics region, including long-distance walking, are guided by the principles contained in the Wet Tropics Nature Based Tourism Strategy which was developed by the Wet Tropics Management Authority in consultation with various stakeholders including land managers, the tourism industry and indigenous people (Wet Tropics Management Authority, 2000). The Nature Based Tourism Strategy was released in August 2000 and aims to provide policy guidelines for the development and management of tourism within the Wet Tropics region (Wet Tropics Management Authority, 2000). The Nature Based Tourism Strategy particularly aims to foster the development of nature-based tourism that is both culturally appropriate and ecologically sustainable (Wet Tropics Management Authority, 2000). The Wet Tropics Management Authority subsequently developed the Wet Tropics Walking Strategy which was released in October 2001 and specifically focuses upon walking related activities. The Wet Tropics Walking Strategy operates under the broad policy framework provided by the Wet Tropics Nature Based Tourism Strategy and aims to coordinate the management of a network of high quality walking tracks that offer a diversity of walking experiences throughout the region, on land both within and external to the Wet Tropics World Heritage Area (Wet Tropics Management Authority, 2001).

Management of long-distance walking tracks within the Wet Tropics region is also subject to various legislative and planning regulations. Both the Thorsborne Trail and the Mt. Bartle Frere Track are subject to the provisions of the *Environment Protection and Biodiversity Conservation Act 1999,* the *Native Title Act, 1993*, the *Nature Conservation Act 1992,* and the *Forestry Act, 1959* (Wet Tropics Management Authority, 2000). In addition, management of the Thorsborne Trail on Hinchinbrook Island is also guided by the provisions of the *Great Barrier Reef Marine Park Act 1975* (Commonwealth legislation) the *Marine Parks Act, 1982,* and the *Coastal Protection and Management Act, 1995*, while operational management is outlined in the Hinchinbrook Island National Park Management Plan (Queensland Parks and Wildlife Service, 1999). Management of the Mt. Bartle Frere Track is subject to the *Wet Tropics World Heritage Protection and Management Act 1993* and the Wet Tropics Management Plan, 1998 (Wet Tropics Management Authority, 2000). There is currently no operational management plan for Wooroonooran National Park. Table 3.4 provides a concise summary of the principal international conventions, government legislation and policies that guide the management of the two study sites.

Table 3.4 Regulations governing the management of the two long-distance walking tracks under investigation.

Conventions, legislation and policies guiding management	**Mt Bartle Frere Track**	**Thorsborne Trail**
International conventions including World Heritage listings		
World Heritage Convention	✓	✓
Great Barrier Reef World Heritage Area (Listed 1981)		✓
Wet Tropics of Queensland World Heritage Area (Listed 1988)	✓	
Legislation		
Environment Protection and Biodiversity Conservation Act, 1999	✓	✓
Native Title Act, 1993	✓	✓
Nature Conservation Act 1992	✓	✓
Forestry Act, 1959	✓	✓
Great Barrier Reef Marine Park Act 1975		✓
Marine Parks Act, 1982		✓
Coastal Protection and Management Act, 1995		✓
Wet Tropics World Heritage Protection and Management Act 1993	✓	
Policies and operational plans		
Wet Tropics Nature Based Tourism Strategy	✓	✓
Wet Tropics Walking Strategy	✓	✓
Hinchinbrook Island National Park Management Plan		✓

The Wet Tropics Walking Strategy also includes a track classification system that is used by land managers within the Wet Tropics region as the basis for management of individual walking tracks. The track classification system classifies walking tracks into one of five categories according to their physical characteristics (length, width, associated infrastructure), maintenance and monitoring requirements, suitability for walkers of varying levels of fitness and experience, and their biophysical, social and managerial settings (Wet Tropics Management Authority, 2001). The track classification system is summarised in Appendix 1. Under the track classification system the Thorsborne Trail on Hinchinbrook Island is classified as a 'rough track', while the Mt. Bartle Frere Track in Wooroonooran National Park is classified as a 'marked route' (Wet Tropics Management Authority, 2001). Effective future management of long-distance walking within the Wet Tropics region now requires substantial research effort to implement the Wet Tropics Walking Strategy.

3.3 THE MT. BARTLE FRERE TRACK

3.3.1 Location

Mt. Bartle Frere in Wooroonooran National Park is the highest mountain in Queensland with an altitude of 1622 metres above sea level and forms part of the Wet Tropics World Heritage Area (Valentine, 1994). The Mt Bartle Frere Track is an example of a largely unregulated long-distance walking track with minimal visitor facilities and negligible management intervention in terms of control over visitor access. Hikers can walk to the summit of Mt. Bartle Frere by two different walking tracks. The western route begins at the end of Gourka Road, via Topaz Road which is on the Atherton Tableland (Plate 3.1). The track commences at an elevation of over 700 metres, with an average 1 in 8 gradient (Queensland Parks and Wildlife Service, 2001). The eastern route begins on the coastal plains at Josephine Falls to the north of Innisfail. The track begins at an elevation of 100 metres and has an average 1 in 5 gradient (Queensland Parks and Wildlife Service, 2001). Upon reaching the summit all hikers have the option of returning to their starting point via the same route or descending the mountain via the alternative route, although they need to make all of their own transport arrangements for the latter option. The location of the Mt Bartle Frere Track and the various camping grounds is depicted in Figure 3.2.

Plate 3.1 Mt Bartle Frere viewed from Lamins Hill, Gourka Road on the Atherton Tablelands.

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Figure 3.2. Location of the Mt Bartle Frere Track and associated camping grounds.
(Source: Modified from Queensland Parks and Wildlife Service, 2001).

3.3.2 Local weather conditions

Local weather conditions on Mt Bartle Frere are highly seasonal and subject to rapid change requiring hikers to prepare well for their trip. Conditions on the mountain can range from hot and humid during summer months, to sub zero overnight temperatures during winter, and is generally 10 degrees cooler than on the coastal lowlands (Queensland Parks and Wildlife Service, 2001). Walkers often encounter wet and drizzly conditions during winter months, while thunder storms are common during the summer months which results in views from the summit being frequently restricted by cloud. The highest annual rainfall ever recorded at the summit was during 1999 when the mountain received 11,850 mm (Queensland Parks and Wildlife Service, 2001). Mean annual rainfall on Mt Bartle Frere is expected to be similar to that reported by Turton (1991) for nearby Mt Bellenden Ker (9140 mm). Although the majority of hikers are believed to access the summit between July and October when weather conditions are optimal, visitors are nevertheless advised to be well prepared for their hike (Plate 3.2) as weather conditions can rapidly deteriorate (Plate 3.3).

Plate 3.2 Advisory sign at the commencement of the western route to the summit of Mt Bartle Frere via the Atherton Tablelands.

Plate 3.3 Weather conditions can restrict visibility and make track directional markers difficult to locate.

3.3.3 Soils, geology and landforms

Mt Bartle Frere forms part of the Bellenden Ker coastal range and is principally composed of resistant granite, with surrounding meta-sediments derived from the Hodgkinson Formation (Willmott and Stephenson, 1989). Some sections of the Mt Bartle Frere Track are located on basalt soils that are highly susceptible to soil compaction. The steep slopes, high rainfall and relatively high visitation levels mean soils can be prone to severe erosion in places. Large granite boulders and rocky outcrops are a common feature along much of the walking track (Plate 3.4).

Plate 3.4 Granite boulder lookout located between the Northwest Peak and the Summit of Mt Bartle Frere.

3.3.4 Flora and fauna

Vegetation along the track varies with altitude and includes examples of lowland, upland and highland rainforest, in addition to a number of restricted species. The lower slopes and foothills are typically covered in tall large-leafed lowland rainforest and areas of cyclone damaged scrub, with both leaf size and tree height declining with increased altitude (Queensland Parks and Wildlife Service, 2001). Frequent high winds result in highland peaks exhibiting a low dense and relatively even canopy (Plate 3.5), often largely comprised of *Leptospermum wooroonooran*, a species of ti tree that only occurs above 1500 metres (Queensland Parks and Wildlife Service, 2001). The Wet Tropics own Rhododendron, *Rhododendron lochae*, also occurs around an elevation of 1500 metres (Queensland Parks and Wildlife Service, 2001). In addition to possessing unique flora, Mt Bartle Frere contains some faunal species that only occur on the Bellenden Ker Range. These include the Bartle Frere skink, *Bartleia jiguru*, and a species of microhylid frog, *Cophixalus neglectus* (Queensland Parks and Wildlife Service, 2001). The mountain is also home to a high diversity of mammals, reptiles, amphibians and birds, in addition to numerous invertebrate species.

Plate 3.5 Highland vegetation growing on exposed peaks often possesses a relatively even and stunted canopy.

3.3.5 Historical and cultural attributes

Mt Bartle Frere is a source of considerable historical and cultural interest for both indigenous and non-indigenous Australians alike. The local Noongyanbudda Ngadjon Aboriginal people know Mt Bartle Frere as 'Chooreechillum' and regard it as their spiritual home and a place that their spirits return to following death (Queensland Parks and Wildlife Service, 2001). Aboriginal people have retained a close spiritual connection with Mt Bartle Frere for thousands of years having hunted and gathered on the mountain, although they rarely accessed the summit (Queensland Parks and Wildlife Service, 2001; Raymont, 2004. pers. comm., 15 July). Although Aboriginal people are not concerned about hikers walking to the summit of Mt Bartle Frere, they would like to be consulted about any future changes to the way the track is currently being managed (Raymont, 2004. pers. comm., 15 July).

In more recent times the Noongyanbudda Ngadjon people assisted well-known explorer and prospector Christie Palmerston to become the first European to climb to the summit on 26 October 1886 after a three day climb (Queensland Parks and Wildlife Service, 2001). During the 1890s tin miners established a rough trail up the eastern side of the mountain while working a claim near the summit, which has subsequently become the eastern route to the summit (Queensland Parks and Wildlife Service, 2001). The western approach to the summit utilises old Aboriginal tracks and has also been used by European prospectors and adventurers since the 1890s (Queensland Parks and Wildlife Service, 2001). Evidence of past mining activity near the summit is still visible today.

3.3.6 Existing management arrangements and visitation levels

Operational management of the Mt Bartle Frere Track is undertaken by the Queensland Parks and Wildlife Service, with staff from Josephine Falls chiefly responsible for the eastern route and staff from Lake Eacham primarily responsible for the western route. Walkers can overnight at one of the two camping grounds located within a kilometre of the summit, one on each side of the mountain (Figure 3.2). Additional camping grounds exist in close proximity to the start of both routes. The exact number of visitors using the Mt

Bartle Frere Track is unknown as some hikers complete the walk in a day and are therefore not required to complete a camping permit application, while a small number of other walkers are known to camp illegally (Jackson, 2003. pers. comm., 16 May). Nevertheless, it is known that the vast majority of walkers access the Mt Bartle Frere trackheads in private vehicles, and spend between one and two days on the track. On average between 100 and 200 camping permits are issued annually for Mt Bartle Frere, equating to more than 400 camping walkers most years (Table 3.5).

Table 3.5 Mt Bartle Frere Track annual visitation levels compiled from data supplied by the Queensland Parks and Wildlife Service, Lake Eacham and Josephine Falls.

Year	Camping permits	Number of campers/walkers	Notes
1995	146	387	Combined data both routes
1996	No Data	489	Combined data both routes
1997	No Data	514	Combined data both routes
1998	140	423	Combined data both routes
1999	123	407	Combined data both routes
2000	156	441	Combined data both routes
2001	180	522	Combined data both routes
2002	168	439	Combined data both routes
2003	188	455	Combined data both routes
2004	143	336	Combined data both routes

The Mt Bartle Frere Track requires a high degree of self sufficiency among hikers as there is minimal signage and visitor facilities. The track is reasonably well marked although heavy rain or dense cloud can often impede visibility making track markers difficult to locate. Apart from track directional markers and some very limited signage near the summit (Plate 3.6) there are very few facilities once visitors leave the respective trackheads to commence their hike, although water is generally available in close proximity to the two camping grounds located either side of the summit. During October 2004 a number of artificial hand-holds were installed along the eastern route in the area known as the ‘boulder field’ to improve hiker safety during the wet season when rocks become extremely slippery and dangerous to traverse. In the same month a combination camping platform and helicopter pad was constructed adjacent to the top eastern campground to facilitate helicopter access and reduce impacts associated with erection of tents. Kilometre distance markers were also installed along the eastern route to the summit in December 2004.

Plate 3.6 Proud hikers celebrate reaching the Mt Bartle Frere summit.

3.4 THE THORSBORNE TRAIL

3.4.1 Location

The Thorsborne Trail is located on Hinchinbrook Island which is Australia's largest island national park containing over 39,900 hectares of relatively pristine wilderness (Queensland Parks and Wildlife Service, 1999). The island forms part of the Great Barrier Reef World Heritage Area which was declared in 1981 (Valentine, 1994). The Thorsborne Trail is widely acknowledged as being one of the best long-distance walks within Australia (Roe, 2004), and is certainly the most highly regarded long-distance walk within the Wet Tropics region. The trail has also gained international status among hikers for its visual amenity, spectacular scenery and high quality wilderness values (Roe, 2004). In contrast to the Mt Bartle Frere Track, the Thorsborne Trail is an example of a highly regulated long-distance walking track with abundant visitor facilities and virtually complete management control over visitor numbers and access arrangements. The track is 32 kilometres long and extends from Georges Point in the south to Ramsay Bay in the north, and can be walked in either direction (Valentine, 1994). Access to the trackheads at either end is provided by two commercial ferry operators who service the island on a regular basis. The location of the Thorsborne Trail is depicted in Figure 3.3.

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Figure 3.3. Location of the Thorsborne Trail and associated camping grounds. (Source: Modified from Queensland Parks and Wildlife Service, 2004).

Hinchinbrook Island has escaped many of the impacting processes that have accompanied European settlement on much of the adjacent mainland. The island has experienced minimal logging, grazing and agricultural activity, and despite some limited tourism development there are no roads or urban development although one small scale ecotourism resort exists on approximately eight hectares at Cape Richards on the north of the island (Queensland Parks and Wildlife Service, 1999). Camping and day-use activities are also permitted at various locations on the island including Macushla and Scraggy Point (Queensland Parks and Wildlife Service, 1999). Although it was undoubtedly eligible to be included within the Wet Tropics World Heritage Area, Hinchinbrook Island was left out of the original nomination because it had already attained World Heritage status as part of the Great Barrier Reef World Heritage Area listing in 1981 (Valentine, 1994). Nevertheless, the Australian Heritage Commission included Hinchinbrook Island in their scientific study upon which the Wet Tropics nomination was based.

3.4.2 Local weather conditions

Local weather conditions along the Thorsborne Trail are highly seasonal and can range from hot and humid during summer months, to relatively cool overnight temperatures during winter. Walkers can encounter rain during any month of the year although cooler, drier conditions are more common in winter and spring months (Queensland Parks and Wildlife Service, 2004). As a consequence the trail is most popular between May and September when local weather conditions are optimal for camping and hiking. Hikers are permitted to walk the trail in all months of the year with the exceptions of February and March when the ferries do not operate.

3.4.3 Soils, geology and landforms

Hinchinbrook Island boasts a considerable diversity of landforms with the geological and geomorphological processes of the island and channel possessing World Heritage significance. Much of the island is mountainous with Mt Bowen the highest peak with an elevation of 1142 metres, followed by Mt Diamantina (955m), Mt Straloch (922m), Mt Pitt

(722m), and Mt Burnett (655m) (Queensland Parks and Wildlife Service, 1999). Mt Bowen is depicted in Plate 3.7.

Plate 3.7 Mt Bowen is the highest point on Hinchinbrook Island.

There are two distinct rock types on the island with the main mountains surrounding Mt Bowen composed of granite and the area surrounding Mt Pitt and Mt Burnett consisting of silicic volcanics (Queensland Parks and Wildlife Service, 1999). The island also contains extensive dune systems along the north eastern coast which reach a height of up to 60 metres at the northern end of Ramsay Bay, while sand deposits near Georges Point measure up to three kilometres long by two kilometres wide (Queensland Parks and Wildlife Service, 1999). The majority of the island's soils are both shallow and possess low nutrient status (Queensland Parks and Wildlife Service, 1999).

3.4.4 Flora and fauna

Hinchinbrook Island contains extremely high floristic diversity with the Thorsborne Trail passing through various vegetation types including tropical rainforest, wet sclerophyll, mountain heath (refer to Plate 3.8), ti tree swamp, open woodland, mangrove swamp, riparian communities and littoral vegetation. Although 30 plant communities containing about 700 species have been identified on the island, more species undoubtedly exist resulting in Hinchinbrook Island possessing outstanding conservation significance (Queensland Parks and Wildlife Service, 1999). In particular, the island contains one of largest areas of mangroves left in Australia with at least 31 species present in Missionary Bay and along the Hinchinbrook Channel (Queensland Parks and Wildlife Service, 1999), making the mangroves of Hinchinbrook Island some of the most diverse in Australia (Stanton and Godwin, 1989). Some 14 rare or threatened plant species have also been identified on Hinchinbrook Island including *Banksia plagiocarpa* and *Drosera adelae* which are restricted to the island and adjacent mainland, and *Comesperma praexcelsum* which is only known to exist on Hinchinbrook Island (Queensland Parks and Wildlife Service, 1999). Rangers undertake periodic fire management within various vegetation types along the Thorsborne Trail and conducted fuel reduction burns on the section of trail between Zoe Falls and Mulligan Falls during mid 2004 which had implications for both biophysical impact assessments and psychosocial survey responses.

Plate 3.8 Mountain heath vegetation overlooking Sunken Reef Bay.

Faunal attributes of Hinchinbrook Island and surrounds are extremely rich and include at least 19 mammals, 32 reptiles and approximately 150 bird species although formal fauna surveys have not yet been conducted and these numbers are likely to increase (Queensland Parks and Wildlife Service, 1999). Some of the more significant fauna species include the southern cassowary, dugongs, Irrawaddy dolphins, estuarine crocodiles, and the beach stone-curlew (Queensland Parks and Wildlife Service, 1999). Various native rat species are abundant on the island including the fawn-footed melomys (*Melomys cervinipes*) and the white-tailed rat (*Uromys caudimaculatus*), both of which require that campers remove all food from tents and backpacks at night to avoid rat damage (Queensland Parks and Wildlife Service, 2004).

3.4.5 Historical and cultural attributes

The traditional owners of Hinchinbrook Island are the Girramay and the Bandjin people, and although a reasonably large population of predominantly coastal Aboriginal people existed on the island prior to European arrival in 1864, this resulted in the decimation of both the Aboriginal population and much of their culture by the turn of the century (Thorsborne and Thorsborne, 1988). Nevertheless, Hinchinbrook Island remains an area of important cultural and spiritual significance to indigenous people today with evidence of various Aboriginal stone fish traps and middens remaining on the island (Queensland Parks and Wildlife Service, 1999). One such Aboriginal midden is visible within a hundred metres of first commencing the Thorsborne Trail at Ramsay Bay.

Hinchinbrook Island possesses minimal historical significance for non-indigenous people. One notable exception is the wreck of the ‘Texas Terror’, an American B24 Liberator bomber that crashed on the slopes of Mt Straloch in 1942 during World War II (Queensland Parks and Wildlife Service, 1999). Although hikers frequently climb to view the wreck many artifacts have now been removed from the site.

3.4.6 Existing management arrangements and visitation levels

Operational management of the Thorsborne Trail is undertaken by the Queensland Parks and Wildlife Service in Cardwell, who enforce a limit of 40 hikers on the trail at any one time, and encourage a maximum of six in any one group. As a consequence visitors need to book well in advance as demand for permits can exceed supply. The majority of visitors generally spend four days hiking the track (Roe, 2004). Commercial tour operators are not permitted to conduct guided tours on the Thorsborne Trail and there are no plans to modify this restriction in the future (Roe, 2004). The numbers of hikers completing the Thorsborne Trail consistently exceeds 2000 and often approaches 3000 walkers annually as summarised in Table 3.6 below.

Table 3.6 Thorsborne Trail annual visitation levels compiled from data supplied by the Queensland Parks and Wildlife Service, Cardwell.

Year	Camping permits	Number of campers/walkers	Notes
1998	1262	3236	-
1999	1143	2739	-
2000	1006	2573	-
2001	794	2078	Excludes October, November and December
2002	1024	2765	Excludes December
2003	843	2131	-
2004	902	2377	-

Although Thorsborne Trail hikers are still required to be self sufficient, they are provided with a greater range of facilities than is the case on the Mt Bartle Frere Track. All major camping grounds along the trail have toilets and metal rat proof food storage boxes, while some also have picnic tables. The Thorsborne Trail is also reasonably well marked in both directions (Plate 3.9) and has some limited interpretive and warning signage. Prior to commencing their walk all hikers are required to watch a Queensland Parks and Wildlife Service fifteen minute video entitled ‘Without a Trace’ which provides information about minimal impact camping and hiking.

Plate 3.9 Track directional markers along the Thorsborne Trail are different colours depending upon the route taken.

3.5 SUMMARY

This chapter has provided an overview of the Wet Tropics region and has confirmed that the area has outstanding conservation and cultural heritage significance. It has also established that the management of protected areas in the region is undertaken within a complex legislative and policy environment. The chapter has shown that long-distance walking already comprises an important recreational activity within the region, although visitation has the potential to threaten World Heritage attributes if not managed appropriately. The chapter concluded with an introduction to the physical and cultural parameters associated with the two study sites being the Mt Bartle Frere Walking Track and the Thorsborne Trail and has demonstrated that the two tracks offer visitors distinctly different experiences and are subject to dissimilar management regimes.

CHAPTER 4 – METHODOLOGY

4.1 INTRODUCTION

This chapter outlines the methodology used to answer the five research questions previously outlined in Chapter 1.

1. What are the biophysical impacts associated with visitor use of long-distance walking tracks within the Wet Tropics region and how do these impacts vary over space and among vegetation types along tracks?
2. How do biophysical impacts associated with visitor use of long-distance walking tracks within the Wet Tropics region vary in response to changing seasonality (wet and dry seasons)?
3. What is the profile of visitors (with respect to demographics, logistic arrangements, motivations) using selected long-distance walking tracks within the Wet Tropics region?
4. How do visitors perceive the natural, social and built environments associated with the two long-distance walking tracks being examined, and the management of these environments?
5. How satisfied are visitors with their experience of hiking the two long-distance walking tracks under investigation and what specific factors enhance or detract from the quality of their experience?

Two principal methodological approaches were utilised. Firstly, biophysical impacts were assessed along both walking tracks using rapid assessment methodology following the selection of a range of appropriate environmental indicators. This was complemented by a simultaneous investigation of visitors' psychosocial experiences using a self-report questionnaire that was completed on a voluntary basis by walking track users.

This chapter is presented in two main sections as follows:

Biophysical Impact Assessment Methodology (Section 4.2)

The first section provides an overview of the biophysical impact assessment methodology used. It describes the environmental indicators used to assess impacts both within quadrats and along linear transects. This section also describes the stratified random sampling research design, sampling methodology, data collection, and data analysis techniques used to investigate biophysical impacts.

Psychosocial Experience Assessment Methodology (Section 4.3)

The second section provides an outline of the methodology used to investigate the psychosocial experiences of long-distance walkers. It commences with a summary of the research design and sampling methodology, before discussing the layout, content and pre-testing of the survey instrument. The survey distribution methods are discussed for each track and the section finishes with a summary of the principal data analysis techniques used.

4.2 BIOPHYSICAL IMPACT ASSESSMENT METHODOLOGY

4.2.1 Research design

Biophysical impacts associated with visitor use of the two long-distance walking tracks under investigation were assessed using rapid assessment methodology in an attempt to quantify the extent of impacts. The majority of field techniques used to assess biophysical impacts are well established within the discipline of recreation ecology. Rapid assessment methodology represented the most appropriate methodology to answer the research questions relating to biophysical impacts within the timeframes and context of this study. Research conducted by Farrell and Marion (2001) within protected areas in Belize and Costa Rica has previously demonstrated that rapid assessment methodology can be used to effectively quantify visitor impacts along trails and at recreation sites within tropical rainforest environments, while favourable results have also been obtained within the temperate zone (Hammitt and Cole, 1998; Leung and Marion, 2000; Deng *et al*. 2003).

Rapid assessment methodology represents a cost-effective and relatively quick means of assessing a range of biophysical impacts in the field and can be replicated by other researchers and protected area managers to assess or monitor longitudinal impact trends (Cole, 1983; Farrell and Marion, 2001; Wilson *et al*. 2000a, 2000b). This methodology has the advantage of not requiring the transportation of large amounts of specialised field equipment which is an important consideration when researching long-distance walking tracks within protected areas as this necessitates that all equipment be manually transported to sampling points via foot (Plate 4.1).

Plate 4.1 Long-distance walking tracks required all field equipment be transported to sampling points via foot.

In practice rapid assessment methodology requires the selection of a range of key biophysical impact indicators that are both responsive to visitor impacts whilst providing robust and meaningful research data (Cole, 1983; Deng *et al*. 2003; Wilson *et al*. 2004a). Indicators should also be policy relevant, analytically valid, cost-effective and simple to understand (Ward *et al*. 2002). As the selection of appropriate indicators is integral to detecting environmental impacts resulting from visitor use, care was taken to ensure that indicators generally possessed the seven desirable characteristics identified by Hammitt and Cole (1998) (Table 4.1).

Table 4.1 Seven desirable features of environmental impact indicators.

1	Measurable – quantitative and subject to measurement.
2	Reliable - capable of being measured precisely by a range of different people, and capable of being replicated over time.
3	Cost effective – capable of being measured using relatively inexpensive equipment and techniques.
4	Significant – related to meaningful impacts that would be regarded as serious problems if they were to eventuate.
5	Efficient – reduces the total number of indicators that need to be assessed by providing an indication of multiple impacts.
6	Responsive – relate to impacts that are subject to management influence.
7	Sensitive – responsive to change in order to provide managers with an early warning system that enables corrective action to be taken before it is too late.

(Source: Derived from Hammitt and Cole, 1998).

This rapid assessment design also drew upon research which used a range of environmental indicators to measure biophysical impacts associated with short-distance walking tracks within the Wet Tropics region. Some indicators that have been demonstrated to be effective in measuring visitor induced trampling within the tropical rainforest environments of North Queensland included measurements of the extent of mineral soil exposure and soil erosion, the extent of root and rock exposure, the extent and depth of organic litter cover, the extent of ground vegetation cover, and counts of seedling density (Turton *et al*. 2000a, 2000b). Research by Butler (2002) conducted on undesignated walking tracks within the Wet Tropics region demonstrated that ground vegetation cover, mineral soil exposure, seedling density, and deliberate damage to vegetation were excellent indicators of biophysical impacts associated with visitor use. Butler also found that seedling density, ground vegetation cover and mineral soil exposure were particularly sensitive indicators capable of providing early warning of impact thereby enabling management to employ mitigation strategies before more severe soil compaction and erosion problems result. It must be emphasised that both of the research projects referred to above (Turton *et al*. 2000a; Butler, 2002) were conducted on short-distance walking tracks with high use intensity, not ungraded long-distance walking tracks. In addition to impacts that are directly attributable to visitor use of long-distance walking tracks, the current research project also sought to record incidences of other adverse biophysical impacts such as those associated with weeds and feral animals. This was deemed necessary since in many ecosystems the potential introduction of weeds, feral animals, and pathogens represent far more significant ecological impacts than localised trampling resulting from human visitation (Buckley and King, 2003).

Following identification of a range of prospective environmental indicators from those reported in the published literature, these were tested under field conditions along informal walking tracks and mountain bike circuits on Saddle Mountain at the rear of the Cairns Campus of James Cook University during August 2003. Potential indicators were tested to ensure that they were accurate, replicable, able to be measured using minimal equipment and capable of producing meaningful research data. Some original environmental impact indicators that have been used elsewhere were rejected on the basis of their being either impractical, inaccurate or producing data that were not meaningful within a tropical long-distance walking track environment. While soil compaction has been assessed in the field by a number of other researchers reviewing trampling impacts (Jim, 1987; Sun and Liddle, 1993a; Graham, 1994, Karger, 1997) it was rejected in this instance for a number of reasons. Firstly, some degree of soil compaction is inevitable and unavoidable in association with the tread zone of a walking track, which to some degree represents a ‘sacrifice’ zone where some impacts are tolerated and indeed expected by management who attempt to ensure that impacts do not extend to the surrounding biota (Hammitt and Cole, 1998; Turton, 2005). Soil compaction data is generally only meaningful in the early stages of impact with most compaction occurring during the first few passes (Hammit and Cole, 1998). Secondly, field trials of penetrometers to assess soil compaction on Saddle Mountain during August 2003 generated results that were highly variable and at times inaccurate depending upon soil moisture conditions, the presence of gravel, and placement of the instrument. Measurements of soil compaction using penetrometers were also found to be unreliable in previous research within tropical rainforest environments (Talbot *et al*. 2003).

While assessments of soil compaction using alternative techniques such as bulk density would undoubtedly have improved the accuracy of field measurements, this technique was not consistent with the rapid assessment approach. Since soil bulk density measurements would have required the collection and transport of sealed soil samples to a laboratory for oven drying and subsequent analysis, this would have necessitated soil samples from both tracks being transported for long distances in a backpack. Given that each walking track consists of rough terrain and that many hundred soil samples would have been required, soil bulk density was dismissed as a realistic alterative measure of soil compaction. Assessments of tread incision depth to quantify soil erosion were found to be similarly unrealistic in the field. As limited sections of both walking tracks under review have undergone minor excavation and/or placement of stepping stones to either improve drainage or access for walkers, this would make determining the height of the natural ground surface difficult to ascertain in some instances. Consequently these two indicators were rejected in favour of others that were believed capable of generating more useful data in the context of the research questions.

This research design utilised a stratified random sampling procedure. Sampling points were randomly established along each track in proportion to the major vegetation types. In stratified sampling a researcher initially divides the population into strata and then draws a random or systematic sample from each subpopulation (Neuman, 1997). This guarantees representativeness by fixing the proportion of each stratum within a sample. Whereas in simple random sampling there is an equal probability of selecting any individual from a population, in stratified sampling there is generally an unequal probability of selection once the population is divided into strata and a simple random sample of each stratum is selected (Henry, 1998). Nevertheless, provided the stratum information is accurate, stratified sampling produces a more representative sample than would be the case using simple random sampling (Pomeroy and Service, 1986; Neuman, 1997). Stratification also lowers the sampling error (Henry, 1998). Stratified random sampling represents an appropriate research design given the biophysical impact research questions posed.

The biophysical impact assessment component required the issue of a Scientific Research Permit from the Queensland Parks and Wildlife Service (QPWS). A Scientific Research Permit (No. WITK01383603) was issued on 12 August 2003 enabling the biophysical impact assessment phase to commence.

4.2.2 Sampling methodology

The sampling methodology adopted enabled assessments of both spatial and temporal variability in biophysical impacts. Spatial variation was assessed by comparing biophysical impacts at 100 sampling points established along each of the two walking tracks under investigation. Spatial comparisons were made within one metre quadrats placed in the tread zone (where hikers step), buffer zone (edge of track), and at a control site located 20 metres from the track centre at each sampling point. In addition to data collection within quadrats, a range of other environmental indicators were assessed along a linear transect that extended for 20 metres in each direction along the track either side of the tread zone quadrat. Figure 4.1 schematically represents the sampling methodology that incorporated both quadrats and transects.

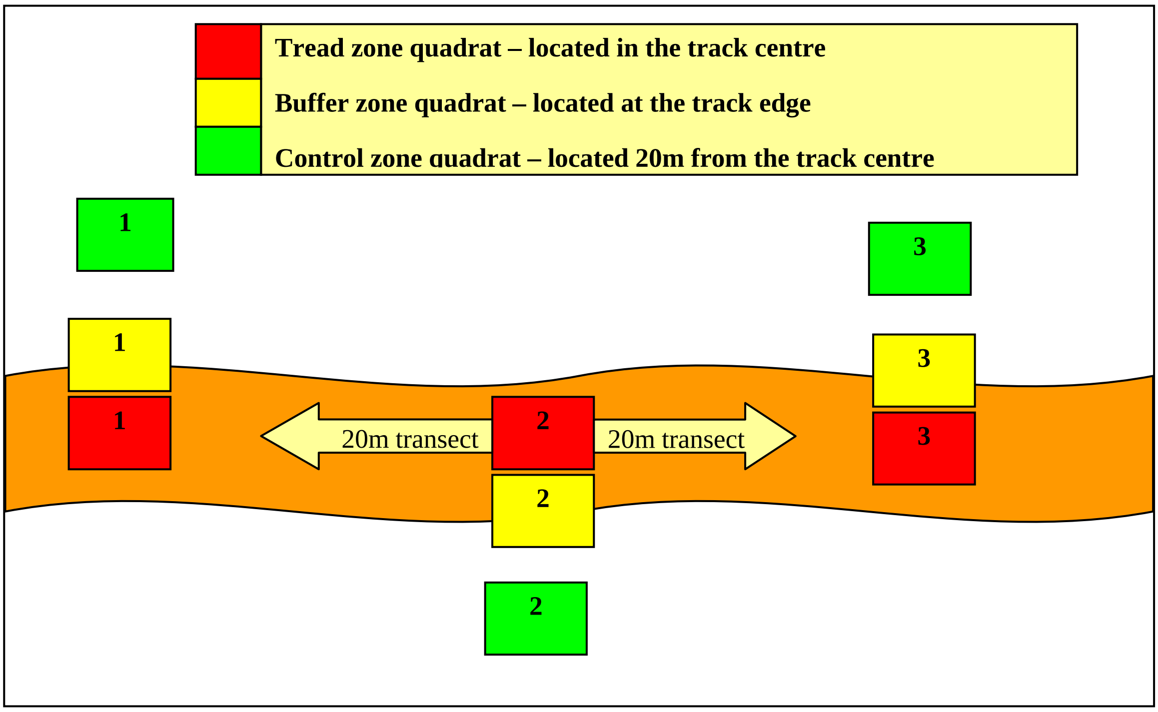

Figure 4.1 Biophysical impact assessment sampling design.

Buffer zone and control samples were alternated from left to right along the track to reduce bias in sampling. Stratification of sampling points according to the four principal vegetation types along each walking track enabled spatial comparisons to be made between vegetation types (Table 4.2). It should be noted that all sections of the Thorsborne Trail comprising beach or low lying coastal headlands were excluded from both the stratification and biophysical impact analysis process due to the pointlessness of attempting to sample walking related impacts within the inter-tidal zone. Broad vegetation types were determined using a combination of forest structural characteristics including growth form, canopy cover and crown separation, species composition, and leaf size consistent with classes outlined by Walker and Hopkins (1998). A combination of elevation and rainforest structural characteristics were then used to delineate between four different types of rainforest that have been identified in trail notes for the Mt Bartle Frere Track (Queensland Parks and Wildlife Service, 2001). Vegetation types along the Thorsborne Trail were determined solely on the basis of forest structural characteristics (Walker and Hopkins, 1998).

Table 4.2 Stratification of sampling points according to vegetation type.

Classification of vegetation type on each track	Length (metres)	Proportion (%)
Mt Bartle Frere		
Tableland forest	4,750	27
Cloud forest	5,072	29
Upland forest	2,869	16
Lowland forest	4,806	28
Total	*17,497*	*100*
Thorsborne Trail		
Closed forest	9,868	49
Open forest	2,555	13
Heath	5,256	26
Swamp	2,417	12
Beach / headlands (*Excluded from sampling*)	11,318	0
Total	*31,414*	*100*

No attempt was made to investigate attenuation effects as the vast majority of hikers who commenced either walk generally completed their hikes. This was certainly the case for Thorsborne Trail hikers who were transported to Hinchinbrook Island via commercial ferries (which subsequently departed) and needed to complete the entire walk in order to obtain transportation from the island back to the mainland. The sampling methodology adopted also enabled assessments of temporal variability in biophysical impacts. Temporal variations were compared by undertaking replicated sampling during both the wet and dry seasons of 2004. Control zone quadrats were excluded from seasonal comparisons because although they provide interesting data about natural (background) environmental variability, they do not provide insights into impacts associated with long-distance walking activities. Whilst it was not possible to eliminate pre-existing cumulative impacts from extended visitor use over many years, the replicated wet and dry season sampling methodology provided at least some opportunity to consider the concept of *ecosystem resilience* associated with reduced visitor numbers during the wet season.

A trundle wheel (Plate 4.2) was used to measure both track distances and the lengths of vegetation types along each walking track. A trundle wheel was preferred to a GPS (Global Positioning System) unit as the latter was rendered inoperable by the high canopy cover along both walking tracks that prevented satellite access. Once the relative lengths and proportions of vegetation types were known for each track the 100 sampling points were randomly stratified and established in the field. In practice the lengths of each vegetation type were divided into ten metre intervals and the required numbers of sampling points drawn from a bucket as determined by their relative proportions (Table 4.2). For example, the stratification of cloud forest (total length 5,072 metres) involved selecting 29 sampling points from a possible 507. These were then ranked in ascending order to facilitate placement upon the walking track with the trundle wheel.

Plate 4.2 Trundle wheel used to measure track distances and to stratify the relative lengths of vegetation types.

Sampling points were established on Mt Bartle Frere during December 2003 and on Hinchinbrook Island during March 2004, and were identified by nailing a small (approximately 120 mm x 120 mm) flat diamond shaped metal marker to the base of the closest suitable tree on the track edge (refer to Plate 4.3). The ongoing use of both walking tracks by hikers throughout the year meant that it was not feasible to establish permanent quadrat or transect points on either walking track. Rather the exact position of each quadrat and transect had to be reestablished using a tape measure and reference to the semi-permanent metal markers nailed to trees. In this way it was possible to ensure that quadrats were placed in exactly the same locations during both wet and dry season sampling. The metal markers were cut from one millimeter brown colour bond steel sheets which ensured that they would not deteriorate within the life of the research project, while still remaining sufficiently light to enable them to be transported in a backpack for long distances. The metal markers were consecutively numbered (1-100) on each walking track using a black permanent marker pen with this number subsequently used to uniquely identify that location as one of the 100 sampling points where biophysical impact assessment data was collected.

Plate 4.3 Locating quadrats and linear transects adjacent to a sampling point marker on the Thorsborne Trail.

4.2.3 Quadrat sampling

A range of indicators were assessed within each quadrat. Track width was measured using a tape measure to record the active track width or the width of track surface at ground level within the tread zone where hikers have repeatedly stepped. In practice track width was recorded by examining the tread zone surface for hiking boot impressions, scuff marks on roots and rocks, or other indicators such as pulverised leaf litter. Topography in the immediate vicinity of sampling zones was assessed into one of three classes (flat, undulating or steep) using a tennis ball to gauge the extent of slope. A tennis ball was placed in the centre of each quadrat and the propensity of the ball to roll was recorded. If the tennis ball remained stationary within the centre of the quadrat the terrain was classified as flat, if the ball immediately rolled beyond the quadrat it was classified as steep and all remaining tennis ball movements resulted in the terrain being classified as undulating. The technique used to assess topography (tennis ball method) was developed by the researcher during this project.

A breakdown of ground cover composition within quadrats was obtained by estimating the relative percentages of bare soil, leaf litter, tree roots, rocks, woody debris and living vegetation recorded within each quadrat. Care was taken to ensure that the combined percentages of ground cover composition within each quadrat summed to 100 percent. Organic litter cover depth was measured with a ruler in the centre and in the four corners of each quadrat and an average calculated. Overhead canopy cover was estimated to the nearest five percent by looking upwards through an inverted plastic funnel from the centre of the quadrat. The technique used to assess canopy cover (funnel method) was developed by the researcher during this project. Although an attempt was made to calibrate the funnel method against values obtained using a forest densiometer, comparisons were found to be highly inconsistent due to the differing field of view (proportion of canopy visible using either methodology) and were greatly influenced by canopy height. Seedling density was recorded within each quadrat by counting the number of living dicot seedlings that were less than half a metre (<0.5 m) in height. In this research any woody plant <0.5m in height, with the exception of vines, was counted as a seedling. Soil erosion within quadrats was subjectively categorised into one of four classes (none, slight, moderate, severe) depending upon the extent of exposed tree roots and apparent soil removal. All incidences of weed species within quadrats were recorded. A list of all environmental indicators used in quadrats and a justification for their selection is contained in Table 4.3.

Table 4.3 Quadrat biophysical impact indicators.

Environmental indicators	Explanation for selection of indicators
Vegetation type	Enables biophysical impact comparisons to be made between different vegetation types
Track width at ground level in tread zone (m)	Track width can indicate track problem areas in addition to influencing light levels available to weed species
Track topography (estimated into 3 classes)	Topography has implications for drainage and also ultimately influences soil erosion potential
Estimated ground cover – bare mineral soil (%)	Exposed soil is generally more susceptible to erosion and smearing and can also be indicative of trampling
Estimated ground cover - leaf litter (%)	Leaf litter helps protect the underlying soil and can be an indicator of the extent of trampling occurring
Estimated ground cover – tree roots (%)	Exposed tree roots can provide an indication of soil erosion and walking track surface stability
Estimated ground cover - rocks (%)	Rocks generally indicate a stable track surface with very high resistance to trampling impacts
Estimated ground cover – woody debris (%)	Woody debris helps protect underlying soil while larger debris (tree falls) can indicate poor track maintenance
Estimated ground cover – living vegetation (%)	The extent of living vegetation such as shrubs, seedlings and ground covers can indicate trampling impacts
Organic litter cover depth	Organic litter cover depth can provide an indication of track wear associated with pulverisation by boots
Estimate of overhead canopy cover (%)	Canopy cover protects soil from raindrop splash and reduces light available for weed establishment.
Seedling density (number of incidences <0.5 m high)	Seedling counts provide an indication of the extent to which walkers impact upon seedling recruitment
Extent of soil erosion (estimated into 4 classes)	Soil erosion can threaten the long term sustainability of walking tracks and can create safety hazards for walkers
Evidence of weeds (number and species)	Weed can threaten the integrity of surrounding vegetation, in addition to being unsightly to some visitors

Plate 4.4 Measuring track width and organic leaf litter depth within a one metre square quadrat on Mt Bartle Frere Track. Note the numbered brown sampling point marker nailed to a tree.

4.2.4 Transect sampling

Additional indicators were assessed along the 20 metre transect either side of each tread zone quadrat, with all but two indicators restricted to the confines of the track clearing. The two exceptions were litter and human body waste which were recorded even if they occurred beyond the confines of the walking track clearing. Social trails occurring along 20 metre transects were counted and the reason for their creation (if apparent) was recorded. Incidences of separate pieces of litter were counted and the nature of the object recorded as being either plastic, glass, metal, organic or other. It should be noted that related pieces of litter that were obviously all parts of a whole, such as three separate pieces of banana skin, were only counted as one piece of litter. Counts were also made of incidences of human body waste (faeces or toilet paper) and vegetation damage (trampled seedlings, broken branches, nails, wire and carvings in trees etc. Individual weeds were not counted along 20 metre transects but rather were estimated into one of four classes (none, slight, moderate, severe) depending upon the severity of the infestation. Counts were made of incidences or evidence of feral animals, with cane toads and pig diggings being the only sightings. Incidences of additional track problems were noted along transects with these being grouped as fallen trees, low overhanging branches and drainage problems. A list of transect indicators and a justification for their selection is contained in Table 4.4.

Table 4.4 Transect biophysical impact indicators.

Description of indicators	Explanation for selection of indicators
Counts of social and undesignated trails and reason for same if apparent	Undesignated trails indicate inappropriate visitor behaviour and increase the potential for soil erosion, vegetation trampling and weeds
Counts of human litter (number of incidences)	Litter provides an indication of inappropriate visitor behaviour and can result in both adverse biophysical impacts and negative psychosocial experiences
Counts of human body waste disposal (evidence of faeces and toilet paper)	Evidence of human body waste indicates inappropriate visitor behaviour and can contaminate water or degrade experiences for other walkers
Counts of human vegetation damage (carvings, nails in trees, broken branches etc.)	Vegetation damage provides an indication of inappropriate visitor behaviour and can result in plant fatalities and degrade the experiences of other hikers
Evidence of weeds (estimated into four classes depending on frequency)	The spread of weed species along walking tracks can threaten the integrity of the surrounding vegetation, in addition to being unsightly to some visitors
Evidence of feral animals (counts of feral animal sightings and pig diggings)	Feral animals can threaten ecosystem integrity in addition to adversely impacting upon the quality of visitor experiences
Identification of track problem areas (recorded as present or absent)	Track problems identified included soil erosion, track braiding, fallen trees, low overhanging branches, impeded drainage and potential safety hazards

4.2.5 Data collection

Biophysical impact assessments were undertaken for two extended periods at each study site, once in the wet season and once in the dry season of 2004. On both occasions rapid assessment methodology was used to assess biophysical impacts at each of the 100 sampling points. Environmental indicators were first assessed within the tread, buffer, and control zones at each sampling point using a one metre quadrat constructed from PVC pipe. Field measurements were initially taken in the tread zone at the centre of the track. Next buffer zone (or edge of track) samples were taken adjacent to each tread zone and finally control zone samples were taken within the undisturbed forest at a distance of 20 metres from the track centre. It should be noted that as a consequence of safety concerns associated with steep slopes and cliff edges along the Mt Bartle Frere Track it was not always possible to sample 20 metres from the track centre, necessitating control zones being established as close as practicable to this distance.

After field measurements were completed within quadrats at each sampling point, additional indicators were assessed along the 20 metre linear transects either side of the tread zone quadrat.

Data collected within the tread, buffer and control zones were recorded on a ‘Quadrat Field Proforma’ (Appendix 2), while data collected along transects were recorded on a ‘Transect Field Proforma’ (Appendix 3). The majority of field proformas were printed on water resistant paper to ensure data integrity during wet conditions. Prior to commencing biophysical impact sampling along tracks all field volunteers were trained in the assessment of environmental indicators and correct completion of the two field proformas to ensure consistency between recorders. Field volunteers conferred with the researcher if they were unsure about any aspects of data collection at any time during field sampling. Periodic checks of data recorded by field volunteers were made to ensure data accuracy and reduce the likelihood of sampling errors.

Plate 4.5 Severe soil erosion associated with the Mt Bartle Frere Track.

4.2.6 Data analysis

All biophysical impact assessment data were transcribed from field proformas into an SPSS (Statistical Package for Social Sciences) data file in conjunction with code books to ensure data integrity (Appendix 4 and 5). Following the completion of data entry the final database was screened for administrative errors such as missing or incorrect entries. All data were then assessed for normality of distribution and skewness, outlying scores, and for homogeneity of variance to determine if it was suitable for various parametric analysis techniques since normality is a prerequisite for many statistical tests. Normality was assessed using a combination of histograms, Q-Q plots, Stem-and-Leaf plots and the one-sample Kolmogorov-Smirnov test. The vast majority of variables were not normally distributed and data were unable to be normalised. This mandated that non-parametric comparative data analysis techniques were used. All assumptions were satisfied for all statistical methods used throughout the analysis phase. Combinations of descriptive and comparative statistics were subsequently used to analyse the data sets as outlined below.

Descriptive Statistics

Various descriptive statistics were used to describe the biophysical impact assessment results obtained from each walking track during the sampling period. These included a range of measures of central tendency and variability (mean, median, minimum, maximum, range, and standard errors) for the environmental indicators. Biophysical impact results were generally presented using box and whisker diagrams (depicting medians and percentiles), mean and standard error bars, percentages, frequency bar graphs and tables. Means were used to compare interval or continuous data, while medians were used to compare rank or ordinal data.

Comparative Statistics

The Kruskal Wallis *H* test was initially used to compare spatial variability between the tread, buffer and control zones associated with sampling points along each walking track. The Kruskal Wallis *H* test compares the sum of ranks in groups to determine if the distribution of variables is the same in all groups (Norušis, 1996). It is designed for use with non-parametric numeric data measurements that can be ordered and represents the non-parametric equivalent of one-way analysis of variance (Norušis, 1996). The Kruskal Wallis *H* test has a number of generic assumptions that must be satisfied before testing can proceed. The test requires that all data be collected from independent, randomly obtained samples from populations of the same shape and assumes equal variances, although the data need not be from normal populations (Norušis, 1996; Coates and Steed, 2003). Once it was determined that significant differences existed between the three sampling zones, a Mann Whitney *U* test was used for post-hoc comparisons to determine exactly where the differences occurred.

Mann Whitney *U* is the non-parametric equivalent of the two sample t-test and does not assume that data has either a normal distribution or that variances are homogenous (Dytham, 1999). The Mann Whitney *U* test is computed in exactly the same manner as the Kruskal Wallis *H* test (including the same assumptions) except that there are only two groups (Norušis, 1996). Following advice from the University statistician a Bonferronni correction was applied to each Mann Whitney *U* test in order to keep the significance level at 0.05. Mann Whitney *U* tests were also used to compare the influence of seasonality (wet and dry seasons) upon environmental indicators along both tracks. The confidence level or level of significance for both tests is commonly set at 0.05 (95 percent confidence) or 0.01 (99 percent confidence) with level of significance usually represented by the letter P (Reid, 1987). Consequently a test result of P = 0.0006 can be interpreted as meaning that there are only 6 chances in 1000 that the statistic is unreliable (Reid, 1987). The significance level was consistently set at the 0.05 level, but results that satisfy a higher standard of significance were reported.

Chi-square tests were used to examine relationships between a range of categorical variables that generated frequency data including vegetation type, topography, soil erosion and feral animals. The Chi-square test requires that all observations have been obtained via random sampling and are independent, with a lowest expected cell frequency of five (Coates and Steed, 2003). The Chi-square test for relatedness or independence is used to compare frequency data or counts of particular variables (Zar, 1984). This test is often used to analyse the relationship between two categorical variables, in order to determine if a relationship exists (Coakes and Steed, 2003). Interpretation of the Chi-square test result requires examination of the statistic generated to determine if it is below the alpha level set for the test. In this research the significance level for all Chi-square tests was set at the 0.05 level.

4.3 PSYCHOSOCIAL EXPERIENCE ASSESSMENT METHODOLOGY

4.3.1 Research design

The collection of psychosocial experience data from visitors requires a number of decisions to be made about the design and conduct of the research well in advance to commencement. For example, researchers need to determine whether questionnaires, personal interviews, visitor observations or any combination of these techniques will be the more efficient and effective means of obtaining the desired data in order to answer specific research questions. It was decided that a self-report visitor questionnaire with a cross-sectional design was the most appropriate methodology given the research questions. Cross-sectional designs produce a snapshot of groups at one point in time and produces results that are largely descriptive (Fink, 1995). Questionnaire surveys represent a highly credible and effective methodology to collect information about the activities and expectations of visitors in relation to natural areas and are widely used for this purpose (Newsome *et al*. 2002; Moore *et al*. 2003). Questionnaires allow respondents to provide a self-reported appraisal of the nature and quality of the human-environment encounters being investigated. In this context an appraisal is best understood as ‘an individual’s personal impressions of a setting’ (Gifford, 1996. p. 48). Surveys enable researchers to maximise the number of participants that contribute research data, while mimimising some of the ethical and temporal constraints associated with other data collection techniques such as behavioural observations.

The psychosocial experience assessment required both a Scientific Research Permit from QPWS and the approval of the James Cook University Human Ethics Committee. A Scientific Research Permit (No. WITK01383603) was issued by QPWS on 12 August 2003 while Human Ethics Approval (Notice No. H1655) was granted by James Cook University on 29 August 2003 enabling the psychosocial experience assessment component to proceed.

4.3.2 Sampling methodology

Once the decision was made to collect psychosocial data from visitors via a survey instrument, it was necessary to develop a suitable sampling methodology that would both maximise response rates and be representative of the population of walking track users. This was achieved by adhering to a number of guiding principles that were widely reported in the published literature and summarised below. A sample effectively represents a model or subset of a larger population and is used to gain information about the entire population, with good samples generally being representative of the whole population (Henry, 1998). A large sample size that is representative of the total population enables conclusions drawn from the population subset to be extrapolated to the entire population (Newsome *et al*. 2002). Henry (1998) suggests that the overall quality of research can be improved by having a smaller sampling frame but increasing the response rate from the population being sampled. However, the smaller the population size, the larger the sampling ratio needs to be to obtain an accurate and robust sample (Neuman, 1997), with the added advantage that larger samples have smaller sampling errors (Lipsey, 1998).

Debate exists about what constitutes an adequate sample size and what is an appropriate response rate. Neuman (1997) suggests that for populations of less than 1,000, researchers need to aim for a sampling ratio of about 30 percent or 300 returned surveys, and need to distribute in the order of 700-800 surveys since response rates of between 50-60 percent are common for questionnaires. A response rate of between 50-60 percent is generally regarded as acceptable, with anything above 90 percent considered excellent and anything below 50 percent usually considered poor (Neuman, 1997). Similar guiding principles are espoused by Babbie (1992) who suggests that a sample size of at least 400 should be the aim if a researcher wants to be 95 percent confident that their results are within 5 percent of the values for the entire population. In reality the minimum sample size is often determined by a rule of thumb or the commonly accepted amount within a discipline and also depends on the population size, practical limitations, the topic, and the response rate researchers feel comfortable with (Neuman, 1997). In light of the above it was decided that response rates would be maximised within resource constraints in order to gain the largest sample possible.

The research was conducted using a convenience sampling methodology that provided every visitor who hiked either walking track during the sampling period with an opportunity to complete a survey form. Although sampling was restricted to hikers who were literate in English, this nevertheless included the vast majority of walkers. In this research the sampling frame or total population available for sampling included everybody who hiked either of the two walking tracks under investigation within the 12 month sampling period which extended from 1 April 2004 to 31 March 2005. Survey response rates for each walking track were calculated as the percentage of distributed questionnaires that were completed and returned to the researcher. Sample representativeness for each walking track was calculated by determining the percentage of total walkers who completed a survey. On Hinchinbrook Island total numbers of hikers were obtained using QPWS camping permit figures for the sampling period. On Mt Bartle Frere sample representativeness was complicated by the fact that a substantial proportion of track users complete the walk within a day and are therefore not required to register for a camping permit, while a small number of other hikers are known to camp illegally to avoid payment of camping fees (Jackson, 2003. pers. comm., 16 May). Nevertheless, QPWS camping permit data represented a useful starting point although these figures underestimate the total numbers of walkers accessing the summit.

4.3.3 Survey instrument

The survey instrument used was developed and progressively refined throughout the course of 2003 and early 2004 through repeated pre-testing. During the survey design phase, pre-test surveys were conducted on two occasions to assess the effectiveness of the survey instrument. A preliminary pre-test survey was conducted during late October 2003 with eight hikers who walked the Mt. Bartle Frere Track over a two day period in the company of the researcher. A second more extensive pre-test survey was later conducted within a classroom setting on 27 February 2004 with 27 students from the School for Field Studies near Yungaburra on the Atherton Tablelands. Both pre-test surveys resulted in subsequent minor modifications to the questionnaire in order to enhance overall clarity and effectiveness of the survey instrument.

Care was taken to simplify and standardise the format of questions as much as possible to both increase response rates and minimise administrative errors during completion by respondents, and assist subsequent data input and analysis. Similarly, due diligence was applied to the wording of questions and the range of possible responses to ensure that they were neither leading nor threatening to visitors as this can influence responses (Frankfort-Nachmias and Nachmias, 1992; Horneman *et al*. 2002; Newsome *et al*. 2002). The structural format of questions and the wording of quantitative rating scales used in sections of the survey instrument intentionally mirrored those used by Bentrupperbäumer and Reser (2002) in an earlier site-based survey of visitors using predominantly day-use recreational sites within the Wet Tropics region. While results of surveys submitted by long-distance walkers were not readily comparable with those obtained from visitors using picnic areas and for the most part short-distance walking tracks, it was nevertheless appropriate to standardise survey instruments despite the differing spatial scales of visitor activity. This will allow researchers to combine and replicate both surveys in future years to enable the collection of longitudinal data on an expanded range of visitor activities across the Wet Tropics region should this be desired.

The final survey incorporated a range of response formats. Visitors were required to use a combination of quantitative rating scales, close-ended categorical or fixed choice responses, and open-ended formats. The vast majority of questions used a six-point importance rating scale format that required respondents to use various scale items including 'not important' to 'very important', 'strongly disagree' to 'strongly agree', and 'extremely difficult' to 'extremely easy'. The provision of a six-point importance rating scale with equal numbers of positive and negative choices enabled responses to any given question to be subsequently collapsed into bipolar categories. For example, 'strongly disagree', 'somewhat disagree' and 'mildly disagree' were combined to form a composite of 'disagreement', while 'strongly agree', 'somewhat agree' and 'mildly agree' responses were combined to form an index of 'agreement'. The use of multiple items to assess any given variable both enhances the internal validity of the survey instrument, and enables summed indices to be calculated (Babbie, 1992; Fink, 1995). Following an analysis of each item, indices can be created for a particular variable by summing importance rating scale responses (Babbie, 1992). Any items included in such an index must have a valid construction, be clearly understandable and be highly correlated with the summed index (Babbie, 1992).

Since self-administered questionnaires should consist predominantly of closed-ended questions (Bourque and Fielder, 2003), the response format within this questionnaire consists mostly of closed questions. Nevertheless, care was taken to ensure that walkers had opportunities to provide more expansive responses through the inclusion of some open questions. Closed questions require survey respondents to select from a limited number of possible responses, which has both advantages and disadvantages. In contrast open questions permit respondents to write whatever they wish although responses invariably require more analysis (Frankfort-Nachmias and Nachmias, 1992; Neuman, 1997; Newsome *et al*. 2002). Following the recommendation of Bourque and Fielder (2003), a residual ‘other’ category was provided in some questions which allowed respondents greater flexibility to submit responses that may not have been provided on the survey form. The very high question completion rate and the limited number of missing values obtained in completed survey forms indicated that the vast majority of respondents were highly cognisant of how to use the various response formats utilised in this questionnaire. Respondents’ written comments in response to open-ended questions provided further evidence of the level of participant understanding.

The layout of the questionnaire commenced with a cover page of introductory information about the conduct of the research project and assured all potential respondents that participation in the survey was voluntary and that all participants would remain anonymous. The length of the survey was restricted to six pages of double sided water-resistant paper, although most of page one was taken up with an explanation of the research project, corporate logos, instructions, and nomination of walking track location, date and time information, and weather conditions during the walk. Inclusion of both the James Cook University and Rainforest Cooperative Research Centre corporate logos on the survey was mandated by these organisations which provided funding assistance to the researcher. However, as surveys originating from universities are more likely to be returned than those from business or private sources (Edwards *et al*. 2002) this was considered desirable in any event. The survey was kept as short as possible as the published literature consistently indicates that short survey forms are more likely to be returned than long survey forms (Edwards *et al*. 2002). A reply paid envelope addressed to the researcher at James Cook University in Cairns was stapled at the end of each survey form to encourage the completion and return of questionnaires. The survey is presented in Appendix 6.

The questionnaire consisted of two distinct sections, Sections A and B. Section A contained a series of questions that requested demographic information. All remaining survey questions were contained within Section B and sought specific information about visitors' experiences of the particular walking track they completed. A thematic summary of the structure of the questionnaire is outlined in Table 4.5 below.

Table 4.5 A thematic layout of the psychosocial experience questionnaire.

Themes	Questions	Examples of types of information collected
Demographics	Section A Q. 1-8	Visitor profile data including place of residence, ethnicity, education, age, gender, perceived level of experience and physical fitness
Logistics	Section B Q. 9-14	Number of adults and children in group, walk arrangements, sources of knowledge about the track, number of days and nights spent completing the walk
Motivations	Section B Q. 15	Motivations for choosing to undertake this particular walking track
Appraisals	Section B Q. 16	Appraisal of the natural environment along this track including perceptions of biophysical impacts
Appraisals	Section B Q. 17	Appraisal of the social environment including perceptions of other people that also used this track
Appraisals	Section B Q. 18-23	Appraisal of the built environment including perceptions of facilities and current track management
Appraisals	Section B Q. 24	Appraisal of a range of potential future management interventions
Reflections	Section B Q. 25-32	Reflections upon the overall quality of experience including satisfaction levels, value for money, factors that enhanced or detracted from the walk, fears and degree of difficulty experienced, willingness to complete the walk again or recommend it to others

Demographics

Walkers were initially asked to nominate their *place of residence* to enable the relative proportions of local, domestic and international respondents to be calculated for each track (Q.1). This was followed by *ethnic background* (Q.2) which has additional value for management wanting to assess the appropriateness of warning signs and track brochures. In Question 3 respondents were asked to nominate the highest level of formal *education* they have completed to date for the purpose of investigating the relationship between education level and various other variables. Questions 4 and 5 asked respondents about their *level of experience* at undertaking long-distance walks by seeking information about the number of times they have been required to stay overnight while completing a walk, and about the duration of the longest walk they have ever completed. Prior experience is known to be an important influence upon satisfaction and also provided insights into the capability of the respondent to undertake a long-distance walk in a remote location requiring a high degree of self-sufficiency. Information provided by respondents about their *perceived physical fitness* (Q.6) offered similar insights into their physical preparedness to undertake a long-distance walk and was used to explore the relationship with a range of other variables related to their overall quality of experience. Section A concluded by requesting information about the respondent's *age* (Q.7) and *gender* (Q.8).

Logistics

Logistical information was sought in Question 9 with respondents being asked about their walk arrangements (*organised tour* or *private walk*). In this research an organised walk was defined as either a tour provided by a commercial tour company in return for payment, or an educational tour organised by a specific group in the community such as a school excursion or an outdoor education camp. It should be noted that almost immediately after survey distribution commenced the only commercial tour company that had formerly offered guided tours to Mt Bartle Frere ceased to operate, resulting in very few survey respondents being part of an organised commercial tour. Question 10 requested information about *group size* (the number of adults and children in the respondent's party). Information concerning the size of groups using long-distance walking tracks has direct relevance to track managers charged with the provision of visitor infrastructure and monitoring access arrangements. Question 11 asked respondents to nominate *information sources* that provided them with knowledge about the walking track. Such information has important implications for future walking track marketing initiatives and interpretation programs. In Question 12 visitors were asked to nominate any *activities* that they had wanted to do but were prevented from doing during the course of the walk. This question sought to identify issues that may have adversely impacted upon the quality of their experience. Questions 13 and 14 asked visitors about the *duration* of their long-distance walking experience including how many nights they camped in the National Park.

Motivations

In Question 15 respondents were asked about their reasons for undertaking this specific long-distance walk. Hikers were asked to rate a mix of experiences and activities associated with long-distance walking using a six-point scale ranging from ‘not important’ to ‘very important’. The scale used to assess respondent motivations was previously used in research conducted by Bentrupperbäumer and Reser (2000, 2002) with day-use visitors within the Wet Tropics region. The data collected provided information about the types of experiences and activities sought by respondents.

Appraisal of the natural environment

The natural environment is integral to the long-distance walking experience for many visitors and was the focus of Question 16 which had two components. Initially respondents were provided with four statements that described the natural environment along the walking track that they were asked to evaluate using a six-point scale ranging from ‘strongly disagree’ to ‘strongly agree’. Walkers were asked to appraise the natural environment in terms of condition, appeal, interest, and whether or not they were concerned about it. Next hikers were asked to rate environmental impacts along the track, including soil erosion, vegetation damage, weeds, feral animals, littering, inadequate disposal of human body waste and undesignated tracks using a six-point scaled response ranging from ‘extremely low’ to ‘extremely high’.

Appraisal of the social environment

In Question 17 visitors were asked to appraise the social environment they experienced during the course of their walk. Using a six-point importance rating scale respondents were asked to rate a number of statements that referred to the number and behaviour of other visitors that they encountered. Such information was necessary to investigate the appropriateness of current visitation levels and was also used to explore visitor perceptions of conflict and crowding.

Appraisal of the built environment

Question 18 asked visitors to appraise the adequacy of existing visitor facilities using a six-point importance rating scale from ‘adequate’ to ‘inadequate’. Respondents were also asked if the provision of additional visitor facilities would enhance their enjoyment of this walking track (Q.19). In Question 20 respondents were provided with a list of facilities and asked to nominate any that they supported being either established or increased along the particular walking track they completed. Hikers were provided with the option to nominate additional facilities to those listed. Questions 21-23 asked respondents to evaluate three statements relating to existing track management, infrastructure construction, and maintenance standards using a six-point importance rating scale that ranged from ‘strongly disagree’ to ‘strongly agree’.

Future management options

The next subsection (Q. 24) asked hikers to rate a range of potential track management interventions. Survey respondents were asked to rate a number of management options using a six-point importance rating scale ranging from ‘strongly disagree’ to ‘strongly agree’. The information provided by hikers in this section was critical to understanding future track management priorities from a visitor’s perspective, and was integral to maintaining the quality of visitor experiences.

Reflections

In Question 25 walkers were asked to reflect upon their overall experience of the walking track in the context of their satisfaction and enjoyment levels, value for money, disappointments, and prior expectations. Respondents were then invited to make some concluding observations (Q. 26-31) about their overall walking experience including their reflections upon factors that enhanced or detracted from their experience, any fears they experienced, the degree of physical difficulty they encountered, and whether or not they would complete the walk again or recommend it to other potential hikers. The purpose of the final section was to allow hikers to provide an overall evaluation of their recent experience. The final question (Question 32) invited respondents to make any other written comments about the particular walking track they completed and the conduct of the survey. Instructions for return of the survey within the attached reply paid envelope were provided on the bottom of the final page.

4.3.4 Survey distribution

The questionnaire and reply paid envelopes were printed by a commercial printer (Bolton Print) in Cairns during March 2004 with surveys first distributed to walkers on 1 April 2004. Survey forms were distributed to hikers using a range of techniques depending on the location and access arrangements for the particular walking track as summarised in Table 4.6. Although the majority of respondents returned their surveys using the reply paid envelopes that were supplied with their questionnaire, some had the opportunity to return completed survey forms to the researcher in person. This was more prevalent for survey respondents who received their questionnaire via options two or three in Table 4.6. Plate 4.6 depicts one of the two QPWS self-registration camping stations for the Mt Bartle Frere Track where surveys were available for collection by hikers, while Plate 4.7 depicts laminated information about the conduct of the survey.

Table 4.6 Survey distribution methods.

	Survey distribution methods	**Mt Bartle Frere**	**Thorsborne Trail**
1	Self collection of survey forms from survey racks located at QPWS self-registration camping stations	✓	
2	Distribution of surveys to respondents by the researcher during seasonal biophysical impact assessments	✓	✓
3	Distribution of surveys to respondents by the researcher during peak visitation periods (e.g. public holidays, weekends, optimum weather conditions)	✓	✓
4	Distribution of surveys to respondents via ferry operators servicing Hinchinbrook Island		✓
5	Distribution of surveys to respondents via mainland commercial shuttle bus operators meeting ferry services		✓
6	Self collection of survey forms from the QPWS Reef and Rainforest Information Centre, Cardwell		✓

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Plate 4.6 Long-distance walkers were able to collect survey forms from QPWS self-registration camping stations located at each end of the Mt Bartle Frere Track.

Questionnaires were distributed for a full 12 month period (1 April 2004 to 31 March 2005) to allow for seasonal variations in weather conditions and annual holiday periods which were both likely to influence participation in long-distance walking activities in the humid tropics. While a longer sampling period would have been desirable to continue to build an expanded data set this was prohibited by the timeframes now imposed for submission of doctoral theses.

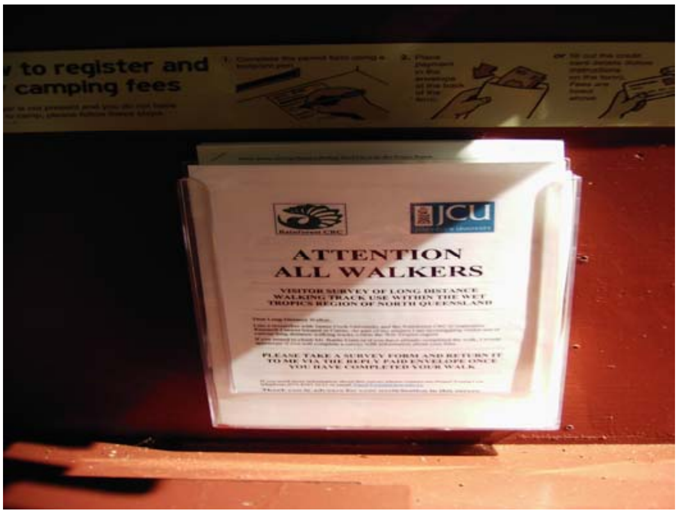

Plate 4.7 Plastic survey rack containing numbered surveys and laminated information sheet providing information about this research.

4.3.5 Data analysis

All psychosocial data collected on questionnaires were transcribed into an SPSS (Statistical Package for Social Sciences) data file by the researcher in conjunction with a code book (Appendix 7) to ensure data integrity. The final database was screened for missing or incorrectly entered data, or other administrative errors. Since the assumption of normality was a prerequisite for many statistical tests, all data was assessed for normality of distribution and skewness, outlying scores, and for homogeneity of variance to determine if it was suitable for parametric analyses. Normality was assessed using a combination of histograms, Q-Q plots, Stem-and-Leaf plots and the one-sample Kolmogorov-Smirnov test. Since the majority of the data were not normally distributed and were frequently in the form of ordinal data, this mandated that predominantly non-parametric data analysis techniques be used. All assumptions were satisfied for all statistical methods used with the exception of random sampling given that this research used a convenience sampling strategy. Importance rating scale data were treated as interval level data following the recommendations of Diekhoff (1992) and Mitchell and Jolly (2001) who argue this is a valid approach. A combination of descriptive and comparative statistics was subsequently used to analyse the data sets, with all analyses duplicated for each walking track.

Descriptive Statistics

A range of measures of central tendency and variability (including mean, median, mode, standard error) were calculated for each survey question. Open-ended questions were analysed using content analysis while respondent ages were collapsed into age categories. Descriptive statistics were used to describe both the survey results obtained from each walking track and to present the amalgamated results from all survey respondents undertaking either walking track during the sampling period. Results were generally presented as tables, percentages, or graphs.

Comparative Statistics

Chi-square, independent sample t-tests, Mann Whitney *U*, factor analysis, Spearman's Rank Order Correlation, and multiple regressions were the main comparative statistics used to investigate the psychosocial experiences of survey respondents. The same significance criterion ($\alpha = .05$) was used throughout the analysis to assess all results.

The Chi-square test for relatedness or independence is used to determine if there is a relationship between various combinations of categorical variables (Pallant, 2005). In this research Chi-square tests were used to asses a number of categorical variables including gender, place of residence, level of physical fitness, education, and level of experience.

The independent-sample t-test enables comparisons of mean scores for continuous variables derived from two different groups (Pallant, 2005). In this research the independent-sample t-test was used to compare the age of respondents between the two walking tracks.

Factor analysis is a relatively complex data reduction technique that looks for clumps or groups among the inter-correlations of a set of variables thereby enabling them to be summarised or reduced using a smaller set of factors or components (Pallant, 2005). While exploratory factor analysis enables a researcher to explore interrelationships among a set of variables, confirmatory factor analysis is used to test or confirm the existence of the structure underlying a set of variables (Pallant, 2005). Factor analysis can also be used to assess both scale dimensionality and the strength and importance of dimensions (Tabachnick and Fidell, 2001). The term factor analysis is generally used interchangeably to describe both principal components analysis (PCA) and factor analysis (FA) since both techniques reduce the original number of variables in a way that accounts for most of the variability in the pattern of correlations, although principal components analysis transforms the original variables into linear combinations using all of the variance in the variables whereas factor analysis estimates factors based upon a mathematical model that only analyses the shared variance (Pallant, 2005).

Tabachnick and Fidell (2001) maintain that it is ‘comforting’ to have in excess of 300 cases prior to undertaking a factor analysis but confess that smaller sample sizes are acceptable especially if the outputs have several high loading marker variables (>0.80). They also recommend that the correlation matrix contain evidence of a number of coefficients higher than 0.3 if the analysis is to be valid (Tabachnick and Fidell, 2001). Ultimately it is the responsibility of the researcher to determine the number of factors that best describes the underlying relationship among variables, which often entails balancing the potential conflict between seeking to explain as much variance as possible whilst simultaneously generating a simple solution with a minimum number of factors (Pallant, 2005). In this research principal components analysis was used to extract components or factors to enable composites of the underlying variables to be calculated.

The Mann Whitney *U* is the non-parametric equivalent of the t-test for independent samples (Pallant, 2005), and does not assume that data has either a normal distribution or that variances are homogenous (Dytham, 1999). Mann Whitney *U* uses the ranks of the data measurements rather than the actual measurements to enable comparisons between two groups (Zar, 1984). In this research a succession of Mann Whitney *U* tests were used to investigate differences between the responses submitted for the two different walking tracks.

Spearman's Rank Order Correlation (rho) is the non-parametric equivalent of Pearson's Product Moment Correlation (r) and examines the strength of a relationship between two continuous variables (Pallant, 2005). In this research it was used to assess the extent of correlation between respondent's perceptions of their own physical fitness and the level of physical difficulty that respondents reported for their walk. The test produces a statistic that ranges from -1 (perfect negative correlation), through 0 (no correlation) to 1 (perfect positive correlation) and also indicates the significance of the correlation (Dytham, 1999).

Multiple regression analysis refers to a family of statistical techniques that can help to explain the relationship between one continuous dependent variable, and a number of independent variables that usually comprise either categorical or continuous data (Pallant, 2005). Regression analysis is used when independent variables are correlated with the dependent variable and with each other (Coakes and Steed, 2003). There are three main types of multiple regression tests (standard or simultaneous, hierarchical or sequential, and stepwise) which differ both in terms of the order in which independent variables are entered into the equation and in the manner in which overlapping variability due to correlation of the independent variables is treated (Coakes and Steed, 2003). A multiple regression can be performed to determine how well a set of variables is able to predict an outcome, and to establish which variable in a set is the best predictor of an outcome (Pallant, 2005). A standard multiple regression analysis requires that all predictor variables are simultaneously entered into the equation to enable the relationship between the whole set of predictors and the dependent variable to be examined (Coakes and Steed, 2003), and is the most commonly used form of the analysis (Pallant, 2005). In this research a standard or simultaneous multiple regression analysis was used to evaluate the extent to which variance in a dependent variable (respondent satisfaction) could be explained or predicted by various independent variables (gender, age, level of experience, place of residence, education, physical fitness, motivations etc.) and the relative contribution of each independent variable.

4.4 SUMMARY

This chapter has provided an overview of the two principal methodological approaches used in this research. It has demonstrated that the rapid assessment methodology used to assess biophysical impacts and the self-report questionnaire used to assess psychosocial experiences were appropriate methodologies to answer the research questions. Each methodological approach has been described in terms of the research design, sampling methodology, data collection and data analysis techniques. The thesis now moves to present the results obtained using these methodologies.

CHAPTER 5 - BIOPHYSICAL IMPACT RESULTS

5.1 INTRODUCTION

This chapter presents the results of biophysical impact sampling associated with two long-distance walking tracks within the Wet Tropics region of North Queensland. The Mt Bartle Frere Track and the Thorsborne Trail have already been described in Chapter 3, while the field sampling methodology and data collection techniques were summarised in Chapter 4. The chapter seeks to provide answers to the following two research questions:

RQ1.What are the biophysical impacts associated with visitor use of long-distance walking tracks within the Wet Tropics region and how do these impacts vary over space and among vegetation types along tracks?(Sections 5.2 and 5.4.2)

RQ2.How do biophysical impacts associated with visitor use of long-distance walking tracks within the Wet Tropics region vary in response to changing seasonality? (Sections 5.3 and 5.4.3)

At the outset it is important to reiterate that field sampling only considered hikers' biophysical impacts upon soil and vegetation associated with tracks, and that no attempt was made to measure impacts upon water and wildlife although these were also undoubtedly impacted by the activities of long-distance walkers. The chapter is presented in three main sections as outlined below.

Spatial Comparisons (Section 5.2)

The first section of this chapter presents spatial comparisons of biophysical impacts for various environmental indicators that were assessed within one metre square quadrats and along 20 metre linear transects at each of 100 sampling points on each track. Spatial comparisons were made among sampling zones (tread, buffer, and control) established at each sampling point, with additional comparisons made among vegetation types along each track. It should be noted that comparisons made among vegetation types excluded control zone data.

Seasonal Comparisons (Section 5.3)

This section presents the results of temporal comparisons made between data collected during both wet and dry seasons, in order to determine if biophysical impacts were influenced by variations in seasonality. Seasonal comparisons were made using tread and buffer zone data only.

Discussion (Section 5.4)

The final section of the chapter attempts to interpret findings made in the current research and where relevant makes comparisons with previous research reported in the literature. The discussion evaluates the current results within the context of recreation impact theory through consideration of the related concepts of resistance and resilience, and also seeks to identify findings that are of relevance from an applied management perspective.

5.2 SPATIAL COMPARISONS

5.2.1 Track topography

Topography within the vicinity of the tread, buffer and control zones at all of the 100 sampling points along each walking track was classified into one of three classes, steep, undulating, or flat. Flat topography can generally be regarded as being less prone to soil erosion, due to the reduced velocity of water runoff. Topographic data from both locations indicates that the Mt Bartle Frere Track has more steep and undulating topography than the Thorsborne Trail (Figure 5.1). Statistical comparisons of topographic data collected from both tracks demonstrated that they had significantly different topography (Chi-square, d.f = 2; x^2 = 213.215; P < 0.001). Thirty percent of all sampling points on the Mt Bartle Frere Track were located on steep terrain with only 14 percent of sampling points located on terrain that could be described as flat. In contrast, almost half (49%) of all sampling points on the Thorsborne Trail were located on flat terrain, and only a minority (7%) were classified as steep. These results were consistent with the commonly held perception that the Mt Bartle Frere Track is the more physically challenging of the two walks.

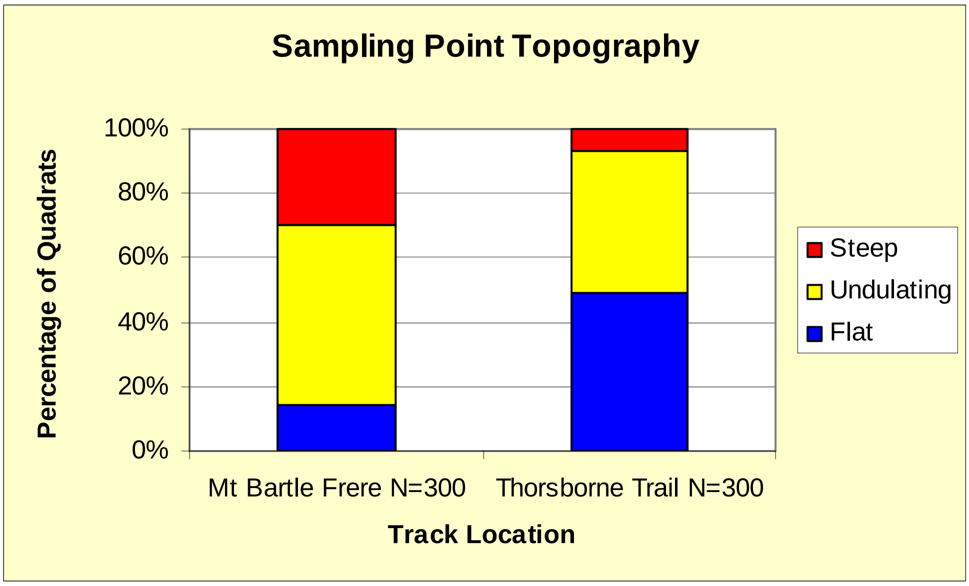

Figure 5.1 Topography associated with sampling points on each walking track.

Flat topography was most prevalent within tableland forest (23%) and cloud forest (18%) on the Mt Bartle Frere Track (Figure 5.2). This result was anticipated given that upland forest and lowland forest are located on the steeper eastern face of Mt Bartle Frere, with tableland forest and cloud forest predominantly situated on the easier western route to the summit.

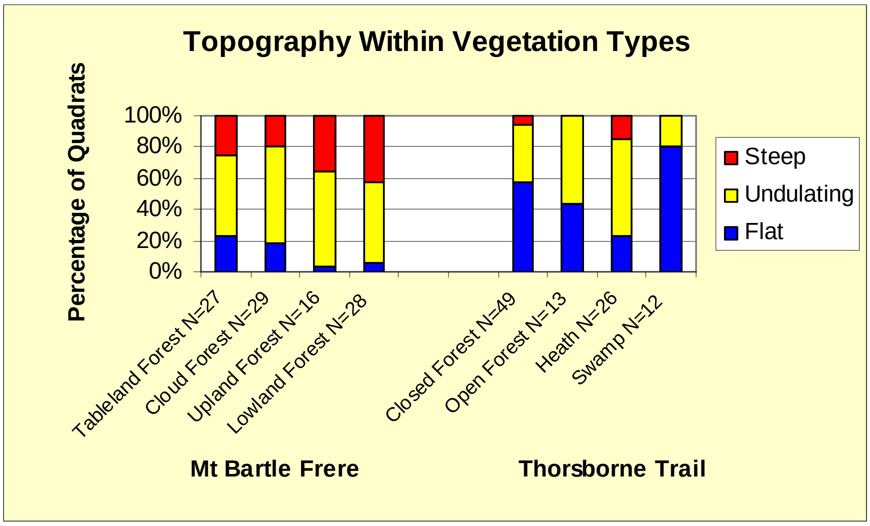

Figure 5.2 Topography within vegetation types associated with each walking track.

A more detailed analysis indicated that flat topography was unequally distributed within the four main vegetation types associated with each track (Figure 5.2). Chapter 3 provides descriptions of the principal vegetation types associated with each track. Terrain was significantly different within the four vegetation communities along the Mt Bartle Frere Track (Chi-square, d.f = 6; x^2 = 47.881; P < 0.001). Topography along the Thorsborne Trail was predominantly flat or undulating across all vegetation types, although some 15 percent of sampling points within heath communities had terrain that was classified as steep (Figure 5.2). Comparisons of topography were made among different vegetation types along the Thorsborne Trail and demonstrated that highly significant differences existed (Chi-square, d.f = 6; x^2 = 93.895; P < 0.001).

Comparisons of topographic data were also made among tread, buffer, and control zones on each track, which are summarised in Figure 5.3. On the Mt Bartle Frere Track, steep topography was found to be more prevalent within control zone quadrats, while undulating topography was reasonably constant across all sampling zones. The relatively lower proportion of flat topography contained within control zone quadrats was believed to be a consequence of the Mt Bartle Frere Track often following a narrow ridgeline to the summit, resulting in many control zones being located on the sides of this ridge. Significant differences in topography were recorded among the three sampling zones (Chi-square, d.f = 4; x^2 = 9.886; P = 0.042) on the Mt Bartle Frere Track. All three sampling zones on the Thorsborne Trail contained greater than 40 percent flat terrain, with this being most prevalent in the tread zone which also had the highest proportion of steep topography (Figure 5.3). Topography was very similar within the buffer and control zones. Differences in topography among the three sampling zones on the Thorsborne Trail were not significant (Chi-square, d.f = 4; x^2 = 6.092; P = 0.192).

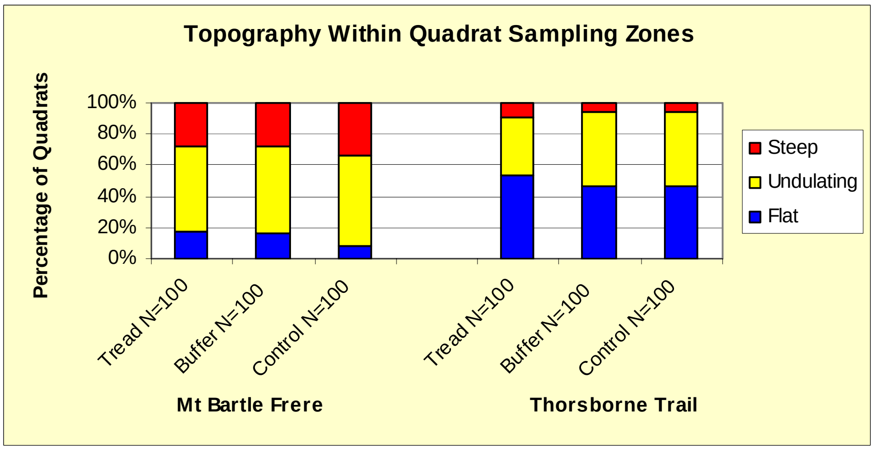

Figure 5.3 Classification of track topography associated with sampling zone quadrats.

5.2.2 Track width

Track width was measured within the tread zone and is best conceptualised as the width of track surface that hikers' boots make contact with as they traverse the trail. As a general rule, the narrower the track width the better as this means a reduction in the area directly impacted upon by passing hikers. Mean track width recorded for the Mt Bartle Frere Track was significantly wider than that recorded along the Thorsborne Trail (Mann Whitney U = 13229.000; $P < 0.001$), although the increased width associated with the Mt Bartle Frere Track (Table 5.1) was most likely the result of hikers widening the track to avoid drainage impeded areas, especially in sections of tableland forest located on basalt soils that are prone to compaction. It should also be noted that most hikers using the Thorsborne Trail view a minimal impact camping and walking video prior to commencing their walk, and this educational resource may have contributed to the narrower track at this location, since walkers have been encouraged to remain on the designated track surface.

Table 5.1 Descriptive analyses of walking track widths (metres).

Track location	*Mean (m) ± 1SE*	*Range (m)*	*Minimum (m)*	*Maximum (m)*
Mt Bartle Frere N = 200	0.95 ± 0.029	2.18	0.42	2.60
Thorsborne Trail N = 200	0.76 ± 0.022	2.02	0.38	2.40

Track width varied in response to changing topography (flat, undulating, steep) on both walking tracks and tended to become narrower as topography became steeper (Figure 5.4). This may be a consequence of hikers preferring to walk two abreast on flatter track sections, or may be the result of steep topography confining track width in locations where there are few suitable handholds. Differences in track width associated with topography on the Mt Bartle Frere Track were not significant (Kruskal Wallis *H*, d.f = 2; *H* = 1.297; P = 0.523), while differences on the Thorsborne Trail were significant (Kruskal Wallis *H*, d.f = 2; *H* = 6.085; P = 0.048).

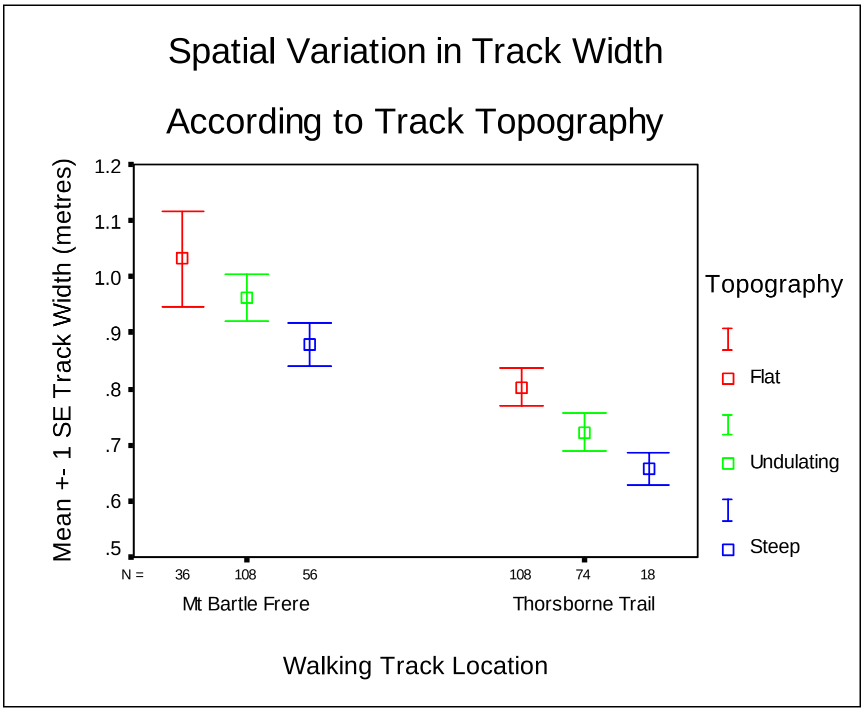

Figure 5.4 Spatial variation in track width (mean ± 1 standard error) associated with topography.

Mean track width varied in response to vegetation type on both walking tracks (Figure 5.5). This was most likely a reflection of variations in ground cover composition within the tread zone of different vegetation types. Variations in quantities of rocks, living vegetation, and woody debris can all influence where hikers step. Track width was most variable within tableland forest along the Mt Bartle Frere Track, where mean width was also widest. Different vegetation types along the Mt Bartle Frere Track had significantly different track widths (Kruskal Wallis *H*, d.f = 3; *H* = 29.714; P < 0.001). Mean track width on the Thorsborne Trail was most variable within swamp communities as hikers would typically be trying to avoid getting wet feet, and least variable within open forest where it was narrowest. Further analysis demonstrated that track width was also significantly different among the four vegetation types along the Thorsborne Trail (Kruskal Wallis *H*, d.f = 3; *H* = 9.797; P = 0.020).

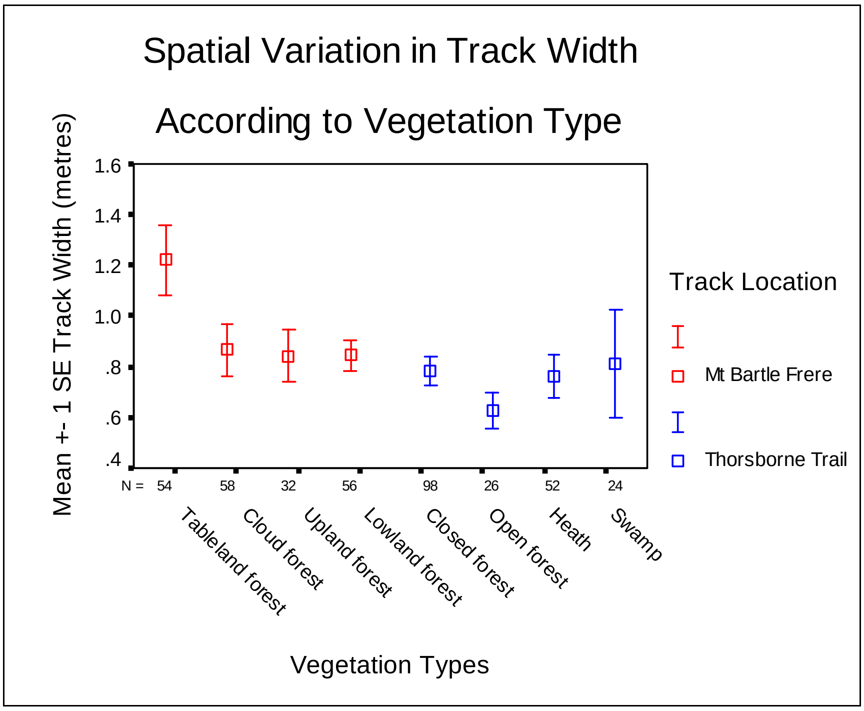

Figure 5.5 Spatial variations in track width (mean ± 1 standard error) associated with vegetation type.

5.2.3 Ground cover composition within quadrats

Ground cover composition was assessed within tread, buffer and control zone quadrats at each sampling point. The relative proportions of exposed mineral soil, leaf litter, tree roots, rocks, woody debris, and living vegetation were estimated (combined total 100 %).

5.2.3.1 Exposed mineral soil

Exposed mineral soil is a useful biophysical impact indicator because it usually means that soils are more susceptible to erosion and compaction in the absence of a protective layer of leaf litter. Exposed mineral soil was most prevalent in the tread zone and least prevalent in the control zone for each track, with quantities of bare soil more prevalent along the Thorsborne Trail in comparison to the Mt Bartle Frere Track (Figure 5.6).

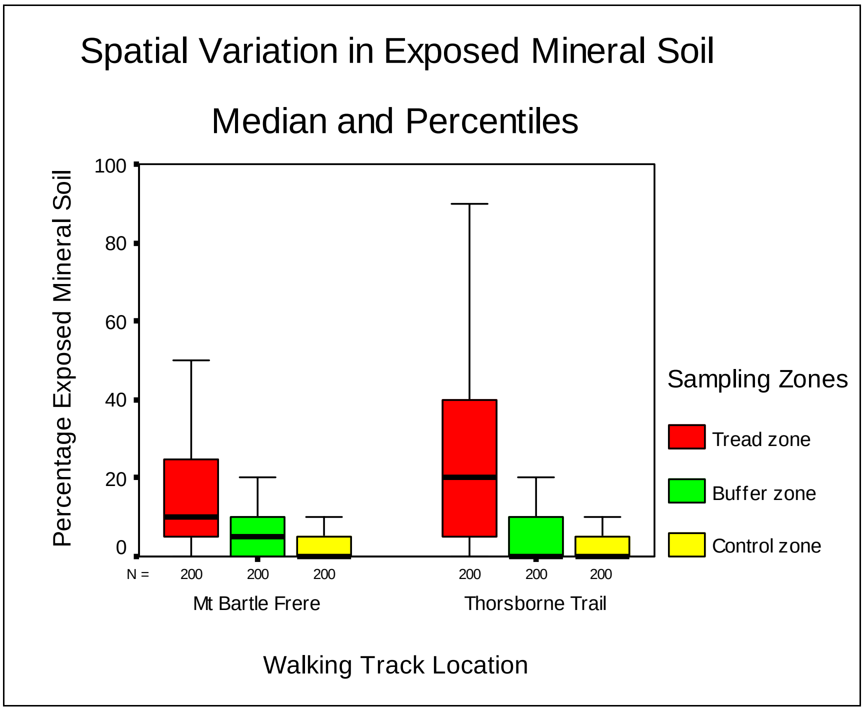

Figure 5.6 Spatial variations in exposed mineral soil (median and percentiles) associated with quadrat sampling zones.

Comparative statistics (Table 5.2) confirmed significant differences existed in the quantity of exposed mineral soil within sampling zones along both walking tracks, while *post hoc* comparisons demonstrated that significant differences occurred among each of the three sets of paired zones (tread and buffer, tread and control, buffer and control).

Table 5.2 Comparative analyses of spatial variation in exposed mineral soil associated with sampling zone quadrats.

Mineral Soil	*Kruskal Wallis H Test*	*Mann Whitney U Test - post hoc comparisons*		
	All Zones N=600	Tread/Buffer N=200	Tread/Control N=200	Buffer/Control N=200
Mt Bartle Frere	P < 0.001* d.f = 2 H = 165.679	P < 0.001** U = 10356.000	P < 0.001** U = 6248.000	P < 0.001** U = 15423.500
Thorsborne Trail	P < 0.001* d.f = 2 H = 156.402	P < 0.001** U = 9355.000	P < 0.001** U = 7016.500	P = 0.009** U = 17279.000

* Statistically significant at the 0.05 level (Kruskal Wallis *H* tests).
** Statistically significant difference between these two track zones at the 0.016 significance level (Mann Whitney *U* tests with Bonferronni correction).

Comparisons of spatial variations in proportions of exposed mineral soil were also made among different vegetation types on each track (Figure 5.7). The relative proportion of exposed mineral soil on the Mt Bartle Frere Track was least prevalent within cloud forest, which was possibly a reflection of the high proportion of rocks and boulders within this vegetation type, as these reduce the potential for areas of bare soil to develop. Quantities of exposed mineral soil were similar across the other three vegetation types. Proportions of exposed mineral soil along the Thorsborne Trail were highest in heath and swamp respectively, and least prevalent within closed forest and open forest. Comparative statistics indicated there were significant differences in the relative proportions of exposed mineral soil recorded among vegetation types on both the Mt Bartle Frere Track (Kruskal Wallis H, d.f = 3; $H = 30.350$; $P < 0.001$), and the Thorsborne Trail (Kruskal Wallis H, d.f = 3; $H = 10.077$; $P = 0.018$).

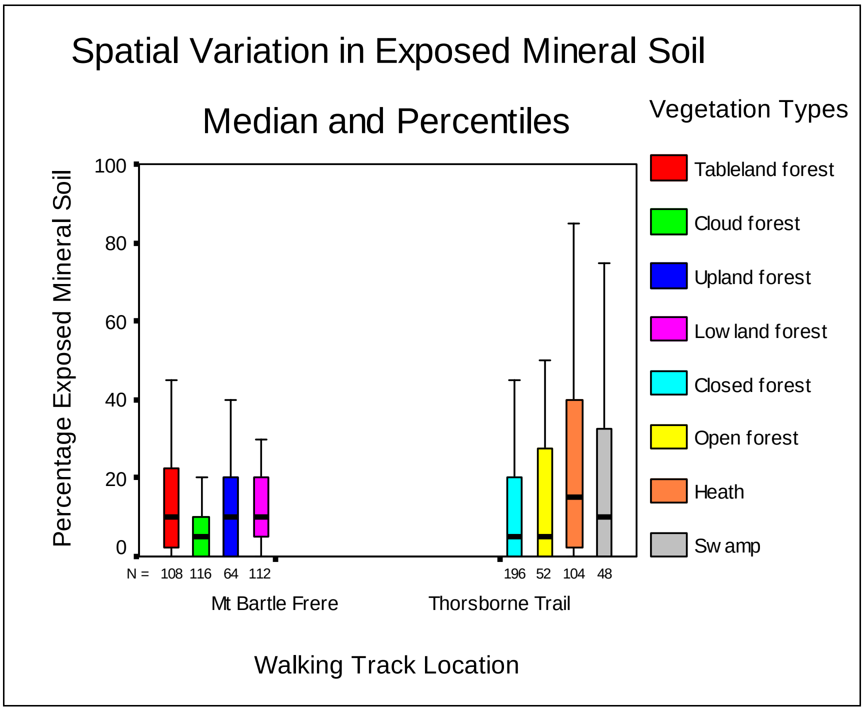

Figure 5.7 Spatial variation in exposed mineral soil (median and percentiles) associated with vegetation types. Control zone data excluded.

5.2.3.2 Leaf litter

Comparisons of leaf litter among sampling zones revealed minimal spatial variability on the Mt Bartle Frere Track (Figure 5.8). The fact that quantities of leaf litter were slightly higher in the tread zone than either the buffer or control zones was most likely related to the incision depth of the track which tended to trap litter in some locations. Quantities of leaf litter were highest in the control zone (42.5%) and lowest within the buffer zone (30%) on the Thorsborne Trail (Figure 5.8).

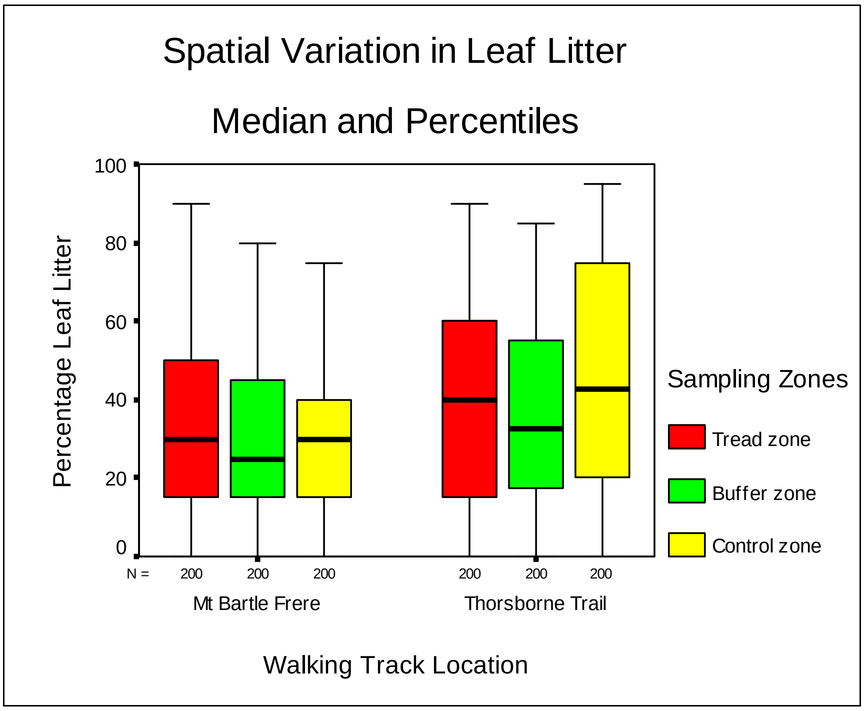

Figure 5.8 Spatial variation in leaf litter (median and percentiles) associated with quadrat sampling zones.

Comparative statistics (Table 5.3) demonstrated that quantities of leaf litter recorded within the three sampling zones on the Mt Bartle Frere Track were not significantly different, which negated the need for *post hoc* comparisons. Relative proportions of leaf litter were significantly different among the three sampling zones on the Thorsborne Trail, with *post hoc* comparisons confirming that significant differences existed between the buffer and control zones.

Table 5.3 Comparative analyses of spatial variation in leaf litter associated with quadrat sampling zones.

Leaf Litter	*Kruskal Wallis H Test*	*Mann Whitney U Test - post hoc comparisons*		
	All Zones N=600	Tread/Buffer N=200	Tread/Control N=200	Buffer/Control N=200
Mt Bartle Frere	P = 0.153 d.f = 2 *H* = 3.756	-	-	-
Thorsborne Trail	P = 0.001* d.f = 2 *H* = 14.752	P = 0.083 *U* = 17998.500	P = 0.023 *U* = 17378.000	P < 0.001** *U* = 15687.500

* Statistically significant at the 0.05 level (Kruskal Wallis *H* tests).
** Statistically significant difference between these two track zones at the 0.016 significance level (Mann Whitney *U* tests with Bonferronni correction).

Comparisons of spatial variations in leaf litter among vegetation types on the Mt Bartle Frere Track revealed that quantities of leaf litter were highest within tableland forest and lowland forest respectively, and least prevalent within cloud forest (Figure 5.9). Reduced quantities of leaf litter within cloud forest were most likely related to reductions in canopy cover (Section 5.2.5) resulting from the high prevalence of rocks (Section 5.2.3.4) at this location. Comparisons of leaf litter associated with vegetation types along the Thorsborne Trail suggested that leaf litter was highest within swamp and closed forest, and substantially lower within heath and open forest respectively. It should be noted that the quantity of leaf litter present within heath communities was undoubtedly reduced by fires that burnt in the period between wet and dry season sampling (Chapter 3).

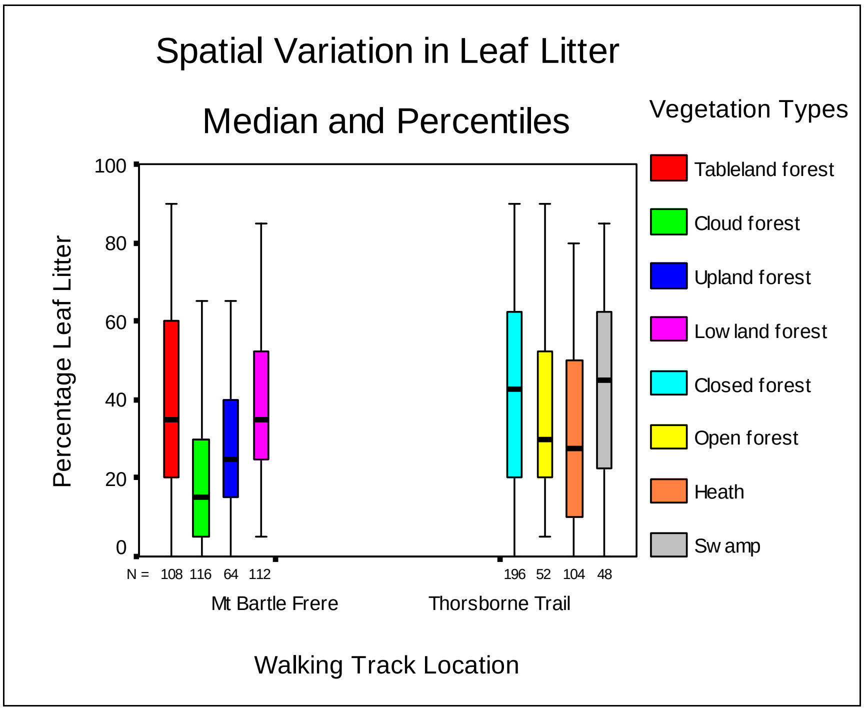

Figure 5.9 Spatial variation in leaf litter (median and percentiles) associated with vegetation types. Control zone data excluded.

Quantities of leaf litter were significantly different among the four vegetation types along both the Mt Bartle Frere Track (Kruskal Wallis *H*, d.f = 3; $H = 60.965$; $P < 0.001$), and the Thorsborne Trail (Kruskal Wallis *H*, d.f = 3; $H = 16.151$; $P = 0.001$).

5.2.3.3 Tree roots

Exposed surface tree roots often result from the displacement of overlying soil and organic matter, but can also indicate an impenetrable rocky substratum. Figure 5.10 depicts tree root exposure within sampling zone quadrats for both tracks. On the Mt Bartle Frere Track, median quantities of tree roots were quite high in all three sampling zones, although they were highest in the tread zone (15%). The extent of tree root exposure recorded within Thorsborne Trail quadrats was substantially lower, with median tree root exposure again highest in the tread zone (5%).

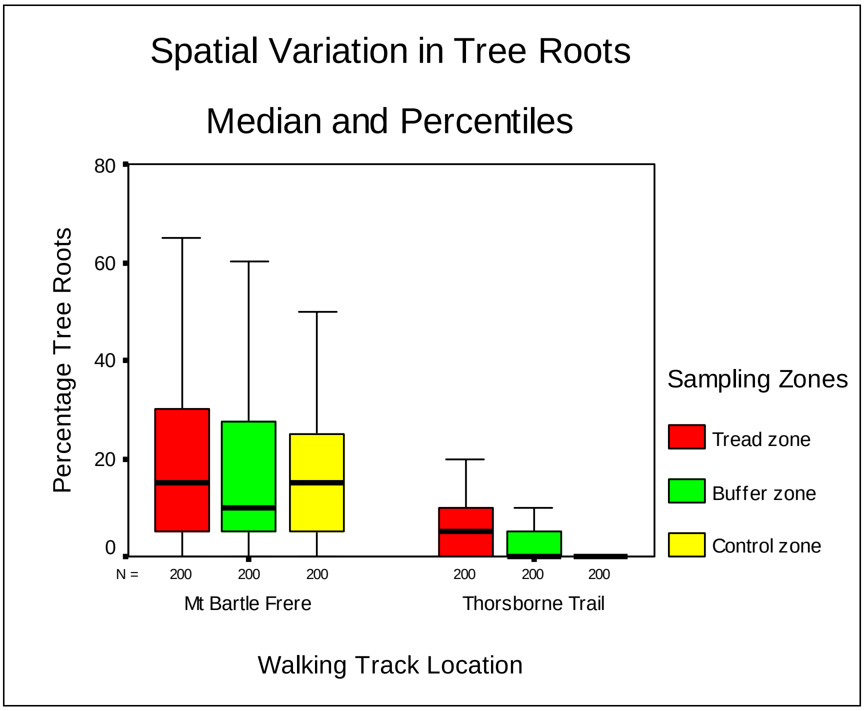

Figure 5.10 Spatial variation in tree roots (median and percentiles) associated with quadrat sampling zones.

Comparative statistics indicated that both tracks had significant differences in the quantities of tree roots recorded within sampling zones, with *post hoc* comparisons among paired sampling zones also significant on the Thorsborne Trail (Table 5.4).

Table 5.4 Comparative analyses of spatial variation in tree roots associated with quadrat sampling zones.

Tree Roots	*Kruskal Wallis H Test*	*Mann Whitney U Test - post hoc comparisons*		
	All Zones N=600	Tread/Buffer N=200	Tread/Control N=200	Buffer/Control N=200
Mt Bartle Frere	P = 0.047* d.f = 2 *H* = 6.116	P = 0.021 *U* = 17354.000	P = 0.148 *U* = 18341.000	P = 0.178 *U* = 18459.000
Thorsborne Trail	P < 0.001* d.f = 2 *H* = 78.094	P < 0.001** *U* = 14423.000	P < 0.001** *U* = 11816.500	P < 0.001** *U* = 17093.500

* Statistically significant at the 0.05 level (Kruskal Wallis *H* tests).
** Statistically significant difference between these two track zones at the 0.016 significance level (Mann Whitney *U* tests with Bonferronni correction).

Comparisons of quantities of exposed tree roots were also made among quadrats located within different vegetation types (Figure 5.11). On the Mt Bartle Frere Track, exposed tree roots were most prevalent within upland forest, which also contained the steepest track sections on the mountain and was therefore highly susceptible to erosion. Exposed tree roots were minimal within all vegetation types along the Thorsborne Trail. Comparative statistics demonstrated that quantities of exposed tree roots recorded within the four different vegetation types on each track were significantly different for the Mt Bartle Frere Track (Kruskal Wallis *H*, d.f = 3; *H* = 15.682; P = 0.001), but not for the Thorsborne Trail (Kruskal Wallis *H*, d.f = 3; *H* = 9.356; P = 0.251).

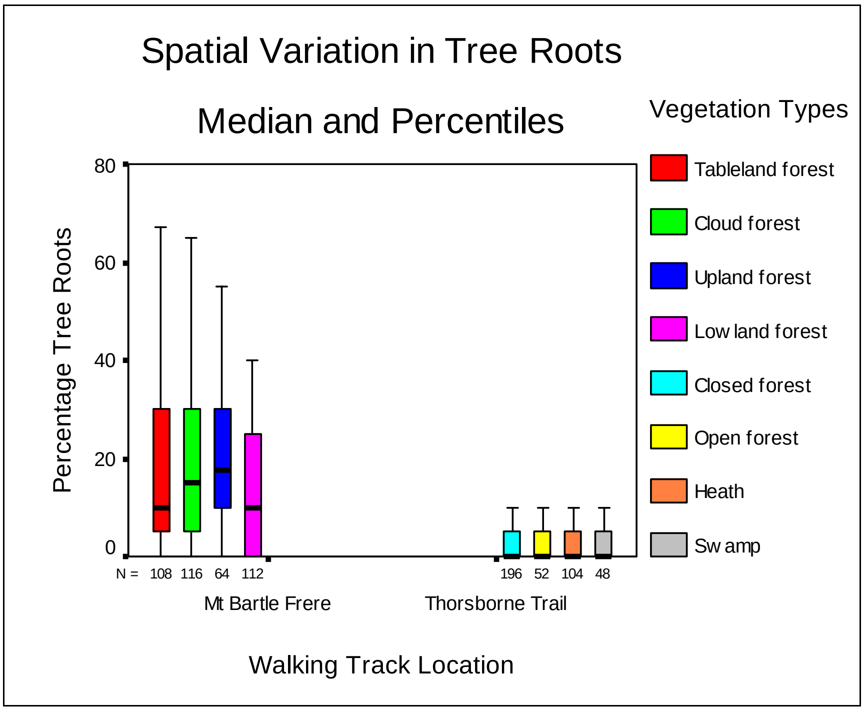

Figure 5.11 Spatial variation in tree roots (median and percentiles) associated with vegetation types. Control zone data excluded.

5.2.3.4 Rocks

Rocks are indicative of a durable and wear resistant track surface and their presence within tread and buffer zone quadrats should not necessarily be interpreted negatively, despite the fact that visitor use may increase their exposure through removal of overlying material. Rocks were more prevalent along the Mt Bartle Frere Track than along the Thorsborne Trail (Figure 5.12). The fact that rocks were equally prevalent within tread and control zone quadrats on the Mt Bartle Frere Track suggests that the presence of rocks within the tread zone at this location may be a natural phenomenon and was not necessarily a negative consequence of hiking use. Proportions of rocks within sampling zones on the Thorsborne Trail were relatively even. Comparative statistics revealed that spatial variation in the quantity of rocks recorded within sampling zone quadrats was not significant on either the Mt Bartle Frere Track (Kruskal Wallis *H*, d.f = 2; *H* = 3.524; P = 0.172), or the Thorsborne Trail (Kruskal Wallis *H*, d.f = 2; *H* = 2.444; P = 0.295).

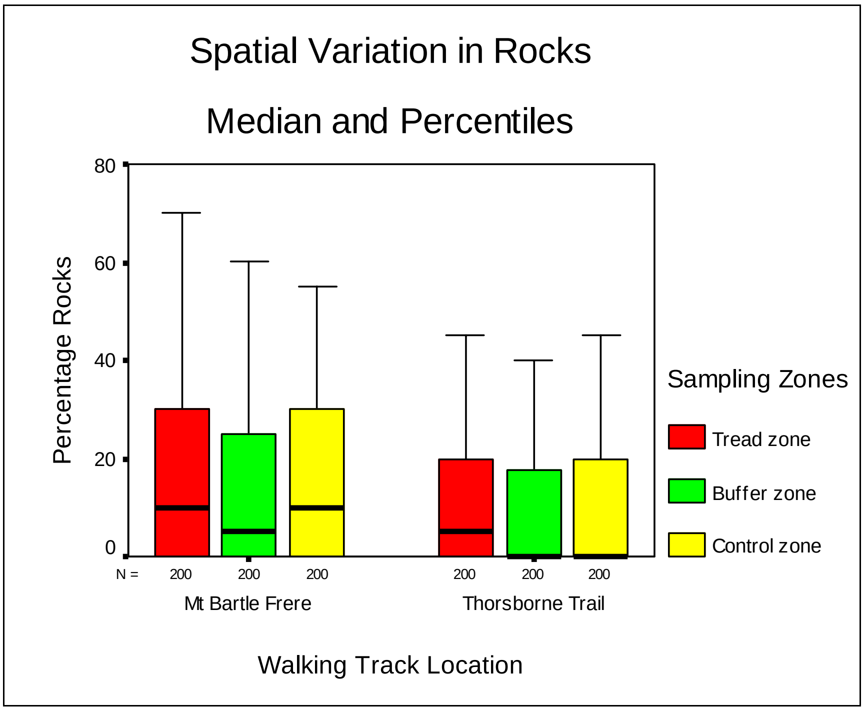

Figure 5.12 Spatial variation in rocks (median and percentiles) associated with quadrat sampling zones.

The relative proportions of rocks recorded within different vegetation types along each track are presented in Figure 5.13. Rocks were least prevalent within tableland forest and most prevalent within cloud forest, although it should be noted that this vegetation type included the extensive boulder field and a number of rocky outcrops near the summit of Mt Bartle Frere. Rocks were most prevalent within heath and closed forest vegetation, and least common within swamp communities along the Thorsborne Trail. Comparative statistics demonstrated there were highly significant differences in the quantities of rocks recorded within different vegetation types on both the Mt Bartle Frere Track (Kruskal Wallis *H*, d.f = 3; *H* = 47.817; P < 0.001), and the Thorsborne Trail (Kruskal Wallis *H*, d.f = 3; *H* = 29.241; P < 0.001).

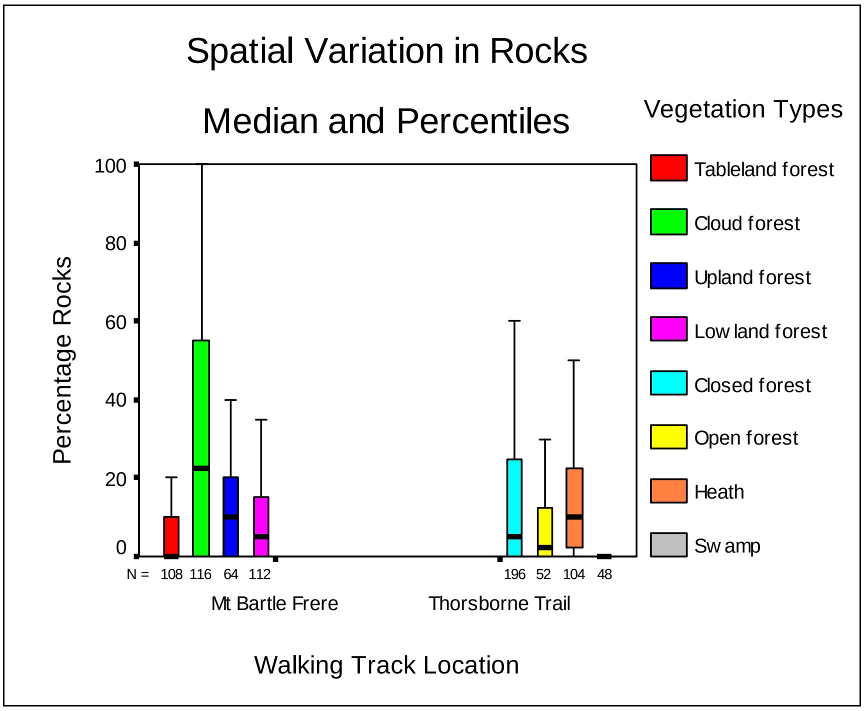

Figure 5.13 Spatial variation in rocks (median and percentiles) associated with vegetation types. Control zone data excluded.

5.2.3.5 Woody debris

Spatial variation in the distribution of woody debris within sampling zones indicated that debris was most prevalent within the control zones and least common within the tread zones associated with each track (Figure 5.14). Overall quantities of woody debris were greater for the Thorsborne Trail than for the Mt Bartle Frere Track. Comparative statistics (Table 5.5) revealed highly significant differences in the quantity of woody debris recorded within all sampling zones on both walking tracks.

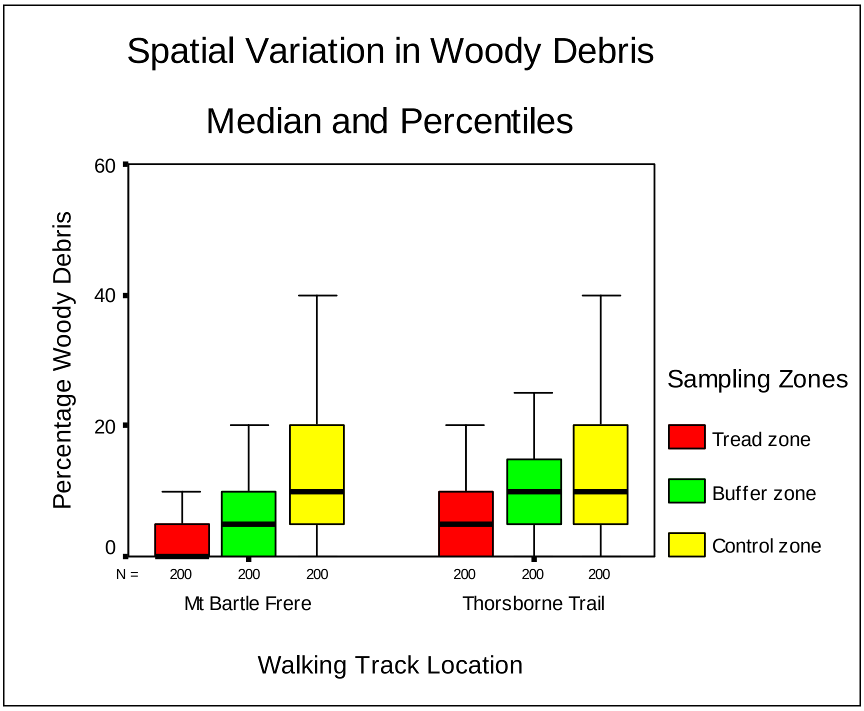

Figure 5.14 Spatial variation in woody debris (median and percentiles) associated with quadrat sampling zones.

Table 5.5 Comparative analyses of spatial variation in woody debris associated with quadrat sampling zones.

Woody Debris	*Kruskal Wallis H Test*	*Mann Whitney U Test - post hoc comparisons*		
	All Zones N=600	Tread/Buffer N=200	Tread/Control N=200	Buffer/Control N=200
Mt Bartle Frere	P < 0.001* d.f = 2 H = 148.448	P < 0.001** U = 14336.000	P < 0.001** U = 6792.000	P < 0.001** U = 11609.500
Thorsborne Trail	P < 0.001* d.f = 2 H = 84.388	P < 0.001** U = 12952.000	P < 0.001** U = 10120.500	P = 0.001** U = 16276.000

* Statistically significant at the 0.05 level (Kruskal Wallis *H* tests).
** Statistically significant difference between these two track zones at the 0.016 significance level (Mann Whitney *U* tests with Bonferronni correction).

Quantities of woody debris were found to vary among vegetation types on both tracks (Figure 5.15). Woody debris was most prevalent within lowland forest and tableland forest along the Mt Bartle Frere Track and least prevalent within cloud forest and upland forest respectively. There was no obvious explanation for the paucity of woody debris recorded within cloud forest and upland forest quadrats near the top of Mt Bartle Frere, although the abundance of woody debris recorded within lowland forest areas was probably related to past cyclonic activity. Quantities of woody debris on the Thorsborne Trail were fairly similar within all forest types, with the exception of open forest communities where it was somewhat higher. The relatively greater abundance of woody debris within open forest was most likely related to the particular tree species that grow within that vegetation type, rather than being related to human visitation. Comparative statistics demonstrated that quantities of woody debris were significantly different among vegetation types on the Mt Bartle Frere Track (Kruskal Wallis H, d.f = 3; H = 32.214; $P < 0.001$), but were not significant on the Thorsborne Trail (Kruskal Wallis H, d.f = 3; H = 3.691; P = 0.297).

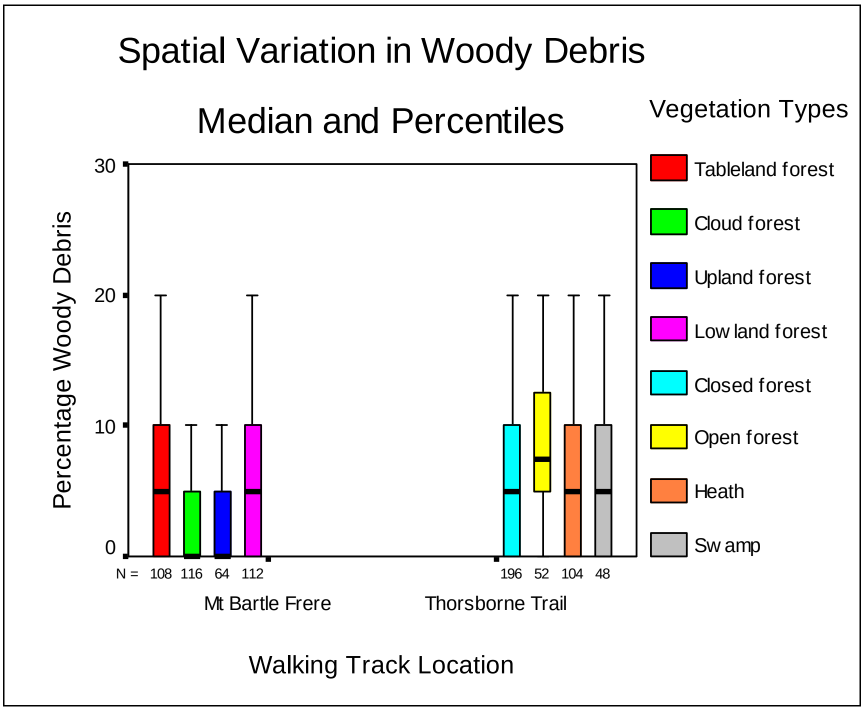

Figure 5.15 Spatial variation in woody debris (median and percentiles) associated with vegetation types. Control zone data excluded.

5.2.3.6 Living vegetation

Estimates of the relative proportions of living vegetation growing within quadrats were made to ensure that ground cover composition accurately reflected the quantity of trees, shrubs, vines, and seedlings present within each sampling zone. Quantities of living vegetation were highest in the buffer zone and lowest in the tread zones on both tracks (Figure 5.16). It is probable that the higher proportion of living vegetation recorded within buffer zone quadrats reflected increased light availability within this zone, although the substantially lower proportions of living vegetation recorded within tread zones was undoubtedly related to the trampling effects of hikers. Comparative statistical tests (Table 5.6) revealed significant differences among sampling zones on both tracks.

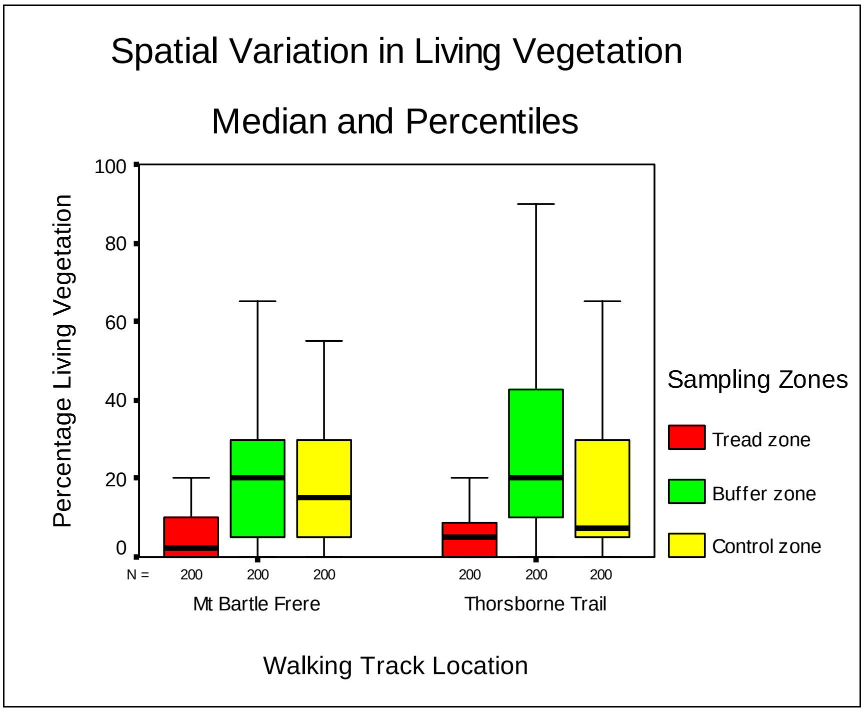

Figure 5.16 Spatial variations in living vegetation (median and percentiles) associated with quadrat sampling zones.

Table 5.6 Comparative analyses of spatial variation in living vegetation associated with quadrat sampling zones.

Living Vegetation	*Kruskal Wallis H Test*	*Mann Whitney U Test - post hoc comparisons*		
	All Zones N=600	Tread/Buffer N=200	Tread/Control N=200	Buffer/Control N=200
Mt Bartle Frere	P < 0.001* d.f = 2 *H* = 129.039	P < 0.001** *U* = 8313.000	P < 0.001** *U* = 9462.000	P = 0.104 *U* = 18135.000
Thorsborne Trail	P < 0.001* d.f = 2 *H* = 149.036	P < 0.001** *U* = 6154.500	P < 0.001** *U* = 12745.000	P = 0.001** *U* = 13224.000
* Statistically significant at the 0.05 level (Kruskal Wallis *H* tests). ** Statistically significant difference between these two track zones at the 0.016 significance level (Mann Whitney *U* tests with Bonferronni correction).				

Quantities of living vegetation within tableland forest were less than half that recorded in any other vegetation type on the Mt Bartle Frere Track, although no explanation was readily apparent for this result (Figure 5.17). Living vegetation was most prevalent within open forest and least common within closed forest on the Thorsborne Trail (Figure 5.17), which was at least partly a reflection of changes in light availability. Significant differences in quantities of living vegetation were recorded among vegetation types along both the Mt Bartle Frere Track (Kruskal Wallis *H*, d.f = 3; *H* = 28.803; P < 0.001), and the Thorsborne Trail (Kruskal Wallis *H*, d.f = 3; *H* = 18.336; P < 0.001).

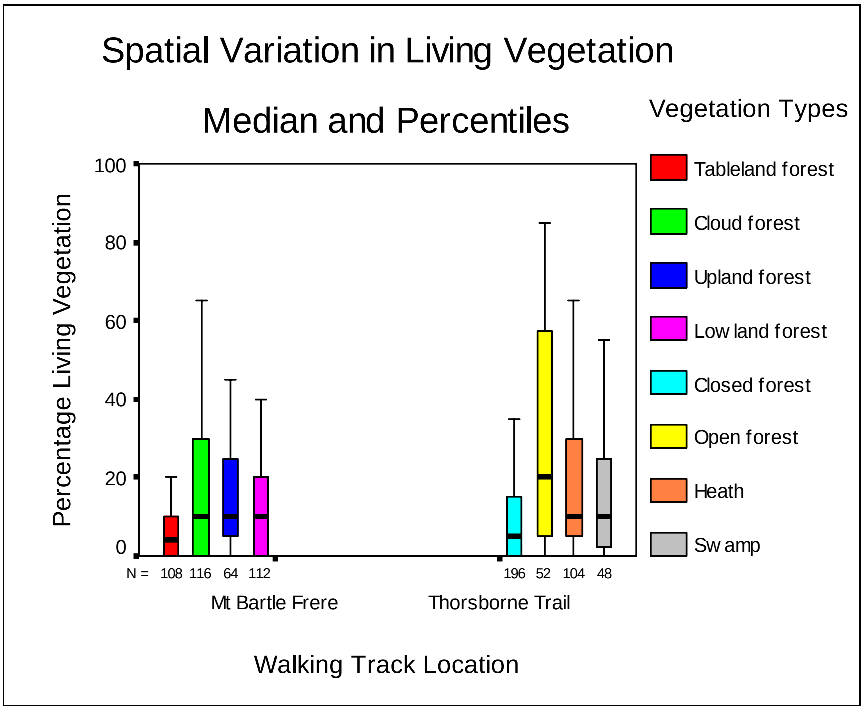

Figure 5.17 Spatial variation in living vegetation (median and percentiles) associated with vegetation types. Control zone data excluded.

5.2.4 Organic litter depth

Organic litter depth provides an indication of the extent of protection afforded to the underlying soil and is usually reduced by pedestrian traffic as hiking boots progressively grind and pulverise organic matter into smaller particles (Chapter 2). Comparisons of mean organic litter depth recorded within sampling zone quadrats demonstrated that organic litter cover depth was deepest in control zone quadrats and most shallow within tread zone quadrats on both tracks (Figure 5.18). These results were anticipated given the known consequences of hiking boots upon organic litter cover depth and the fact that hiking impacts are primarily concentrated within the tread zone, and to a lesser extent the buffer zone.

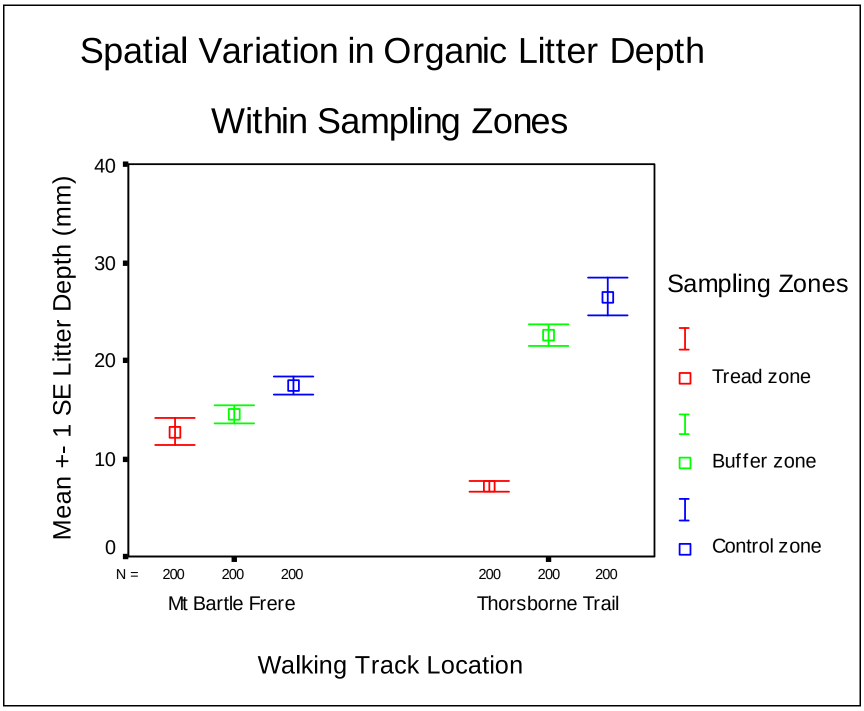

Figure 5.18 Spatial variations in organic litter depth (mean ± 1 standard error) associated with quadrat sampling zones.

Comparative statistics (Table 5.7) revealed highly significant spatial differences in the quantity of organic litter depth among all sampling zones on both tracks, with the exception of comparisons between the buffer and control zones on the Thorsborne Trail.

Table 5.7 Comparative analyses of spatial variation in organic litter depth associated with quadrat sampling zones.

Organic Litter Depth	*Kruskal Wallis H Test*	*Mann Whitney U Test - post hoc comparisons*		
	All Zones N=600	Tread/Buffer N=200	Tread/Control N=200	Buffer/Control N=200
Mt Bartle Frere	P < 0.001* d.f = 2 *H* = 54.401	P < 0.001** *U* = 14742.000	P < 0.001** *U* = 12105.500	P = 0.001** *U* = 16079.500
Thorsborne Trail	P < 0.001* d.f = 2 *H* = 161.647	P < 0.001** *U* = 6867.000	P < 0.001** *U* = 7962.000	P = 0.805 *U* = 19717.000

* Statistically significant at the 0.05 level (Kruskal Wallis *H* tests).
** Statistically significant difference between these two track zones at the 0.016 significance level (Mann Whitney *U* tests with Bonferronni correction).

Spatial variation in organic litter depth was also recorded among the various vegetation types along each track (Figure 5.19). On the Mt Bartle Frere Track mean organic litter depth was highest (24.0 mm) in tableland forest and lowest in upland forest (7.5 mm). Organic litter depth was found to be reasonably uniform along the Thorsborne Trail, with minimal variation (<5 mm) in mean values among the four vegetation types. Mean organic litter depth was highest within closed forest (16.4 mm), and lowest within open forest (12.2 mm). Organic litter depth within heath vegetation would undoubtedly have been deeper had heath communities between Zoe Falls and Mulligan Falls not been burnt during 2004. Organic litter depth was significantly different among the four vegetation types on the Mt Bartle Frere Track (Kruskal Wallis *H*, d.f = 3; *H* = 73.720; P < 0.001), but not on the Thorsborne Trail (Kruskal Wallis *H*, d.f = 3; *H* = 6.380; P = 0.095).

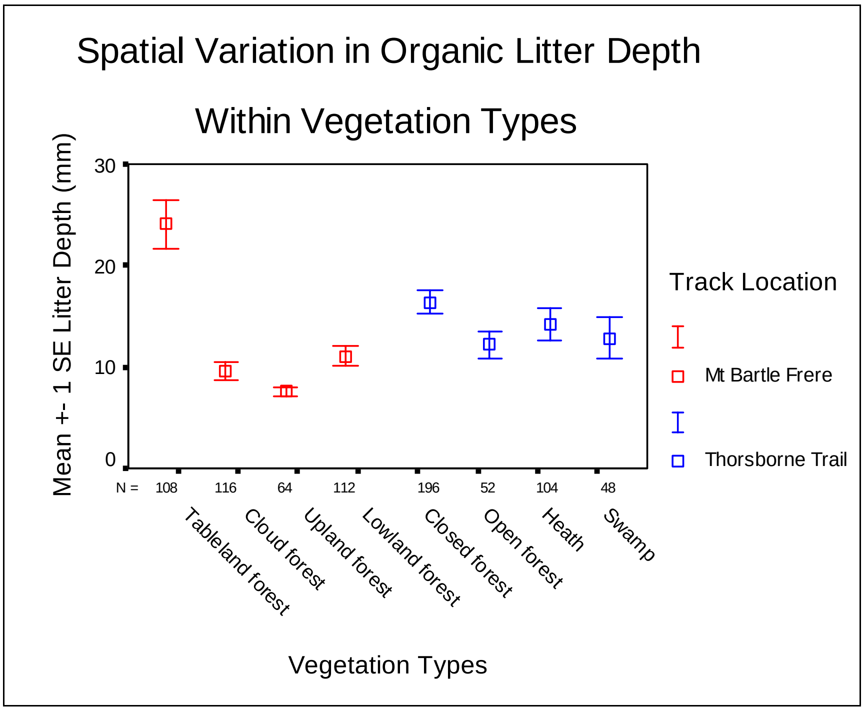

Figure 5.19 Spatial variations in organic litter depth (mean ± 1 standard error) associated with vegetation types. Control zone data excluded.

5.2.5 Canopy cover

Although canopy cover is not generally directly impacted by hikers it remains a useful environmental indicator because it provides an indication of the extent of light available at ground level for seedling and weed establishment, in addition to offering the soil some protection from raindrop splash. Canopy cover can also assist the interpretation of other data such as leaf litter and seedling density. Median canopy cover along the Mt Bartle Frere Track was substantially higher than that recorded for the Thorsborne Trail (Figure 5.20). On the Mt Bartle Frere Track, median canopy cover above the control zone (80%) was slightly lower than that recorded in the other two zones (85%), which was most likely related to rocky outcrops and boulders on either side of the track (Section 5.2.3.4). Median canopy cover on the Thorsborne Trail was highest in the buffer zone (60%) and somewhat lower in both the tread (55%) and control zones (50%) respectively. Spatial variations in canopy cover were only statistically significant between the buffer and control zones on the Thorsborne Trail (Table 5.8).

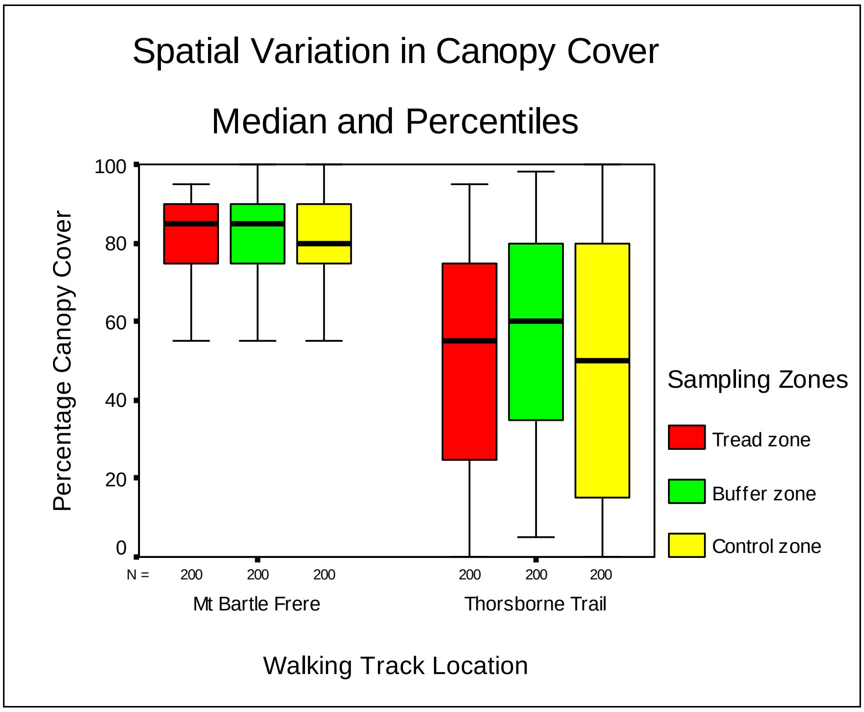

Figure 5.20 Spatial variation in canopy cover (median and percentiles) associated with quadrat sampling zones.

Table 5.8 Comparative analyses of spatial variation in canopy cover associated with quadrat sampling zones.

Canopy Cover	*Kruskal Wallis H Test*	*Mann Whitney U Test - post hoc comparisons*		
	All Zones N=600	Tread/Buffer N=200	Tread/Control N=200	Buffer/Control N=200
Mt Bartle Frere	$P = 0.227$ d.f = 2 $H = 2.968$	-	-	-
Thorsborne Trail	$P < 0.020$* d.f = 2 $H = 7.783$	$P = 0.061$ $U = 17838.500$	$P = 0.289$ $U = 18776.500$	$P = 0.008$** $U = 16933.500$

* Statistically significant at the 0.05 level (Kruskal Wallis *H* tests).
** Statistically significant difference between these two track zones at the 0.016 significance level (Mann Whitney *U* tests with Bonferronni correction).

Considerable variation in canopy cover was detected among vegetation types on both walking tracks (Figure 5.21). Median canopy cover on the Mt Bartle Frere Track was reasonably homogenous within tableland, upland and lowland forest types, but was substantially lower in cloud forest, presumably because of the numerous rocky outcrops and the extensive boulder field near the summit. Median canopy cover on the Thorsborne Trail was similar within both closed forest and swamp, substantially lower within open forest, and minimal within heath. Canopy cover was significantly different among vegetation types on both Mt Bartle Frere Track (Kruskal Wallis *H*, d.f = 3; $H = 87.463$; $P < 0.001$) and the Thorsborne Trail (Kruskal Wallis *H*, d.f = 3; $H = 173.018$; $P < 0.001$).

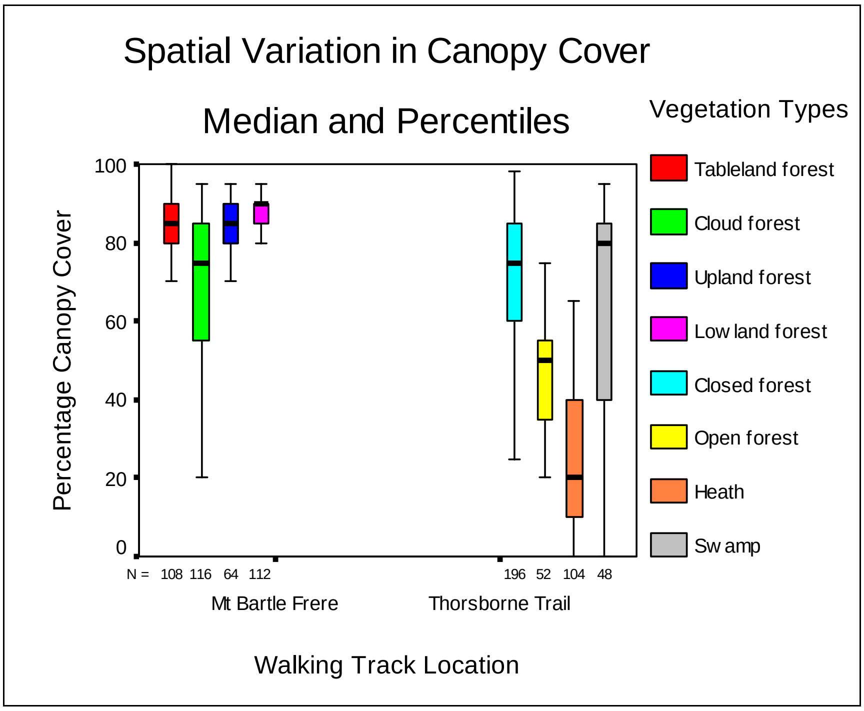

Figure 5.21 Spatial variation in canopy cover (median and percentiles) associated with vegetation types. Control zone data excluded.

5.2.6 Seedling density

Counts of seedling density provide valuable information about ecosystem processes and the effects of trampling. It should be reiterated that seedling density only includes counts of dicot seedlings less than 0.5m tall and does not include other ground covers such as grasses, herbs and vines. Figure 5.22 presents seedling density data recorded within sampling zone quadrats for both tracks. Mean numbers of seedlings on the Mt Bartle Frere Track were highest in the buffer zone (11.4), and as anticipated, lowest within the tread zone (4.5). Mean seedling density on the Thorsborne Trail was again lowest within the tread zone (5.2), but highest within the control zone (12.9). These results provide further evidence that hiking retards seedling establishment and survival within the tread zone of long-distance walking tracks.

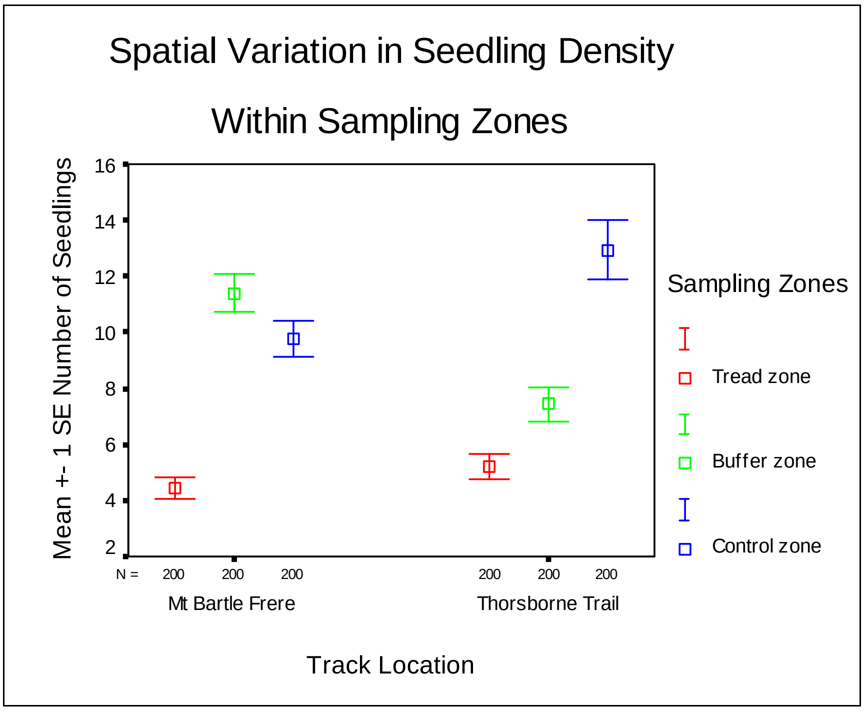

Figure 5.22 Spatial variation in seedling density (mean ± 1 standard error) associated with quadrat sampling zones.

Comparative statistics (Table 5.9) revealed the existence of statistically significant differences between tread and buffer zones, and between tread and control zones on the Mt Bartle Frere Track. Statistically significant differences in seedling density were recorded among all paired sampling zones along the Thorsborne Trail.

Table 5.9 Comparative analyses of spatial variation in seedling density associated with quadrat sampling zones.

Seedling Density	*Kruskal Wallis H Test*	*Mann Whitney U Test - post hoc comparisons*		
	All Zones N=600	Tread/Buffer N=200	Tread/Control N=200	Buffer/Control N=200
Mt Bartle Frere	$P < 0.001$* d.f = 2 $H = 99.542$	$P < 0.001$** $U = 9471.000$	$P < 0.001$** $U = 10854.000$	$P = 0.080$ $U = 17979.000$
Thorsborne Trail	$P < 0.001$* d.f = 2 $H = 33.380$	$P < 0.001$** $U = 15985.000$	$P < 0.001$** $U = 13676.500$	$P = 0.005$** $U = 16745.500$

* Statistically significant at the 0.05 level (Kruskal Wallis *H* tests).
** Statistically significant difference between these two track zones at the 0.016 significance level (Mann Whitney *U* tests with Bonferronni correction).

Spatial variation in seedling density was detected among different vegetation types on each track (Figure 5.23). Mean seedling counts on the Mt Bartle Frere Track were highest within tableland forest and cloud forest, and lowest within upland forest. On the Thorsborne Trail, mean seedling numbers were highest within swamp communities, and lowest within heath communities, although it should be noted that seedling recruitment within heath vegetation may have been adversely impacted by fires during the middle of 2004. Seedling density was significantly different within the four vegetation types on the Mt Bartle Frere Track (Kruskal Wallis *H*, d.f = 3; *H* = 16.901; P = 0.001). Seedling density also varied significantly among vegetation types along the Thorsborne Trail (Kruskal Wallis *H*, d.f = 3; *H* = 41.238; P < 0.001).

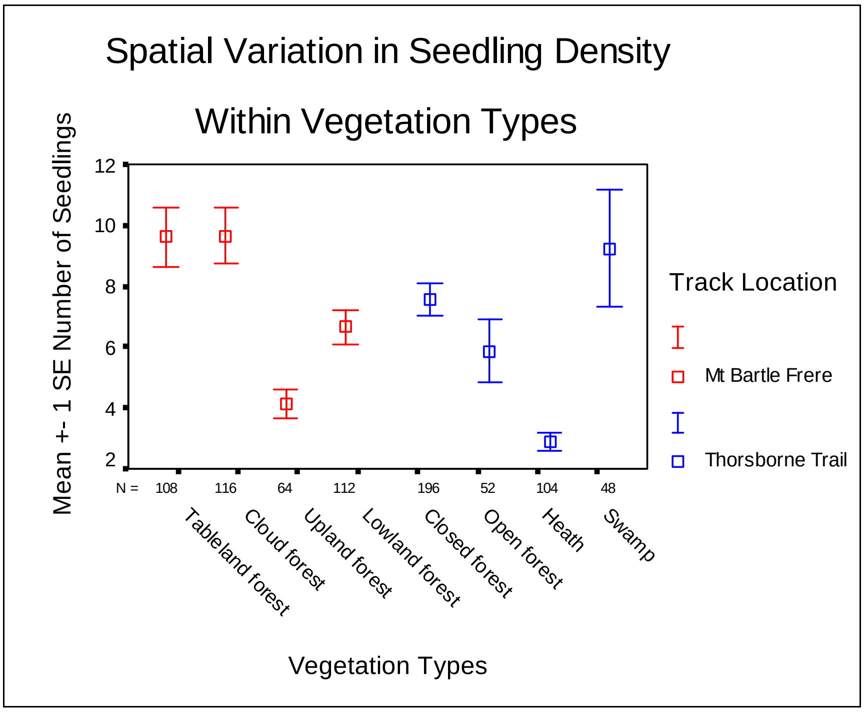

Figure 5.23 Spatial variation in seedling density (mean ± 1 standard error) associated with vegetation types. Control zone data excluded.

5.2.7 Soil erosion

Soil erosion within sampling zone quadrats along each walking track was classified into one of four classes (none, slight, moderate, or severe). Comparisons of soil erosion data presented in Table 5.10 confirmed that erosion was more prevalent on the Mt Bartle Frere Track, with either moderate or severe erosion being recorded in a total of 64 quadrats during the course of sampling. This compared unfavorably with the Thorsborne Trail where no severe erosion was recorded and moderate erosion was only encountered in a total of 17 quadrats. As expected, soil erosion was found to be most prevalent within the tread zones of both walking tracks, thereby confirming a link with visitor use of long-distance walking tracks.

Table 5.10 Extent of soil erosion associated with quadrat sampling zones.

Extent of Soil Erosion (combined wet and dry season samples)	*Number of Quadrats*			*Total*
	Tread	*Buffer*	*Control*	
Mt Bartle Frere Track				
None	81	153	187	421
Slight	68	36	11	115
Moderate	41	10	2	53
Severe	10	1	0	11
Total	200	200	200	600
Thorsborne Trail				
None	134	183	183	500
Slight	52	17	14	83
Moderate	14	0	3	17
Severe	0	0	0	0
Total	200	200	200	600

Comparisons of soil erosion were also made between tread and buffer zone quadrats located within different vegetation types (Figure 5.24). Results suggest that severe erosion was most prevalent within upland forest and cloud forest on the Mt Bartle Frere Track, which also contained the steepest track sections. Severe soil erosion was recorded in 63 percent of upland forest quadrats, and 48 percent of cloud forest quadrats respectively. Although no quadrats from the Thorsborne Trail contained evidence of severe soil erosion, moderate erosion was found to be most prevalent within heath vegetation and non-existent within open forest.

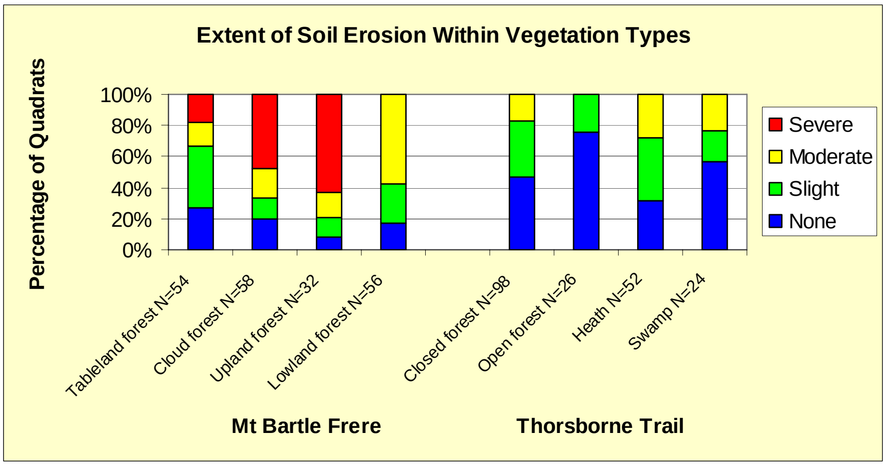

Figure 5.24 Percentage of quadrats (tread and buffer zones only) located within different vegetation types that contained soil erosion of varying severity on each track.

The extent of soil erosion recorded within tread and buffer zone quadrats located within different vegetation types was significantly different on both the Mt Bartle Frere Track (Chi-square, d.f = 9; x^2 = 47.441; P < 0.001), and the Thorsborne Trail (Chi-square, d.f = 6; x^2 = 16.111; P = 0.013).

Although the data presented in Figure 5.24 suggested that track sections located in upland forest and cloud forest on the Mt Bartle Frere Track were more susceptible to severe soil erosion, it is likely that this erosion was related in part to topography. This has been confirmed via analysis of the relationship between tread zone erosion and topography, which reveal that severe erosion was predominantly associated with steep track sections (Figure 5.25). Soil erosion recorded within tread zone quadrats along the Mt Bartle Frere Track varied significantly in response to changing topography (flat, undulating, steep) (Chi-square, d.f = 6; x^2 = 67.443; P < 0.001).

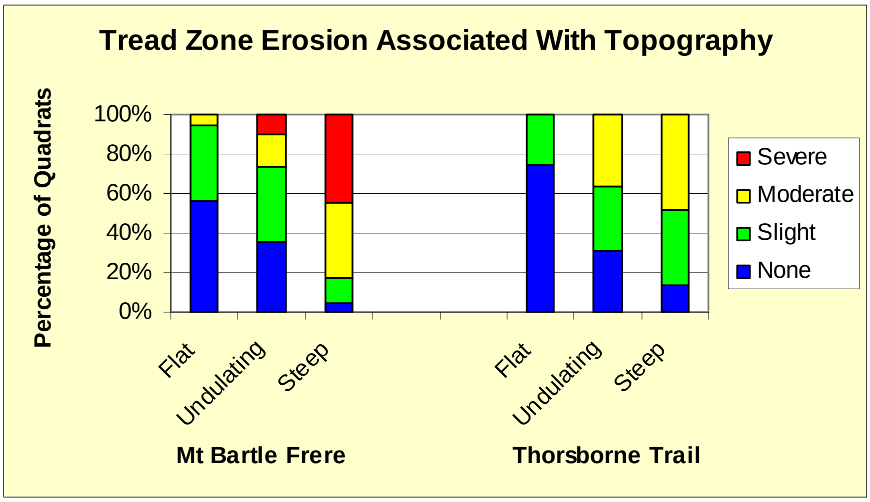

Figure 5.25 Percentage of tread zone quadrats within different topographic types that contained soil erosion of varying severity.

Although no severe soil erosion was recorded on the Thorsborne Trail, moderate erosion was predominantly associated with steep topography. Soil erosion recorded within tread zone quadrats along the Thorsborne Trail also varied significantly in response to changing topography (Chi-square, d.f = 4; $x^2 = 38.025$; $P < 0.001$).

5.2.8 Weeds

The capacity exists for long-distance walkers to inadvertently spread weeds into core areas of the Wet Tropics region. During biophysical impact sampling, weeds were recorded at two spatial scales, both within one metre square quadrats, and along 20 metre linear transects associated with each sampling point. Weeds were almost non-existent within quadrats on both tracks, with only two Giant Bramble plants (*Rubus alceifolius*) being recorded within a lowland forest control zone quadrat on the Mt Bartle Frere Track. No weeds were recorded within any Thorsborne Trail quadrats.

Weeds were also scarce along 20 metre transects, where infestations were classified into one of four classes (none, slight, moderate or severe) depending upon the severity of the invasion. Whilst four 'moderate' infestations (6-10 weeds) and ten 'slight' infestations (1-5 weeds) were recorded on the Mt Bartle Frere Track, only three 'slight' infestations were recorded on the Thorsborne Trail. The principle weed species identified on the Mt Bartle Frere Track were Giant Bramble (*Rubus alceifolius*) and Lantana (*Lantana* *camara*), while Coconuts (*Cocos nucifera*) and Buffalo Couch (*Stenotaphrum sp*.) were recorded along Thorsborne Trail transects. Although ‘severe’ (>10 weeds) infestations were not recorded on either track, they were sighted at either end of the Mt Bartle Frere Track but did not occur within any of the linear transects established in association with randomly established sampling points.

5.2.9 Feral animals

Long-distance walking tracks can function as a conduit for feral animals to access core areas of the Wet Tropics region. Sightings of cane toads and evidence of pig diggings were recorded along linear transects associated with a number of sampling points. Pigs were never actually sighted within transect confines on either walking track, so all references in this section refer to their diggings. The fact that sampling was only conducted during daylight hours undoubtedly reduced the number of potential sightings of feral animals.

The recorded incidences of feral animal activity within different vegetation types are shown in Figure 5.26. On the Mt Bartle Frere Track, feral animal activity was recorded in every vegetation type with pig diggings most prevalent within tableland forest and lowland forest, while cane toads were sighted along transects in both cloud forest and lowland forest. Extensive pig diggings were recorded along transects between Bobbin Bobbin Falls and the car park at the commencement of the western route to the summit. Cane toads and pig diggings were recorded along transects in closed forest near Zoe Bay and Mulligan Falls on the Thorsborne Trail. Pig diggings were also very common within swamp communities along the Thorsborne Trail, where evidence of pigs was recorded in approximately half of all transects surveyed. Feral animal activity differed significantly among vegetation types on the Mt Bartle Frere Track (Chi-square, d.f = 6; x^2 = 11.300; P < 0.080), and the Thorsborne Trail (Chi-square, d.f = 9; x^2 = 54.529; P < 0.001).

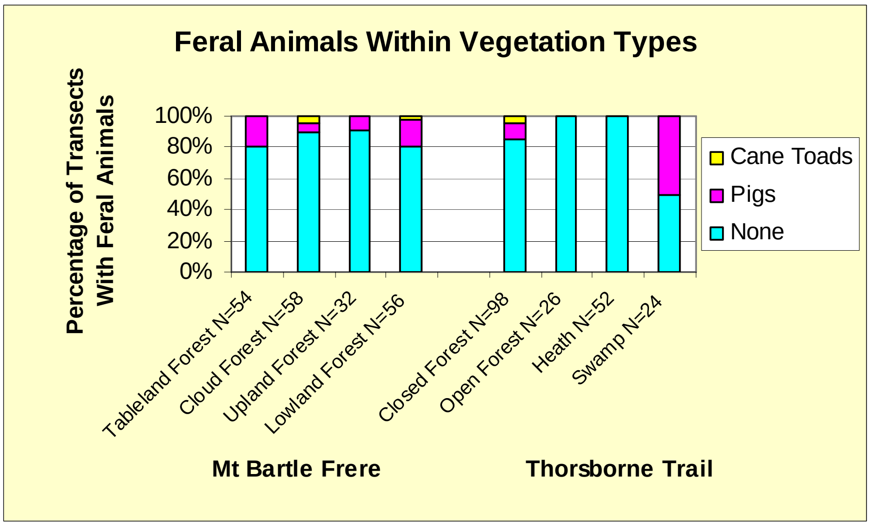

Figure 5.26 Frequency of incidences of feral animal activity (cane toads and pig diggings) recorded along transects within different vegetation types.

5.2.10 Human litter

Although human litter is primarily a threat to the quality of visitor experiences through reduced visual amenity, it can nevertheless have adverse biophysical impacts upon water quality and wildlife. All incidences of litter encountered within the vicinity of transects were recorded and subsequently divided into plastic, paper, food scraps, and 'other' categories (Figure 5.27). A total of 37 separate items of human litter were recorded along transects on the Mt Bartle Frere Track, with paper being the most frequently recorded substance. Miscellaneous litter included a number of cigarette butts, band aids, pieces of foam rubber, and a shoe lace. Human litter was more plentiful within Thorsborne Trail transects with a total of 73 incidences recorded. Litter associated with the Thorsborne Trail primarily consisted of plastic and paper, although 17 miscellaneous items were recorded, including clothing, pieces of rope, a towel, band aids, and a baby wipe.

As this research used a stratified random sampling procedure to locate sampling points on both walking tracks, biophysical impacts within camping grounds were not specifically targeted. Nevertheless, sampling revealed increased quantities of human litter existed in close proximity to camping grounds on both walking tracks. An abundance of litter was also observed within the inter-tidal zone associated with the Thorsborne Trail, particularly at both Sunken Reef Bay and Mulligan Bay. The vast majority of this litter was flotsam and jetsam, which were believed to have originated from marine craft, and not from long-distance walkers.

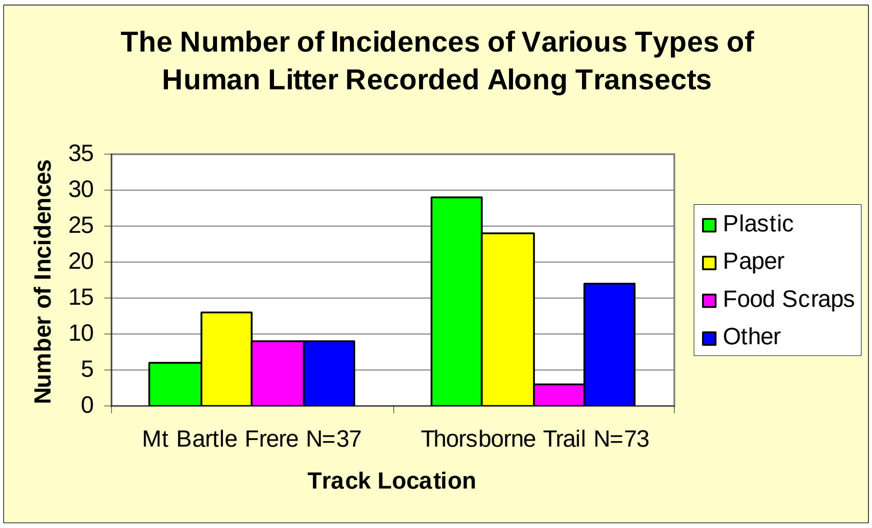

Figure 5.27 Counts of incidences of human litter of different types recorded along transects.

5.2.11 Human body waste

Evidence of toilet paper and fecal waste were recorded adjacent to transects along both tracks, with total numbers of incidences found to be more common along the Mt Bartle Frere Track (13), than the Thorsborne Trail (2). Evidence of human body waste was recorded adjacent to transects near each of the three camping grounds on the Mt Bartle Frere Track and it was particularly disturbing to record three incidences in proximity to the small creek supplying water at the Top Western Campsite. The two incidences of human body waste recorded on the Thorsborne Trail were also troubling because they were associated with transects near the respective Zoe Bay and Mulligan Falls camping grounds which both have toilet facilities. Anecdotal evidence supplied by hikers camped at Zoe Bay at the time of sampling attributed fresh human body waste in the campground to yachters anchored offshore in Zoe Bay.

5.2.12 Social trails

Social or undesignated trails represent informal side tracks that are not sanctioned by management, and have been created by walkers' short-cutting or seeking better access to nearby attractions. Social trails extend the zone of visitor impact beyond the designated track surface and can also expose hikers to unnecessary risks. The number of incidences of social trails recorded along transects were higher on the Mt Bartle Frere Track (39), than on the Thorsborne Trail (25).

While the purpose of many social trails was indeterminate, it was apparent that some undesignated tracks on Mt Bartle Frere enabled hikers to gain access to better views, while others appeared to be shortcuts, and detours around fallen trees. Many undesignated trails associated with the Thorsborne Trail appear to have been created to enable walkers to access fresh water, or to inspect interesting natural features such as trees and rocks. A number of other social trails originating from Thorsborne Trail transects were dead ends, and appear to have resulted from confusion about the location of the marked track, particularly in the vicinity of North Zoe Creek where four informal tracks were recorded along one transect.

5.2.13 Vegetation damage

Human damage to vegetation growing along long-distance walking tracks, whether intentional or inadvertent, can have adverse consequences for the plants concerned, in addition to disturbing the visual amenity of the natural environment. Vegetation damage recorded along transects included trampled seedlings, broken branches, badly scuffed roots, the removal of bark from trees on steep slopes after repeated use as hand holds, axe marks and knife carvings on trees, plaques and nails hammered into trees, and an assortment of materials tied to trees within camping grounds including rope, fishing line and wire. The number of incidences of vegetation damage along transects is depicted for both walking tracks in Figure 5.28.

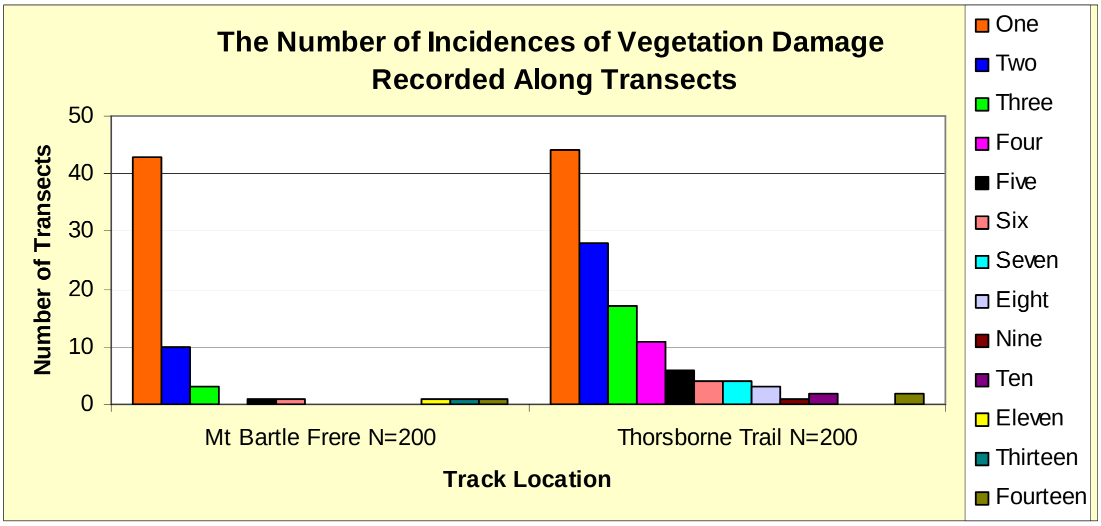

Figure 5.28 Counts of incidences of vegetation damage recorded along transects.

A total of 121 separate incidences of vegetation damage were recorded within transects along the Mt Bartle Frere Track, with a number of these being the result of inappropriate visitor behaviour. For example, there was an abundance of names carved on trees and even a couple of personalised plaques nailed to tree trunks near the summit that tell of the achievement of climbing Queensland's highest mountain. A total of 358 incidences of vegetation damage were recorded along Thorsborne Trail transects, although a large proportion of these were trampled seedlings and broken branches within the tread zone. The relatively higher number of incidences of trampled seedlings and broken branches within the tread zone of the Thorsborne Trail was possibly related to this being a substantially narrower track than was the case on Mt Bartle Frere (Section 5.2.2). Nevertheless, intentional vegetation damage was still prolific within transects near Mulligan Falls where numerous trees have incurred damage as a consequence of nails, ropes, wire and fishing line being used as makeshift clothes lines, or to suspend backpacks in order to avoid rat damage.

While the frequency of vegetation damage varies within different vegetation types, it is important to remember that sampling points were stratified according to vegetation type, and hence numbers of sampling points and associated transects vary accordingly. Figure 5.29 depicts numbers of incidences of vegetation damage recorded within different vegetation types for both walking tracks. Vegetation damage on the Mt Bartle Frere Track appears to have been higher within cloud forest and upland forest, which were both located on the upper reaches of the mountain. The prevalence of vegetation damage in proximity to the summit could be partly a consequence of steep slopes in that vicinity which often requires the use of hand and foot holds, but was undoubtedly also enhanced by prolific carvings on tree trunks near the summit. Vegetation damage along the Thorsborne Trail was *disproportionately high* in open forest, which had exactly half as many transects (26) as heath communities (52), and yet recorded more damage. No explanation was obvious for the extent of vegetation damage recorded within open forest, although it has already been noted above that this vegetation type exhibited the overall lowest mean track width, and perhaps many of the broken branches and trampled seedlings were a consequence of the narrow tread surface. Vegetation damage was also common in association with closed forest transects, although much of the damage was recorded along transects located near the respective camping grounds at Zoe Bay and Mulligan Falls.

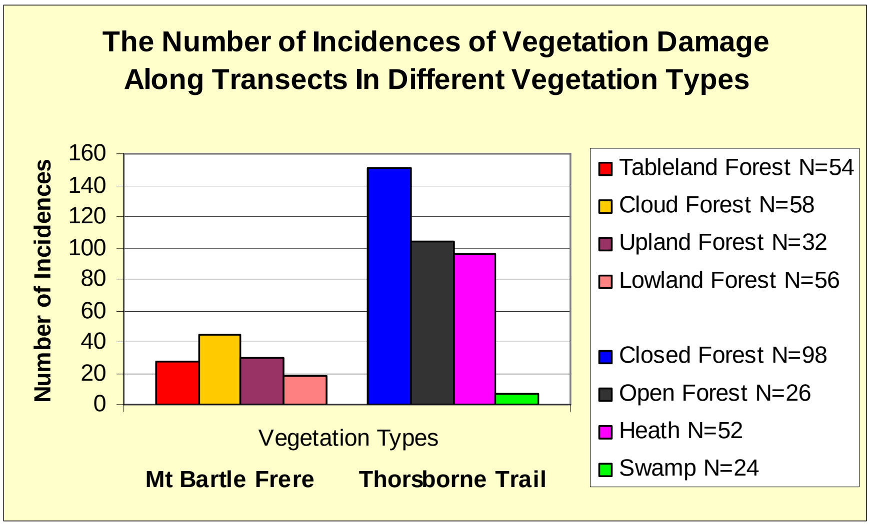

Figure 5.29 Counts of incidences of vegetation damage recorded along transects within different vegetation types.

5.2.14 Additional track problems

A range of additional track problems were recorded along transects, including numbers of fallen trees, low overhanging branches requiring hikers to stoop, and drainage problems (Figure 5.30). These factors provide some indication of track maintenance standards. Data suggested there was minimal impeded drainage on either track, although drainage problems on the Mt Bartle Frere Track were predominantly located within tableland forest near the western trackhead. Fallen trees and low overhanging branches were more prevalent within transects along the Thorsborne Trail, which suggests that some additional track maintenance is required. The majority of tree falls and low overhanging branches were located between Zoe Bay and Little Ramsay Bay.

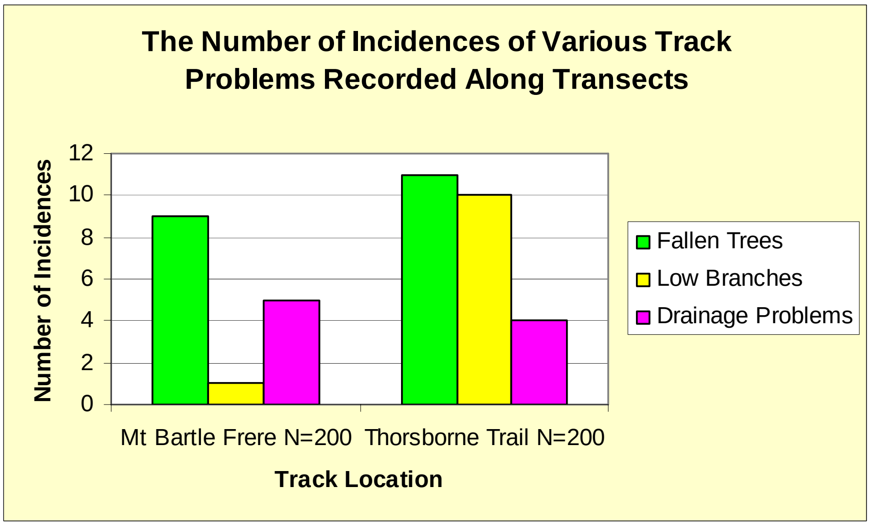

Figure 5.30 Counts of incidences of additional track problems recorded along transects.

5.3 SEASONAL COMPARISONS

Since it was not physically possible to conduct concurrent wet and dry season sampling on both walking tracks, there was some temporal variation among the dates of field sampling during the course of 2004. On the Mt Bartle Frere Track wet season sampling commenced in February but was not completed until May, while dry season sampling was all undertaken within August. On the Thorsborne Trail all wet season sampling was completed during April and all dry season sampling completed during September. To ensure that 2004 was a representative year in terms of long-term climatic averages, rainfall data was obtained for the closest available Bureau of Meteorology weather reporting station to each walking track. Rainfall data used for the Mt Bartle Frere Track was recorded at Bartle View, while data for the Thorsborne Trail was recorded at Cardwell. Appendix 8 provides a breakdown of monthly rainfall and the number of days when rain fell during 2004, while long-term rainfall data are also presented for both locations. The data presented in Appendix 8 confirms that overall both walking tracks experienced typical seasonal variations in climatic parameters during 2004, and that both monthly rainfall and the number of wet days were consistent with longer-term climatic averages recorded near both locations.

5.3.1 Track width

Mean track width recorded within the tread zone decreased slightly during the dry season on both walking tracks (Figure 5.31). It was likely that hikers inadvertently increased track widths to some extent during the wet season, as they attempted to avoid sections of track that were either muddy or inundated by water. Conversely, during the dry season walkers appeared to utilise the centre of the tread zone to a greater extent thereby reducing the surface area impacted by hiking boots. Track width was not significantly different between wet and dry season sampling on either walking track (Mann Whitney *U* tests, Mt Bartle Frere Track *U* = 4791.000; P = 0.609; Thorsborne Trail *U* = 4636.000; P = 0.374).

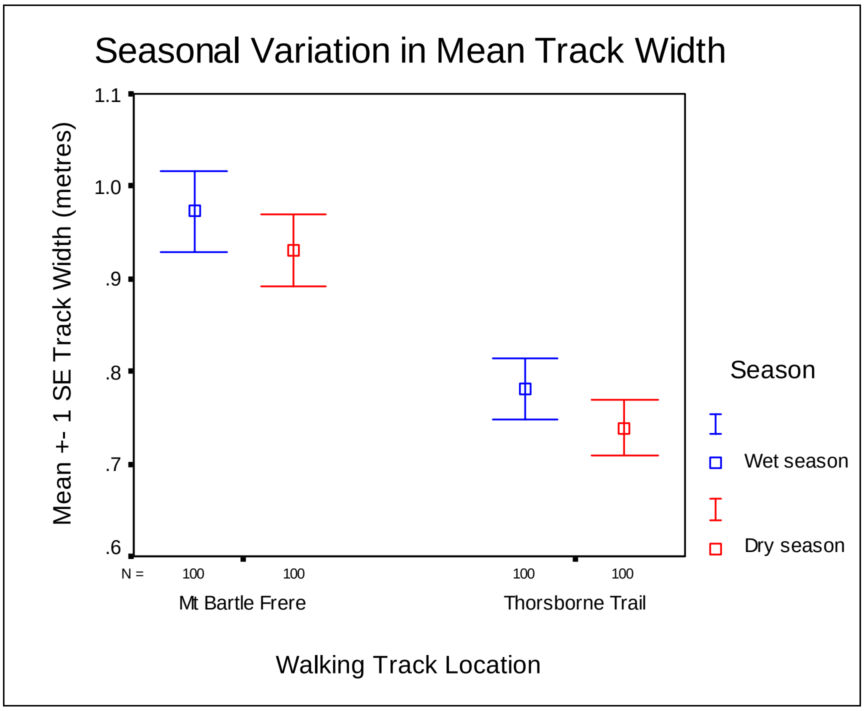

Figure 5.31 Seasonal variation in track width (mean ± 1 standard error) recorded within tread zone quadrats.

5.3.2 Ground cover composition within quadrats

Comparisons of ground cover composition data recorded within tread and buffer zone quadrats during both wet and dry seasons suggested there was minimal seasonal variation on either track. Control zone data was intentionally excluded from all seasonal analyses, because the second research question was specifically directed at assessing seasonal variations in biophysical impacts that resulted from *visitor use*, rather than changes that may have been associated with natural variations in environmental parameters.

5.3.2.1 Exposed mineral soil

Seasonal variations in quantities of exposed mineral soil are presented in Figure 5.32 for both tracks. Seasonality appears to have had minimal influence upon the proportion of bare soil recorded on the Mt Bartle Frere Track, where median results remained unchanged. Median quantities of bare soil were highest on the Thorsborne Trail during the dry season, when variability was also greatest. Increases in the relative proportions of bare soil recorded during the dry season were likely to be the result of extended visitor use prior to the Thorsborne Trail being spelled for part of the wet season. Seasonal variations in the relative proportions of exposed mineral soil were not significantly different on either the Mt Bartle Frere Track (Mann Whitney U = 19006.000; P = 0.379), or the Thorsborne Trail (Mann Whitney U = 17843.500; P = 0.057).

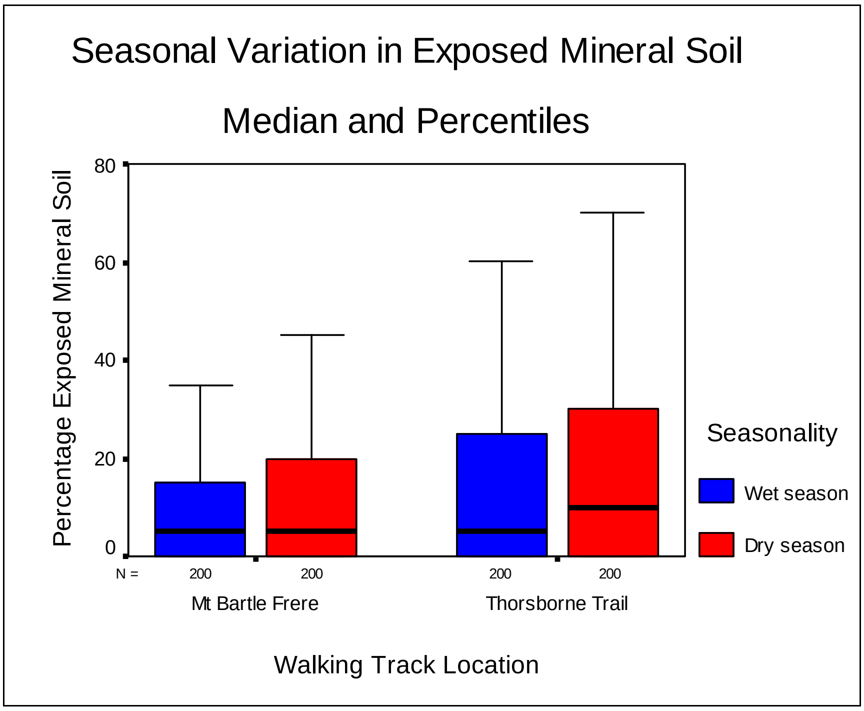

Figure 5.32 Seasonal variation in exposed mineral soil (median and percentiles) recorded within tread and buffer zone quadrats.

5.3.2.2 Leaf litter

Median leaf litter recorded within quadrats on the Mt Bartle Frere Track was constant during both seasons, although increased volumes of organic litter were recorded during the wet season (Figure 5.33). It was originally anticipated that leaf litter would be more prevalent during the dry season as a consequence of leaf falls associated with moisture stress to plants. There was no obvious explanation for the results obtained on the Mt Bartle Frere Track, except to suggest that the completion of dry season sampling in August may have preceded the onset of maximum leaf litter fall at this location. The median proportion of leaf litter recorded in quadrats along the Thorsborne Trail was highest during the dry season. This was despite prescribed burns being conducted within heath vegetation during the interval between wet and dry season sampling. Seasonal variations in leaf litter were not significantly different between wet and dry seasons on either the Mt Bartle Frere Track (Mann Whitney *U* = 19179.500; P = 0.477), or the Thorsborne Trail (Mann Whitney *U* = 19068.000; P = 0.419).

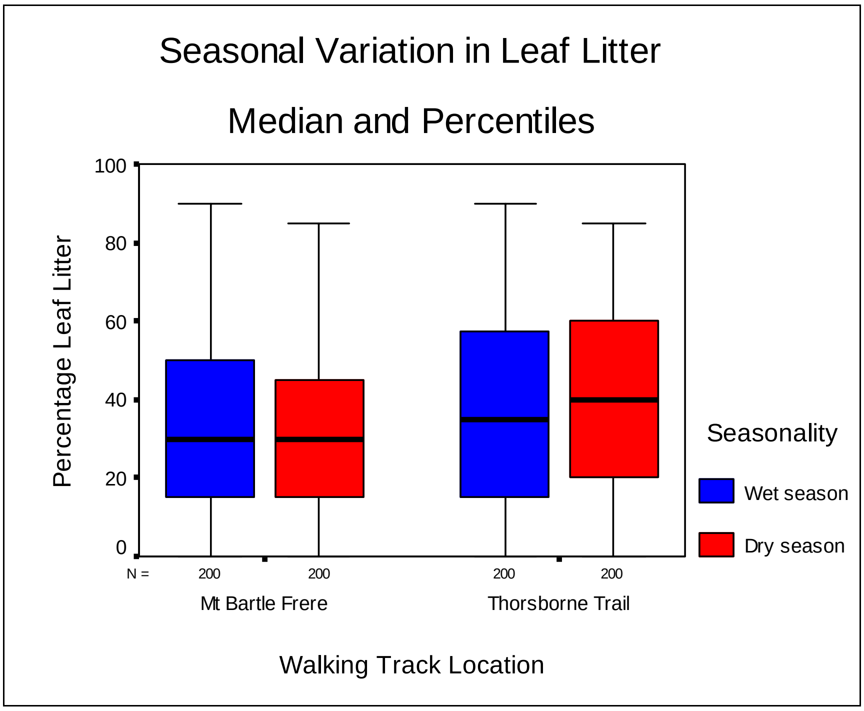

Figure 5.33 Seasonal variation in leaf litter (median and percentiles) recorded within tread and buffer zone quadrats.

5.3.2.3 Tree roots

The prevalence of tree roots within tread and buffer zones did not appear to be influenced by seasonality on either track (Figure 5.34). These results suggest that tree roots may not be a good indicator of short-term environmental changes. Comparative statistics suggested that the relative quantities of tree roots were not significantly different between wet and dry season sampling on either track (Mann Whitney *U* tests, Mt Bartle Frere Track *U* = 19876.500; P = 0.914; Thorsborne Trail *U* = 19826.500; P = 0.866).

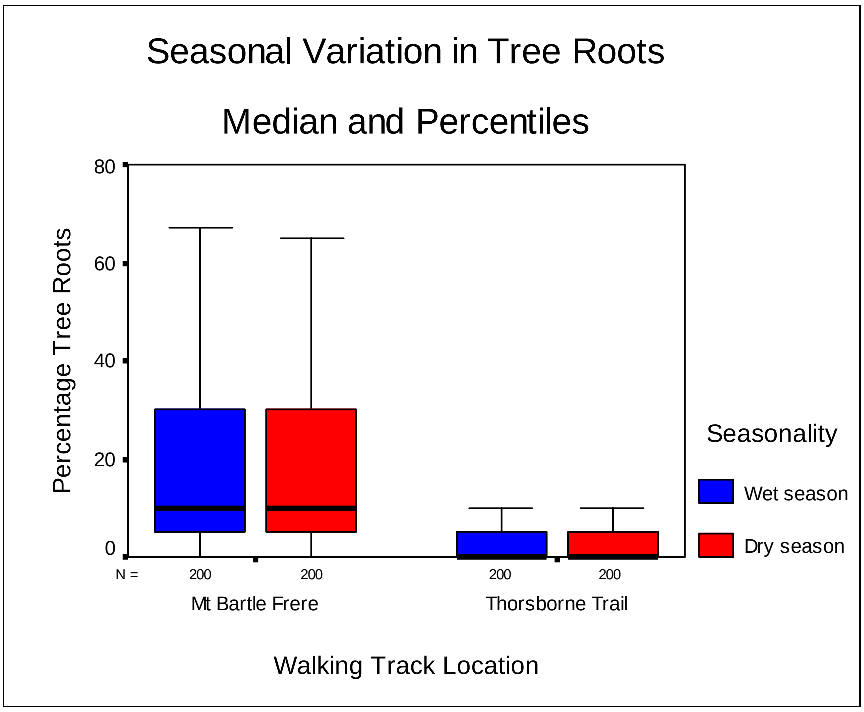

Figure 5.34 Seasonal variation in tree roots (median and percentiles) recorded within tread and buffer zone quadrats.

5.3.2.4 Rocks

The quantity of rocks present within tread and buffer zone quadrats did not appear to exhibit any seasonal variation on either walking track (Figure 5.35). The highly durable nature of rocks suggests that seasonal variations in the proportions of rocks would only occur if overlying soil and leaf litter were displaced. Proportions of rocks recorded within tread and buffer zones were not significantly different between wet and dry seasons on either track (Mann Whitney *U* tests, Mt Bartle Frere Track *U* = 19817.500; P = 0. 869; Thorsborne Trail *U* = 19415.000; P = 0. 594).

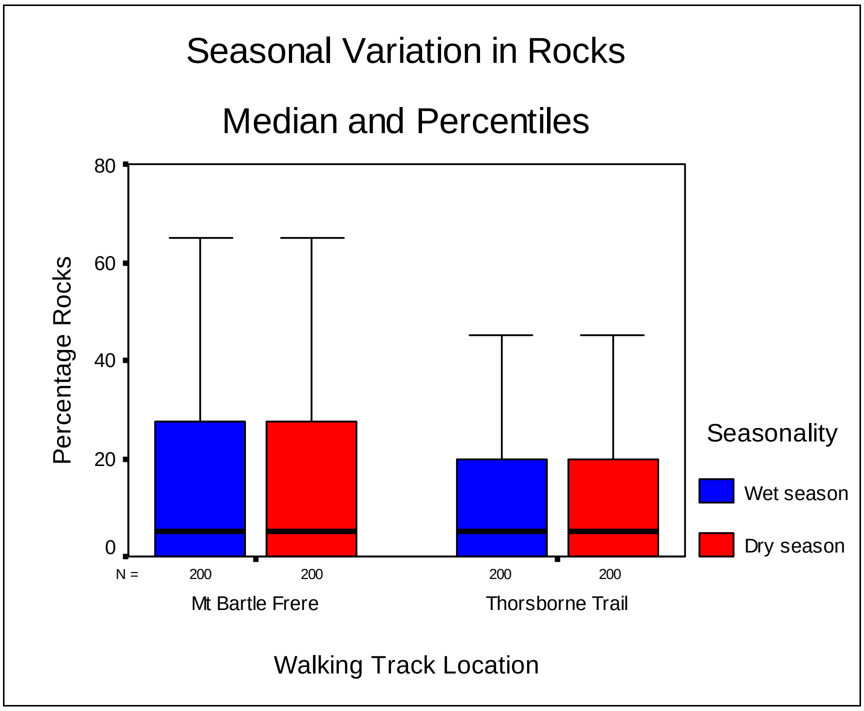

Figure 5.35 Seasonal variation in rocks (median and percentiles) recorded within tread and buffer zone quadrats.

5.3.2.5 Woody debris

Median quantities of woody debris remained constant across both sampling intervals on the Mt Bartle Frere Track (Figure 5.36). Median proportions of woody debris were also unchanged on the Thorsborne Trail, although there was a higher frequency of small quantities of debris recorded during the dry season. Despite the fact that prescribed burns were conducted within some sections of heath vegetation along the Thorsborne Trail in the period between wet and dry season sampling, this appears to have had minimal influence upon the overall quantity of woody debris. Relative proportions of woody debris were not significantly different between wet and dry season sampling on either the Mt Bartle Frere Track (Mann Whitney U = 18404.500; P = 0.138), or the Thorsborne Trail (Mann Whitney U = 18049.000; P = 0.081).

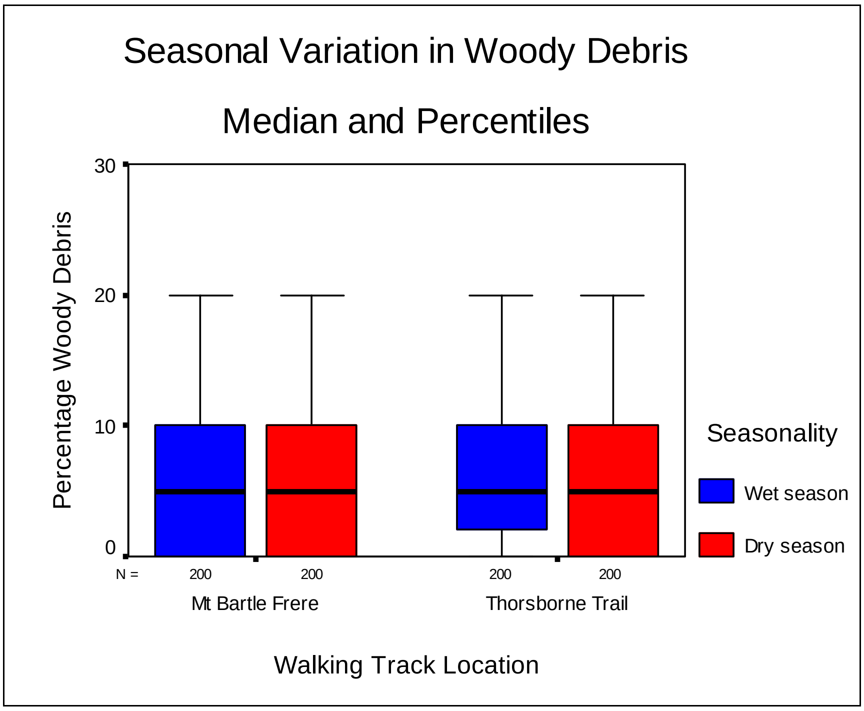

Figure 5.36 Seasonal variation in woody debris (median and percentiles) recorded within tread and buffer zone quadrats.

5.3.2.6 Living vegetation

The quantity of living vegetation measured within tread and buffer zone quadrats on the Mt Bartle Frere Track was somewhat higher during the dry season, than in the wet season (Figure 5.37). Proportions of living vegetation recorded along the Thorsborne Trail declined during the dry season, with some of this reduction in biomass undoubtedly a consequence of prescribed burning operations conducted during the intervening period since wet season sampling was undertaken. Proportions of living vegetation recorded within tread and buffer zone quadrats were not significantly different between wet and dry season sampling at either location (Mann Whitney U tests, Mt Bartle Frere Track U = 19013.500; P = 0.383; Thorsborne Trail U = 18516.500; P = 0.194).

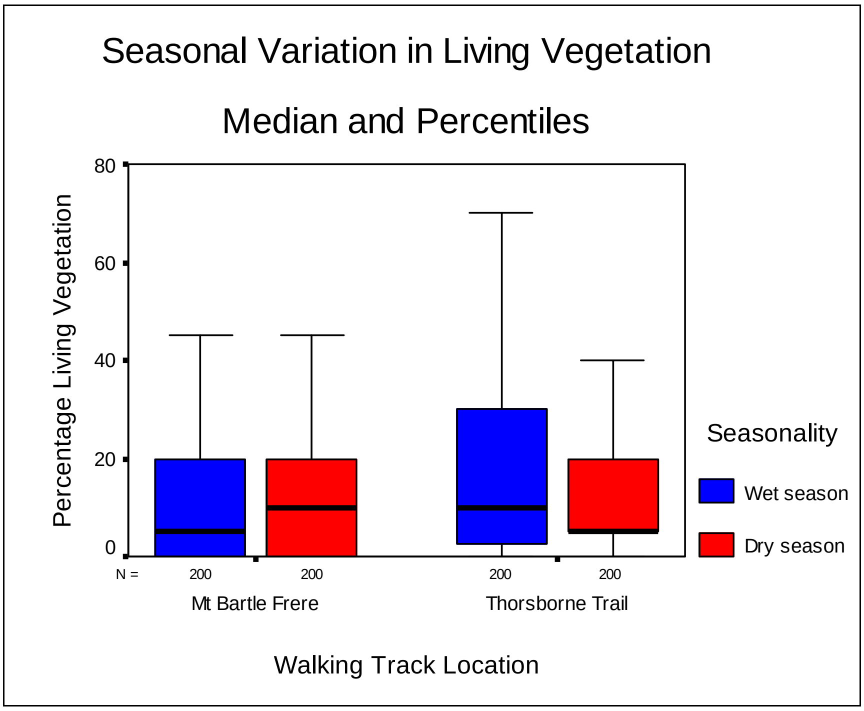

Figure 5.37 Seasonal variation in living vegetation (median and percentiles) recorded within tread and buffer zone quadrats.

5.3.3 Organic litter depth

Seasonal variation in organic litter depth is a consequence of temporal changes in the rate of organic litter accumulation and decay. On the Mt Bartle Frere Track, organic litter depth during the dry season was substantially reduced to that which had been measured in the wet season of the same year, although median litter depth (10 mm) remained unchanged (Figure 5.38). No obvious explanation was apparent, although it was plausible that much of the organic litter present during wet season sampling had either decomposed or was displaced, and that dry season sampling occurred prior to the period of maximum leaf fall. It should also be noted that the Mt Bartle Frere Track was unseasonably wet during July 2004 (Appendix 8), and that rainfall during this month directly preceded dry season sampling that occurred in August. Consequently, a large proportion of organic litter may have been displaced from sampling zones by precipitation. Organic litter depth associated with the Thorsborne Trail displayed minimal overall seasonal variation, which suggests that reductions in quantities of organic litter associated with mid-year fires in heath communities was offset by organic matter accumulation in other vegetation types. Median organic litter depth was unchanged (10 mm) on the Thorsborne Trail during both seasons. Statistically significant seasonal differences in organic litter depth were recorded for the Mt Bartle Frere Track (Mann Whitney U = 16942.000; P = 0.006*), but not for the Thorsborne Trail (Mann Whitney U = 19851.500; P = 0.896).

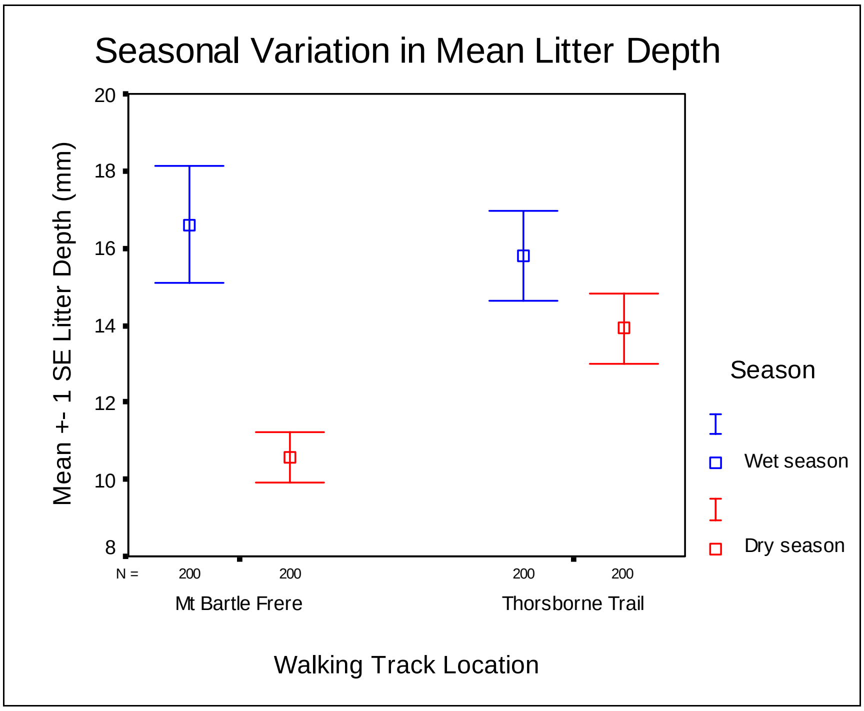

Figure 5.38 Seasonal variation in organic litter depth (mean ± 1 standard error) recorded within tread and buffer zone quadrats.

5.3.4 Canopy cover

The extent of canopy cover showed minimal seasonal variation on either track which was to be expected given the high proportion of evergreen forest at both locations (Figure 5.39). Median canopy cover on the Mt Bartle Frere Track remained unchanged between wet and dry season sampling, but increased slightly on the Thorsborne Trail during the dry season. The results obtained on the Thorsborne Trail were contrary to expectations, given the usual propensity of vegetation to accelerate leaf drop as a consequence of increased moisture stress at this time of year. Consequently, it was possible that seasonal variability in canopy cover recorded on the Thorsborne Trail was the result of errors in field sampling, rather than variability in environmental parameters. Seasonal variations in the extent of canopy cover were not significantly different between wet and dry seasons on the Mt Bartle Frere Track (Mann Whitney U

= 18041.000; P = 0.186), or the Thorsborne Trail (Mann Whitney *U* = 19939.000; P = 0.958).

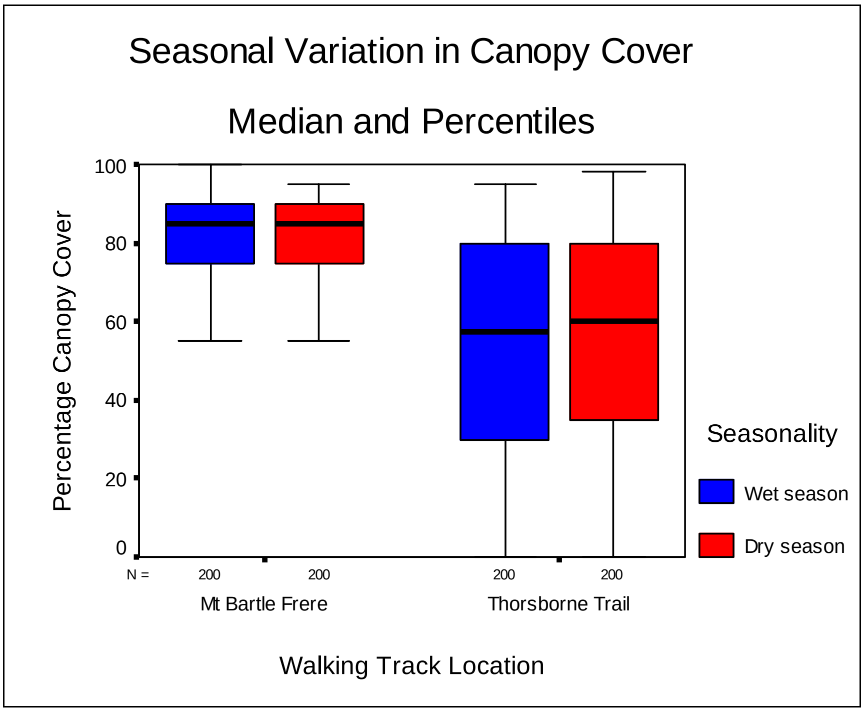

Figure 5.39 Seasonal variation in canopy cover (median and percentiles) recorded within tread and buffer zone quadrats.

5.3.5 Seedling density

Comparisons of wet and dry season counts of numbers of seedlings within tread and buffer zone quadrats revealed minimal seasonal variability in seedling density on either walking track, although slightly more seedlings were recorded during the wet season (Figure 5.40). This suggests that seedlings establish during the period when moisture is most available, but that some seedling mortality is incurred during the seasonally dry conditions in the second half of the year. The small decline in seedling density following the wet season could also have been a consequence of an increase in seedling trampling resulting from increased visitor numbers during the dry season. There were no significant seasonal differences in seedling density on either walking track (Mann Whitney *U* tests, Mt Bartle Frere Track *U* = 19676.500; P = 0. 779; Thorsborne Trail *U* = 19545.500; P = 0. 693).

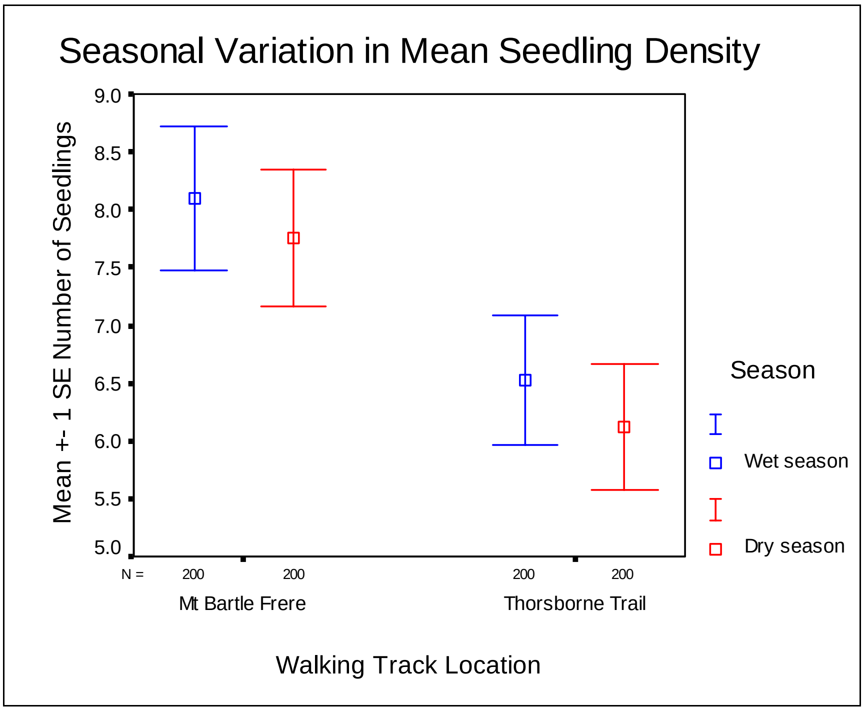

Figure 5.40 Seasonal variation in seedling density (mean ± 1 standard error) recorded within tread and buffer zone quadrats.

5.3.6 Social trails, human litter, and body waste

While the number of incidences of social trails, human litter, and human body waste were not necessarily influenced by seasonality, they nevertheless demonstrated some temporal variability (Figure 5.41). On the Mt Bartle Frere Track numbers of social trails were found to be more prevalent during the wet season, which was most likely a consequence of the higher incidence of tree falls and drainage impeded track sections at that time of year, which required hikers to detour. Conversely, the fact that human litter and body waste were more frequent on the Mt Bartle Frere Track during the dry season was probably a consequence of increased visitation levels during that period of the year. The Thorsborne Trail recorded a higher incidence of social trails and human litter during the dry season, although body waste remained evenly distributed across the year. No obvious reason existed for the increased number of social trails along the Thorsborne Trail during the dry season, except to suggest that a number appear to have been associated with watercourses so may have been related to the reduced availability of fresh water during the drier months.

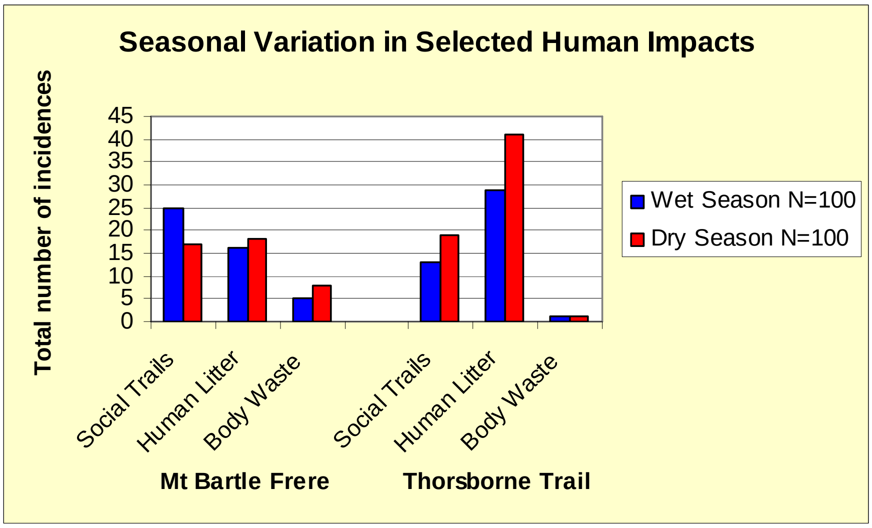

Figure 5.41 Seasonal variation in the total numbers of incidences of social trails, human litter, and human body waste recorded along transects.

5.3.7 Vegetation damage

Incidences of human induced vegetation damage were more prevalent along both walking tracks during the wet season (Figure 5.42). The increased prevalence of vegetation damage recorded during wet season months was believed to be at least partly related to hikers trampling newly established seedlings. Vegetation damage also undoubtedly resulted from hikers attempting to avoid sections of track that had either impeded drainage or fallen trees that necessitated detours.

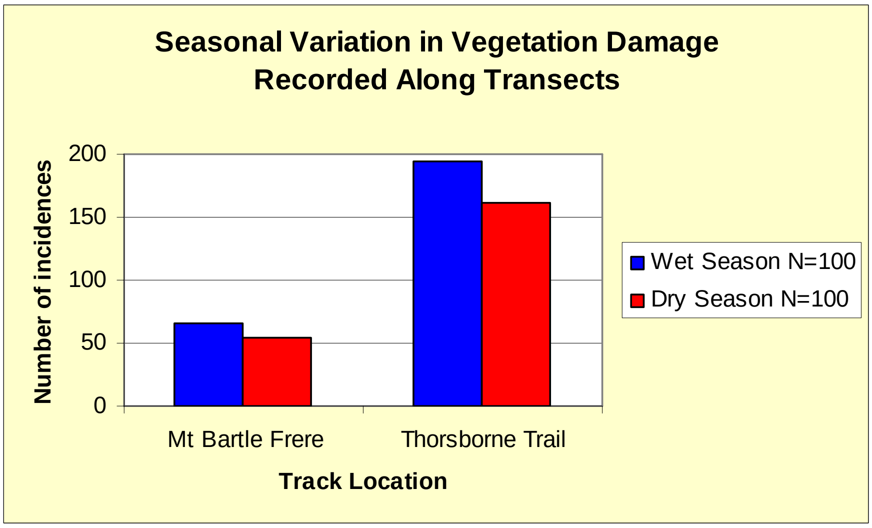

Figure 5.42 Seasonal variation in the total number of incidences of vegetation damage recorded along transects.

5.3.8 Additional track problems

Overall, track problems were found to be more extensive during the wet season on both tracks (Figure 5.43). On the Mt Bartle Frere Track, incidences of fallen trees were twice as prevalent during the wet season as in the dry season. Furthermore, low overhanging branches were only recorded during wet season months, which suggest that track maintenance standards along the Mt Bartle Frere Track were superior during the dry season. The Thorsborne Trail also had substantially more fallen trees during the wet season than in the dry season, although low overhanging branches were the reverse, being more prevalent in the dry season. As expected, impeded drainage was only an issue on both walking tracks during the wet season when rainfall was highest.

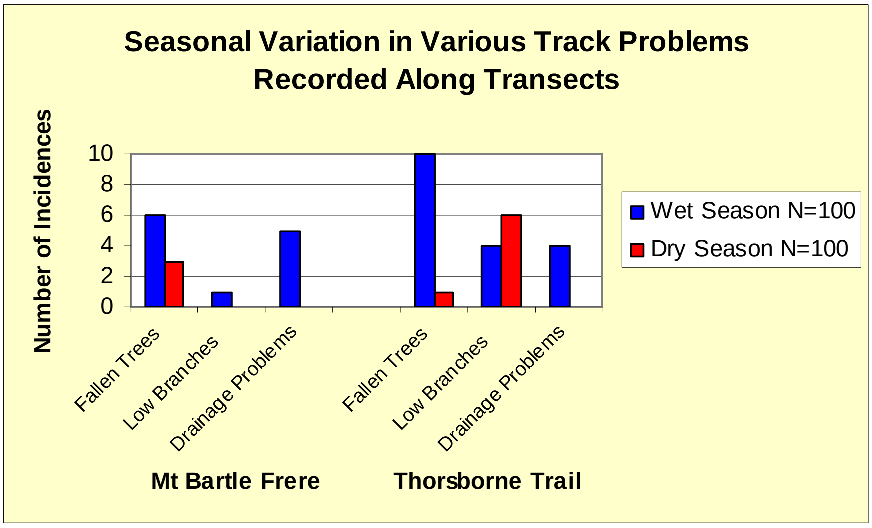

Figure 5.43 Seasonal variation in the total number of incidences of additional track problems recorded along transects.

5.4 DISCUSSION

5.4.1 Introduction

The focus of this component of the research has been to explore *biophysical impacts* associated with visitor use of long-distance walking tracks using the concepts of *resistance* and *resilience* as an overarching theoretical and analytical framework, although the discussion is structured according to *spatial* and *temporal* comparisons. The results presented previously are also discussed from an applied management perspective and some have immediate implications for both *site* and *visitor management*.

It is important to reiterate at the outset that very little is known about the impacts of recreation upon long-distance walking tracks within wet tropical ecosystems (Boucher *et al*. 1991; Sun and Liddle, 1993a; Talbot *et al*. 2003; Turton, 2005), and that most previous research has been conducted in temperate locations (typically North America, Europe, New Zealand etc.). Although comparisons of results between tropical and temperate locations are interesting these have been kept to a minimum in the following discussion due to the distinctly different climatic, edaphic, and vegetative parameters that exist which can influence the *resistance* and *resilience* of recreational sites (Liddle and Greig-Smith, 1975; Cole and Trull, 1992, Cole and Bayfield, 1993). Rather, it is argued that greater benefit can be obtained by attempting to interpret the influence of *site specific* factors that exist at both locations and seeking to situate results within both *theoretical* and *applied management* contexts.

5.4.2 Spatial variations in biophysical impacts

Spatial comparisons of biophysical impacts demonstrated that both the extent and severity of impacts varied among sampling zones (tread, buffer, control), among vegetation types, and in response to changes in topography. These results have also enabled overall evaluations of biophysical impacts on both tracks. The following discussion does not intend to revisit all results previously presented but rather attempts to review *key findings*. The discussion initially addresses findings of relevance to the first of two research questions.

RQ1.What are the biophysical impacts associated with visitor use of long-distance walking tracks within the Wet Tropics region and how do these impacts vary over space and among vegetation types along tracks?

Comparisons of spatial variability among sampling zones

In general, biophysical impacts were predominantly confined to the tread and buffer zones, whilst control zones were generally not impacted by recreational activities. This was an important finding because it confirms that hikers do cause impacts on the environment and corroborates previous research from short-distance walking tracks in tropical rainforest environments that demonstrated most biophysical impacts tend to decrease in a curvilinear relationship with increased distance from the track centre (Day and Turton, 2000b). This finding was also consistent with research originating from the temperate zone which has established that recreational use impacts are usually concentrated within a small proportion of the total area associated with walking tracks (Hendee *et al*. 1990; Hammitt and Cole, 1998). These results reinforce the notion of tread zones effectively representing ‘sacrifice’ areas that incur substantial damage in order to minimise impacts upon the surrounding biota (Cole, 1983, 1985; Hammit and Cole, 1998; Turton, 2005) and confirm the importance of using a combination of appropriate *site* and *visitor management* strategies to minimise expansion of this zone.

Despite the fact that impacts were predominantly restricted to the tread/buffer zones (sacrifice zone), a number of findings specifically identified various soil (exposed mineral soil, organic litter depth, soil erosion) and vegetation (tree roots, woody debris, living vegetation, seedling density) attributes as having been impacted upon by hiker trampling and behaviour. Table 5.11 provides an overall comparison of trends in biophysical impacts among sampling zones on each track, with highest and lowest results shown for each environmental indicator.

Table 5.11 Comparisons of environmental attributes among sampling zones.

Environmental indicators	*Mt Bartle Frere Track Sampling zones*			*Thorsborne Trail Sampling zones*		
	Tread	*Buffer*	*Control*	*Tread*	*Buffer*	*Control*
Mineral soil	Highest		Lowest	Highest		Lowest
Leaf litter	Highest		Lowest		Lowest	Highest
Tree roots	Highest		Lowest	Highest		Lowest
Rocks	*Highest	Lowest	*Highest	*Highest	Lowest	*Highest
Woody debris	Lowest		Highest	Lowest		Highest
Living vegetation	Lowest	*Highest	*Highest	Lowest	Highest	
Organic litter depth	Lowest		Highest	Lowest		Highest
Canopy cover	Same	Same	Same	Lowest	*Highest	*Highest
Seedling density	Lowest	Highest		Lowest		Highest
Soil erosion	Highest		Lowest	Highest	Lowest	
*Highest – denotes equal highest						

The finding that *exposed mineral soil* was most prevalent in tread zones and least prevalent in control zones (Figure 5.6) was anticipated and suggests exposed mineral soil was closely correlated with long-distance walking activity within impact zones. Although some extent of exposed mineral soil is considered acceptable on a long-distance walking track (Hammitt and Cole, 1998; Turton, 2005), these findings confirm the importance of encouraging hikers to remain within the established tread zone. Exposed mineral soil has previously been identified as a concern on long-distance walking tracks because it becomes more susceptible to compaction and being transported away via wind or water erosion (Manning, 1979; Cole, 1987). As a consequence, these findings have some potential implications for future *site* and *visitor management* because they suggest that managers need to keep track widths to a minimum during the construction phase, ensure track drainage remains adequate, and work to encourage hikers to remain within the tread zone through good design and information dissemination.

Quantities of *exposed tree roots* were most prevalent in the tread zone on both tracks (Figure 5.10), which was consistent with previous findings that hiking activity contributes to the removal of overlying soil and organic litter within the tread zone (Manning, 1979; Cole, 1983, 2000). The fact that median quantities of exposed tree roots were higher in the control zone than the buffer zone on the Mt Bartle Frere Track (Figure 5.10) suggests this may have been a naturally occurring phenomenon rather than a consequence of trampling. As *rocks* were also more common in control zones than buffer zones (Figure 5.12) this appears to suggest that the prevalence of exposed tree roots was a consequence of the rocky substratum impeding root penetration.

Woody debris was least common in the tread zone and most prevalent in the control zone on both tracks (Figure 5.14). This finding suggests that hikers and/or managers contributed to the breakdown and relocation of woody debris from within the tread zone. One probable explanation for this finding was that walkers have either inadvertently trampled or intentionally removed woody debris that impeded their access within the tread and buffer zones, although managers may have also contributed to this process during periodic track maintenance. The presence of large pieces of woody debris, such as fallen trees, would tend to indicate a lack of track maintenance while the presence of smaller pieces of debris can suggest an absence of recent track use.

Quantities of *living vegetation* were most prevalent within buffer zones, and as anticipated, least prevalent within the tread zone on both tracks (Figure 5.16). These findings suggest that some plants were able to take advantage of the increased light availability that exists within buffer zones as a result of interactions between sun-earth geometry and linear track clearings (Denslow, 1980; Canham, 1988), whilst largely avoiding the trampling effects that take place in the adjacent tread zone. The fact that living vegetation was least prevalent within the tread zone was consistent with previous research which has demonstrated that trampling can adversely impact upon living vegetation within the impact zone either through direct damage to foliage, stems, and surface roots, or indirectly via transformation of the soil habitat (Kuss, 1986a; Sun and Liddle, 1993a; Sun and Walsh, 1998).

As expected, mean *organic litter depths* were found to be shallowest in the tread zone and deepest in the control zone on both tracks (Figure 5.18). These findings were consistent with previous research which has demonstrated that hiking activity can have adverse impacts upon organic litter depths within both tropical (Jim, 1987; Turton *et al*. 2000a; Talbot *et al*. 2003) and temperate locations (Manning, 1979; Kuss, 1983; Cole, 1987). The fact that organic litter depths within tread zones were reduced by trampling tends to make the underlying soil more vulnerable to erosion (Cole, 1987; Liddle, 1997; Hammitt and Cole, 1998). This finding has relevance from a *site management* perspective because it emphasises the importance of retaining canopy cover and ensuring adequate drainage on long-distance walking tracks in order to minimise the adverse consequences of reductions in organic litter depth.

An interesting finding to emerge from the research was that *seedling counts* were higher within the buffer zone than the control zone on the Mt Bartle Frere Track (Figure 5.22). The most likely explanation for this result was that seedlings growing within the buffer zone had increased light availability to assist their establishment (Chazdon, 1986; Denslow, 1987; Whitmore, 1990), although this would be in part dependent upon a range of factors including the height of the surrounding forest, aspect, slope, and diurnal and seasonal variations in sun-earth geometry (Canham, 1988; Turton, 1993). This finding has some important *site management* implications because it reinforces the essential contribution that retention of canopy cover and initiatives that help reduce track widening can make to help retard the establishment of weeds along long-distance walking tracks located in tropical rainforest environments.

As anticipated *soil erosion* was most prevalent within the tread zone, and generally least prevalent in the control zone on both tracks (Table 5.10). These results can be at least partly attributed to increased quantities of exposed mineral soil (Figure 5.6) and reduced organic litter depths (Figure 5.18) in the tread zones at both locations. These findings were consistent with previous research which has demonstrated that soil erosion is often closely associated with the presence of exposed mineral soil in impacted zones (Bratton *et al*. 1979; Manning, 1979; Tinsley and Fish, 1985). Since surface water runoff from walking tracks can be up to 40 times greater than within undisturbed tropical rainforest (Wallin and Harden, 1996) this finding has some potential *site management* implications because it further emphasises the importance of maintaining canopy cover, mimimising track widths, and ensuring adequate drainage to help prevent erosion along tracks.

Comparisons of spatial variability among vegetation types

The fact that biophysical impacts varied among vegetation types on both tracks suggests some ecosystems were more *resistant* and *resilient* to hiker trampling and behaviour than others. On the Mt Bartle Frere Track, tableland forest (exposed mineral soil, exposed tree roots) and upland forest (exposed tree roots, soil erosion) had a higher incidence of impacts that were a cause for concern. The impacts of most concern on the Thorsborne Trail were predominately recorded within heath (exposed mineral soil, soil erosion), whilst exposed tree roots were minimal across all vegetation types. Table 5.12 provides a summary of trends in biophysical impacts among vegetation types on each track, with highest and lowest results shown for each environmental indicator.

Table 5.12 Comparisons of environmental attributes among vegetation types.

Environmental indicators	*Mt Bartle Frere Track Vegetation types*				*Thorsborne Trail Vegetation types*			
	Tableland forest	*Cloud forest*	*Upland forest*	*Lowland forest*	*Closed forest*	*Open forest*	*Heath*	*Swamp*
Topography	Flattest			Steepest			Steepest	Flattest
Mineral soil	Highest	Lowest			Lowest		Highest	
Leaf litter	Highest	Lowest				*Highest	Lowest	*Highest
Tree roots	*Highest	*Highest	*Highest	Lowest	Same	Same	Same	Same
Rocks	Lowest	Highest			Highest			Lowest
Woody debris	*Highest	*Lowest	*Lowest	*Highest	*Lowest	Highest	*Lowest	*Lowest
Live vegetation	Lowest	Highest			Lowest	Highest		
Litter depth	Highest		Lowest		Highest	Lowest		
Canopy cover	Highest	Lowest			*Highest		Lowest	*Highest
Seedling counts	*Highest	*Highest	Lowest				Lowest	Highest
Soil erosion			Highest	Lowest		Lowest	Highest	
Feral animals	*Highest		Lowest	*Highest		*Lowest	*Lowest	Highest
*Highest – denotes equal highest *Lowest - denotes equal lowest								

Quantities of *exposed mineral soil* were least prevalent within cloud forest on the Mt Bartle Frere Track, with little difference detected among the other three vegetation types (Figure 5.7). The low prevalence of exposed mineral soil within cloud forest was most likely related to the high abundance of rocks within this forest type (Figure 5.13). Somewhat surprisingly, quantities of exposed mineral soil on the Thorsborne Trail were lowest in closed forest and most prevalent within heath vegetation (Figure 5.7). These results were contrary to expectations since heath is generally considered to possess many of the plant morphological features that are believed to contribute to *high resistance*, whilst closed forest (predominantly consisting of rainforest species) is typically considered to have *low resistance* (Table 2.8). These findings appear to suggest that the results obtained on the Thorsborne Trail were influenced by other site specific factors such as topography which was steepest within heath (Figure 5.2).

The fact that *exposed tree roots* were found to be more prevalent within vegetation types at higher elevations along the Mt Bartle Frere Track (Figure 5.11) appears to be contrary to previous research findings reported from the Grampians National Park in Victoria where environmental *resilience* was found to increase in association with increased elevation (Arrowsmith and Inbakaran, 2002). Rather, the results obtained in the current study suggest that ecosystem *resilience* associated with the Mt Bartle Frere Track was more likely to be a consequence of other site specific environmental parameters (such as slope, vegetation and soil type), rather than higher elevation.

Quantities of *woody debris* were found to vary among vegetation types but overall were more prevalent within communities on the Thorsborne Trail (Figure 5.15). Spatial variation in the prevalence of woody debris within different vegetation types was most likely related to the particular characteristics of vegetation communities, rather than being a consequence of visitor activity. This was an important finding because quantities of coarse woody debris recorded within different vegetation types provide some indication of ecosystem stability given the known importance of debris for soil protection, faunal habitat, nutrient storage, and as sites for seedling establishment (Newsome *et al*. 2002).

Significant differences were recorded in the quantities of *living vegetation* within different ecosystems on each track (Figure 5.17). These findings were most likely a reflection of the particular *resistance* and *resilience* characteristics of vegetation communities on each track. Median quantities of living vegetation were highest within open forest and heath on the Thorsborne Trail, both of which had a higher prevalence of plants with morphological characteristics that are considered to have *high resistance* to trampling, including woody and sclerophyllous leaves, and low spreading growth forms (Kuss and Graefe, 1985), and highly flexible stems (Sun and Liddle, 1993b, 1993c). Measurements of living vegetation were lowest within closed forest on the Thorsborne Trail, which was consistent with the notion that tropical rainforests possesses *low resistance* to trampling related impacts (Talbot *et al*. 2003; Turton, 2005).

Organic litter depths were found to be most shallow within upland forest and cloud forest on the Mt Bartle Frere Track (Figure 5.19). These findings have been attributed to the increased prevalence of rocks within these vegetation types (Figure 5.13), and to the fact that canopy cover within cloud forest was significantly lower than any other vegetation type (Figure 5.21) resulting in less leaf litter. An alternative explanation was that plant species growing in exposed locations near the summit tend to have small leaves and a relatively stunted canopy (Queensland Parks and Wildlife Service, 2001), and this may have contributed to reduced quantities of organic litter within these two vegetation types.

Another interesting observation to emerge from the Mt Bartle Frere data was that significant differences were recorded in the prevalence of *soil erosion* measured within different vegetation types with erosion being more common within cloud forest and upland forest (Figure 5.24) which were both located in close proximity to the summit. Although these results may have been partly related to vegetation type, they were more likely to have been due to altitudinal variations in rainfall intensity and/or a consequence of the prevalence of steep topography, particularly in upland forest (Figure 5.2).

Comparisons of spatial variability associated with topography

Mean *track width* was found to vary in response to spatial variations in topography on both tracks, being widest on track sections with flat topography and narrowest on sections with steep topography (Figure 5.4). This finding suggests hikers were more likely to walk in single file and keep to the defined tread zone on track segments with steep topography, whilst increased track widths on flat surfaces appeared to be related to hikers attempting to avoid mud associated with track sections with impeded drainage. An alternative explanation was that some hikers may have chosen to walk two or more abreast on some flat sections to communicate with each other. These results suggest that appropriate *site management* strategies may include locating new walking tracks on resistant and well drained surfaces and ensuring that tread zones have adequate drainage, whilst suitable *visitor management* strategies might include the provision of information to make visitors more aware of the importance of remaining within the established tread zone.

Both moderate and severe *soil erosion* were most frequently associated with steep tread zone topography (Figure 5.25). Results demonstrated that severe soil erosion was overwhelmingly associated with steep topography on the Mt Bartle Frere Track whilst moderate soil erosion on both tracks tended to occur on sections of track with steep topography. These findings were consistent with previous research that has demonstrated most soil erosion takes place on track sections with either steep slopes or uncontrolled surface water runoff (Cole, 1983; Sutherland *et al*. 2001), or on sections lacking canopy cover (Obua and Harding, 1997).

Soil erosion should be considered a potentially serious problem on both of these tracks. In addition to being unsightly and costly to mitigate (Bratton *et al*. 1979; Wallin and Harden, 1996), erosion from within the tread zone can pose a threat to the safety of hikers. Erosion can increase sediment loads entering streams with adverse consequences for water quality (Farrell and Marion, 2001; Newsome *et al*. 2002), which is an important consideration on track sections where freshwater supplies are limited. Erosion also has the potential to spread *Phytophthora cinnamomi* to new locations on the Mt Bartle Frere Track (Gadek and Worboys, 2002).

Findings made in relation to *soil erosion* have potential implications from an applied management perspective as they confirm that *site management* practices which control surface water runoff and lead to the retention of canopy cover are critical to prevent soil erosion along walking tracks with steep slopes in high rainfall environments. Turton (2005) has concluded that extensive site hardening is generally not feasible to prevent soil erosion on long-distance walking tracks, both from the standpoint of the level of resources required and the fact that this is aesthetically inappropriate within a wilderness setting. Nevertheless, it was interesting to note that site hardening has been used extensively in association with long-distance walking tracks in other locations such as the Tasmanian Wilderness World Heritage Area (Hawes, 1996), and may become more acceptable to hikers within the Wet Tropics region with appropriate *visitor management* strategies to assist them to understand the need for tradeoffs between maintaining the quality of their experiences and mimimising environmental damage.

Comparisons between tracks

Overall, results suggested that both tracks exhibited reasonably low levels of ecological disturbance given the nature of this recreational activity. Existing biophysical impacts were largely confined to the vicinity of the immediate track at both locations and do not appear to pose a threat to ecosystem integrity. Nevertheless, a number of biophysical impacts on both tracks (for example, increased quantities of exposed mineral soil, reductions in quantities of leaf litter, soil erosion) appeared to be directly related to trampling by hikers, whilst others (such as social trails, human litter, and the inadequate disposal of human body waste) were the direct consequence of inappropriate behaviour by hikers. Some other impacts recorded on both tracks (such as the presence of weeds and feral animals) were not directly attributable to hikers, although their abundance may have been enhanced by the behaviour and activities of long-distance walkers.

Although mean *track width* was found to be somewhat wider on the Mt Bartle Frere Track than on the Thorsborne Trail (Table 5.1), average widths were still less than one metre at both locations. Since narrow track widths can help to restrict the onset of soil erosion (Smith and Turton, 1995; Turton, 2005), minimise linear barrier effects (Goosem, 1997; Goosem and Turton, 2000), and discourage the establishment of weeds (Chazdon, 1986; Denslow, 1987), this was a positive finding. One possible explanation for the differences between the two tracks was that walkers using the Thorsborne Trail were required to view a minimal impact hiking video which specifically alerted hikers to the problem of going beyond the track as marked which may have contributed to the narrower track widths at this location. Previous research has demonstrated that the provision of interpretive information and education can assist visitors to reduce their biophysical impacts within a recreation setting (Orams, 1995; Sun and Walsh, 1998), and may have had a beneficial influence in the case of the Thorsborne Trail although the specific contribution of the video as an influence upon visitor behaviour was not explored within visitor surveys.

An interesting finding to emerge from the research was that quantities of *exposed mineral soil* were proportionately higher on the Thorsborne Trail than on the Mt Bartle Frere Track (Figure 5.6). These findings were best explained using the perspectives of ecosystem *resistance* and *resilience* as results suggest that the two tracks differed in their capacity to both resist and recover from human induced trampling, most probably as a consequence of variations in site conditions (topography, soil, and vegetation types). Previous research has demonstrated that ecosystems vary in their resistance and resilience characteristics both in terms of natural phenomena (cyclones, fire etc.) and human induced impacts (Pimm, 1991; Liddle, 1997; Odum and Barrett, 2005). Nevertheless, the substantially higher visitation levels on the Thorsborne Trail provide an alternative explanation for this finding since visitation levels have previously been shown to potentially influence the extent of impact (Cole, 1987; Ravinski, 1991).

Quantities of *exposed tree roots* were substantially higher on the Mt Bartle Frere Track than on the Thorsborne Trail where they were minimal (Figure 5.10). One possible explanation for this finding was the extremely steep topography associated with the Mt Bartle Frere Track, as previous research reported from tropical rainforests in Uganda has demonstrated significant correlations between tree root exposure and slope (Obua and Harding, 1997). An alternative explanation for the increased prevalence of exposed tree roots on the Mt Bartle Frere Track was that the rocky substratum within all three sampling zones (Figure 5.12) decreased tree root penetration.

Counts of incidences of *human litter* (Figure 5.27), *social trails*, and *human vegetation damage* (Figure 5.28), were all higher on the Thorsborne Trail than on the Mt Bartle Frere Track. Since these three biophysical impacts were all manifestations of inappropriate visitor behaviour, these findings were somewhat surprising given that hikers from the Thorsborne Trail were required to view a short interpretive video prior to commencing their walk. It was originally anticipated that this video would translate into more environmentally responsible behaviour on this track. As a consequence, the most plausible explanation for these findings was that all three impacts were more prevalent on the Thorsborne Trail as a result of substantially higher visitation levels at this location, and were possibly related to recreational conflict resulting from perceptions of crowding (Chapter 6).

Numbers of incidences of *human body waste* were highest on the Mt Bartle Frere Track, most notably near the Top Western Camping Ground. This is a critical finding from an applied management perspective and is believed to reflect the absence of toilet facilities and the inherent difficulties associated with digging suitable holes in the ground given the often high prevalence of rocks (Figure 5.13) and the dense mat of surface tree roots (Figure 5.11) associated with much of the Mt Bartle Frere Track. This finding should alert managers to the potential for contamination of the only available water source located in close proximity to this camping ground, and the possible serious health implications for visitors (Climburg *et al*. 2000). As a consequence of this finding it was recommended that management consider constructing a toilet facility at this location in order to reduce the current water contamination risk. Other options that might be considered include better education of walkers in relation to the appropriate disposal of body waste either through signage or interpretive information, or mandating that hikers carry their waste out as currently occurs in some wilderness locations in the United States (Hendee *et al*. 1990).

Although the random sampling strategy used in this research did not specifically attempt to assess the spatial distribution of biophysical impacts in proximity to areas where hikers congregated, impacts on both tracks appeared to be more prevalent near high-use areas where hikers frequently gathered such as camping grounds, lookouts and swimming holes. In particular, *human vegetation damage*, *litter*, and *human body waste* were more prevalent within proximity to high-use nodes. This finding was consistent with previous research reported from Zhangjiajie National Forest Park in China which found that trampling impacts upon soil and vegetation were not evenly distributed in space and tended to be more prevalent in association with nodes of human activity such as open areas (Deng *et al*. 2003).

5.4.3 Seasonal variations in biophysical impacts

The following discussion reviews *key research findings* made between wet and dry season results and suggests there was minimal seasonal variation in biophysical impacts between wet and dry season sampling on either track as many of the recorded differences failed to reach statistical significance. Nevertheless, many environmental attributes still provided useful information in relation to the nature and extent of seasonal variation that occurs on long-distance walking tracks in tropical rainforest environments. Temporal comparisons between wet and dry season results address the second research question.

RQ2.How do biophysical impacts associated with visitor use of long-distance walking tracks within the Wet Tropics region vary in response to changing seasonality?

Comparisons of environmental attributes between wet and dry seasons

There are a number of potential interpretations as to why there was *minimal seasonal variation* in results between wet and dry season sampling. Firstly, it was likely that many of the impacts measured during this research also included pre-existing *cumulative impacts* sustained over a longer time period which made it more difficult to differentiate between wet and dry season impacts that occurred within the sampling period. Secondly, it was probable that a number of environmental attributes underwent some degree of wet season recovery since this period has low visitation and provides optimal conditions for plant growth. As previously noted (Chapter 3), the Mt Bartle Frere Track receives only limited wet season use as most hikers prefer to walk in the dry season when conditions are optimal, whilst the Thorsborne Trail is closed to all visitors during February and March each year as a consequence of management concerns about intermittent flood events and hiker safety. This suggests that current reductions in hiker numbers during the wet season on both the Mt Bartle Frere Track (voluntary) and the Thorsborne Trail (regulatory) are working and have reduced wet season impacts. A third factor which may have contributed to the lack of temporal variability in results was the relatively short time period that elapsed between replicated wet and dry season sampling (Appendix 8). Table 5.13 provides a summary of trends in biophysical impacts between seasons for each track, with highest and lowest results shown for each environmental indicator.

Track width

An interesting finding to emerge from the research was that mean track width tended to be somewhat wider on both tracks during wet season sampling (Figure 5.31). This finding has been attributed to hikers attempting to avoid drainage impeded track sections which were only recorded during the wet season (Figure 5.43). These results appear to endorse a recommendation made by Turton (2005) that all long-distance walking tracks and high-use camping grounds within the Wet Tropics region be closed during the annual wet season to both protect the ecosystem from additional biophysical impacts and to facilitate recovery in relation to impacts already sustained.

Exposed mineral soil

Exposed mineral soil was highest during the dry season on both tracks (Figure 5.32), although differences were not statistically significant. Since most hikers visited during the dry season, increased quantities of exposed mineral soil during this period were most likely related to increased numbers of walkers. This finding lends support to the notion that tropical rainforests possess *high resilience* to disturbance (Kuss, 1986a; Day and Turton, 2000b) as results suggest that some extent of recovery is currently occurring during the wet season. Previous research conducted on short-distance walking tracks within the Wet Tropics World Heritage Area also failed to identify any significant seasonal differences in exposed mineral soil, although quantities of bare soil were slightly higher during wet season sampling (Turton *et al*. 2000a). These findings are supportive of long-distance walking tracks being periodically spelled for at least part of the wet season to facilitate setting *resilience*.

Table 5.13 Comparisons of environmental attributes between seasons.

Environmental indicators	*Mt Bartle Frere Track Season*		*Thorsborne Trail Season*	
	Wet season	*Dry season*	*Wet season*	*Dry season*
Track width	Highest	Lowest	Highest	Lowest
Mineral soil	Lowest	Highest	Lowest	Highest
Leaf litter	Highest	Lowest	Lowest	Highest
Tree roots	Same	Same	Same	Same
Rocks	Same	Same	Same	Same
Woody debris	Same	Same	Same	Same
Living vegetation	Same	Same	Highest	Lowest
Organic litter depth	Highest	Lowest	Highest	Lowest
Canopy cover	Same	Same	Same	Same
Seedling density	Highest	Lowest	Highest	Lowest
Soil erosion	Same	Same	Same	Same
Social trails	Highest	Lowest	Lowest	Highest
Human litter	Lowest	Highest	Lowest	Highest
Human body waste	Lowest	Highest	Same	Same
Human vegetation damage	Highest	Lowest	Highest	Lowest

Leaf litter

Quantities of leaf litter were found to be highest on the Mt Bartle Frere Track during the wet season but were highest on the Thorsborne Trail during the dry season (Figure 5.33). These opposing findings suggest that proportions of leaf litter were most probably influenced by site specific factors such as vegetation type, the timing of leaf litter fall, and the rate of organic litter decomposition, rather than necessarily being a consequence of hiking activity. Since the trampling effects of hiking boots have been shown to accelerate the decomposition of organic litter (Manning, 1979; Quinn *et al*. 1980; Kuss 1986b; Talbot *et al*. 2003), and as maximum leaf litter fall is known to occur during the late dry season (Sun and Liddle, 1993b), it was originally anticipated that quantities of leaf litter would be more prevalent during the wet season on both tracks. Caution is therefore urged in the interpretation of these results as the timing of dry season sampling undoubtedly preceded the period of maximum leaf litter fall on both tracks (Appendix 8). As a consequence, measurements of leaf litter quantities appear to be of minimal use for seasonal comparisons within tropical rainforest environments given the potential for the timing of litter fall to unduly bias results.

Exposed tree roots, rocks and woody debris

The relative proportions of tree roots (Figure 5.34), rocks (Figure 5.35), and woody debris (Figure 5.36) remained virtually unchanged between wet and dry season sampling suggesting these attributes were not greatly impacted by changing seasonality. The fact that quantities of woody debris remained virtually unchanged between wet and dry season sampling suggests there is presently a balance between production and decomposition of debris. These findings also suggest that these three environmental indicators are of questionable value for seasonal comparisons of trampling impacts.

Seedling density

Mean seedling density was highest during the wet season on both tracks (Figure 5.40), although results were not statistically significant. Although these findings initially appeared to suggest that seedling mortality was higher during the dry season as a consequence of increased trampling activity, seedling density was also found to be higher in control zones during the wet season which suggests there was some natural seedling mortality taking place during this period, most probably as a consequence of limited moisture availability. Previous research conducted in relation to short-distance walking tracks and camping grounds has demonstrated a similar tendency for seedling density to increase during the wet season as a consequence of increased fruiting activity among rainforest species (Smith and Turton, 1995; Turton *et al*. 2000a), and this may have also impacted upon results in the current research.

Organic litter depth

Significant reductions in organic litter depth were recorded between wet and dry season sampling on the Mt Bartle Frere Track, while organic litter depth was also somewhat lower on the Thorsborne Trail during the dry season (Figure 5.38). These findings suggest both tracks underwent some degree of wet season recovery consistent with the notion of tropical rainforests having *high resilience*. The results obtained in the current study appear to be contrary to those obtained during previous research within the Wet Tropics World Heritage Area which found quantities of organic litter tended to be highest during the dry season when decomposition rates were lowest (Turton *et al*. 2000b). Nevertheless, it should be reiterated that dry season sampling was undertaken prior to the period of maximum leaf fall on both tracks (Appendix 8), having been completed during August on the Mt Bartle Frere Track and during September on the Thorsborne Trail. As organic litter is known to decay more slowly during the dry season as a result of reduced moisture availability within tropical rainforest environments (Cornu *et al*. 1997) it would be reasonable to expect that both locations would have substantially more organic litter cover in place by the commencement of the subsequent wet season. Had dry season sampling been undertaken later in the season (October – November), differences with wet season results may not have been as pronounced. These findings question the usefulness of using organic litter depth for seasonal comparisons of trampling impacts within tropical rainforest environments.

Human litter and body waste

Incidences of human litter and body waste recorded along transects were more prevalent during the dry season (Figure 5.41). These results were most likely a reflection of increased visitation levels during the dry season, although they could also be a consequence of rapid decomposition and washing away of material during the wet season. Increased incidences of human litter along the Thorsborne Trail during the dry season may have also been related to various aspects of the social environment which were identified as sources of recreational conflict by some hikers (Chapter 6).

As previous research has demonstrated that inappropriate disposal of human body waste and litter have the potential to pollute water supplies in natural areas (Hawes, 1996; Bridle and Kirkpatrick, 2003, 2005), this finding suggests that freshwater quality may have been substantially reduced during the dry season when visitation levels were highest but freshwater replenishment was lowest. These findings were relevant from a *visitor management* perspective because they suggest that hikers need to be properly informed in relation to the safety of freshwater supplies during the dry season since contaminated water can result in a range of human diseases (Climburg *et al*. 2000).

Human vegetation damage

Human vegetation damage was more prevalent during the wet season on both tracks (Figure 5.42). These results were most likely a consequence of hikers attempting to avoid tree falls and muddy track sections, which were also more common during the wet season (Figure 5.43). The increased proliferation of fallen trees and drainage impeded track sections during wet season sampling were related to seasonal variations in environmental conditions including the increased frequency of tropical storms. These findings appear to further support wet season closures as a way of reducing human vegetation damage during the period when ecosystem *resistance* is lowest (Turton and Stork, 2006).

5.5 SUMMARY

This chapter has demonstrated that both long-distance walking tracks had only low levels of ecological damage, and that some evidence of wet season recovery (consistent with the notion of tropical rainforests having *high resilience*) is occurring. Biophysical impacts associated with hiking activity were predominantly confined to the tread zone on both tracks and do not threaten ecosystem integrity, although they did vary over space in response to changes in vegetation type and topography, and over time in response to changing seasonality. The results obtained in this research appear to suggest that both tracks displayed some evidence of *resilience* as evidenced by the wet season recovery of a few impact indicators, most notably exposed mineral soil, seedling density and organic litter depth. These findings were generally supportive of the introduction of at least partial wet season closures for long-distance walking tracks within the Wet Tropics region to facilitate ecosystem *resilience*.

The results presented in this chapter have provided managers of both the Mt Bartle Frere Track and the Thorsborne Trail with a cross-sectional ‘snapshot’ of ecological condition under current use levels and existing management regimes that could be used as the basis for a longitudinal monitoring program. The extent and severity of impacts measured in this research are likely to be representative of other long-distance walking tracks within the Wet Tropics region. It is therefore reasonable to suggest that these results can be extrapolated to other long-distance walking tracks within tropical rainforest locations with similar environmental parameters, management regimes, and visitation levels provided that site specific factors are taken into consideration.

CHAPTER 6 – PSYCHOSOCIAL EXPERIENCE RESULTS

6.1 INTRODUCTION

This chapter presents the results of psychosocial experience sampling of visitors using two long-distance walking tracks within the Wet Tropics region of North Queensland. These results reflect the analysis of 623 completed survey questionnaires received from respondents from 18 different countries including Australia. Based on this sample of visitors using the two walking tracks over a 12 month period in 2004-2005, this chapter seeks to answer the following three research questions.

RQ3. What is the profile of visitors (with respect to demographics, logistic arrangements, motivations) using selected long-distance walking tracks within the Wet Tropics region? (Sections 6.3 and 6.6.2)

RQ4. How do visitors perceive the natural, social and built environments associated with the two long-distance walking tracks being examined, and the management of these environments? (Sections 6.4 and 6.6.3)

RQ5. How satisfied are visitors with their experience of hiking the two long-distance walking tracks under investigation and what specific factors enhance or detract from the quality of their experience? (Sections 6.5 and 6.6.4)

Results are presented within a thematic structure that also reflects the order of the three research questions above. The results obtained from the two walking tracks are always presented together to enable the reader to make between track comparisons, and where appropriate combined results for both tracks are presented.

The chapter is presented in five main sections as follows:

Sampling Characteristics (Section 6.2)

The first section of this chapter provides an overview of various sampling characteristics including the target population, survey response rates, sampling ratio, sample validity, reasons for non-participation and survey rejection rates.

Respondent Characteristics (Section 6.3)

This section presents a summary of respondents' personal characteristics including place of residence, gender, age, education, perceived physical fitness, level of experience, and motivations for walking. It also summarises various logistical arrangements including sources of information about the walk, group size and the duration of the walk.

Appraisal of Environment and Management (Section 6.4)

The third section of the chapter reports respondents' appraisal of the natural, built and social environments encountered on each track. It also presents information about respondents' perceptions of current track management and their preferences for future management action.

Satisfaction and Overall Quality of Experience (Section 6.5)

This section presents results in relation to respondents' satisfaction levels, and describes factors that either enhanced or detracted from their experiences. It also summarises information supplied by respondents about their experiences of fear and perceptions of physical difficulty during the course of their walk.

Discussion (Section 6.6)

The final section of this chapter discusses psychosocial experience results within the context of the theoretical framework. Results are also considered within the context of previous research, and from site and visitor management perspectives.

6.2 SAMPLING CHARACTERISTICS

6.2.1 Sampling period

The sampling period extended from 1 April 2004 to 31 March 2005 on each walking track. This represented a full 12 month sampling period that ensured seasonal variations in weather conditions, and annual school holiday periods were included. All unused survey forms were removed from field distribution points on 1 April 2005. To account for the lag time in postage completed survey forms were accepted until 30 April 2005, which was declared the cut-off date.

6.2.2 Target population

Whilst the term *population* usually refers to the total number of individuals within a geographical location, the *target population* is generally a subset of the larger pool that the researcher intends to study (Neumann, 2000), or would ideally like to study (Kent, 2001). In this research the target population consisted of long-distance walkers and included any visitor who hiked either of the two long-distance walking tracks under investigation during the sampling period.

6.2.3 Survey response rates

The survey response rate, also referred to as the active survey response rate, can be defined as the percentage of questionnaires completed by respondents who were contacted about a survey (Neuman, 2000). In this research the survey response rate equated to the percentage of distributed questionnaires that were subsequently completed and returned to the researcher. The combined response rate from both walking tracks was 90.3 percent, with 623 surveys being adequately completed and returned to the researcher from 690 distributed surveys. On the Mt Bartle Frere Track a total of 269 surveys were collected by hikers of which 226 were returned to the researcher, representing a response rate of 84.0 percent. On the Thorsborne Trail a total of 421 questionnaires were distributed to walkers of which 397 were subsequently returned representing a response rate of 94.3 percent. A number of factors are believed to have contributed to the high response rate within this research project. Most importantly members of the target population were prepared to commit time and effort to assist research that they considered relevant to this particular recreational activity. The high response rate was undoubtedly also due to the fact that surveys were distributed using a variety of methods on both walking tracks (Chapter 4 provides a comprehensive description of all survey distribution methods), and respondents were provided with reply paid envelopes in which to return completed survey forms.

6.2.4 Sampling ratio

The ratio of the sample size to the target population size is known as the sampling ratio (Neuman, 2000). In this research the sampling ratio was determined by calculating the percentage of long-distance walkers who completed a survey on each walking track (the sample size) as a proportion of the total number of long-distance walkers who completed each walk during the sampling period (the target population). During the 12 month sampling period 226 respondents (the sample size) from the Mt Bartle Frere Track completed and returned a survey form, with 159 respondents having completed the walk within a day and the remaining 67 having camped overnight within the National Park. The exact size of the target population could not be determined for the Mt Bartle Frere Track since a large number of walkers complete the walk within one day and are neither counted by management nor required to register for a camping permit, while some hikers are known to camp illegally (Chapter 3). Nevertheless, it is known that during the sampling period a total of 291 hikers obtained permits to camp overnight on the Mt Bartle Frere Track, and that 67 (23.0%) of these participated in the survey. If the same sampling ratio (23%) was extrapolated to the remaining component of the sample who completed the Mt Bartle Frere Track within one day (159), this would suggest a possible target population of 691 day visitors and an overall target population of campers and day visitors in the vicinity of 982 at the highest end.

During the same period a total of 2,656 hikers (the target population) were issued with permits to walk the Thorsborne Trail and 397 (the sample size) of these participated in this research. Consequently the sampling ratio for the Thorsborne Trail was 14.9 percent. Table 6.1 presents monthly camping permit data for both walking tracks. It should be noted that monthly camper nights represents the number of person nights spent camping on each walking track. For example, during April 2004 a total of three camping permits were issued to enable ten hikers to legally camp on the Mt Bartle Frere Track but since seven of these campers spent two nights on the mountain the monthly camper nights totaled 17.

Table 6.1 Monthly camping permit data for both tracks for the sampling period.

Monthly data for the sampling period	**Mt Bartle Frere Track**			**Thorsborne Trail**		
	Monthly Camping Permits	Monthly Campers	Monthly Camper Nights	Monthly Camping Permits	Monthly Campers	Monthly Camper Nights
April 2004	3	10	17	83	238	864
May 2004	11	23	30	119	324	1,169
June 2004	10	22	23	134	356	1,210
July 2004	19	44	50	125	359	1,331
August 2004	22	50	70	139	356	1,321
September 2004	13	29	36	131	356	1,262
October 2004	21	46	52	128	326	1,198
November 2004	14	30	31	48	129	469
December 2004	6	13	13	35	71	226
January 2005	2	6	6	10	25	115
February 2005	4	7	7	6	11	27
March 2005	7	11	12	34	105	401
Total	132	291	347	992	2,656	9,593

Although there is often debate about what constitutes an adequate sample size (Babbie 2001; Kent, 2001), the sampling ratios and sample size (623) outlined above are considered to be more than adequate for this study on the following basis. Neuman (2000) maintains that as a rule of thumb sampling ratios for smaller populations (1,000) require a larger sampling ratio in the vicinity of 30 percent whilst larger populations (10,000) only require a sampling ratio of about 10 percent. Kent (2001) believes that as a general rule the sample size should be 100 multiplied by the maximum number of categories that are to be used for percentage calculations, which in the current research is six. A sample of 200 cases is generally considered sufficient to allow for relevant statistical analyses and credible interpretation of results in student projects, although caution should be exercised when interpreting statistical results (Kent, 2001).

6.2.5 Sample validity

The 623 long-distance walkers who participated in this survey are believed to represent a valid cross-section of the target population. All members of the target population who were hiking during the sampling period were provided with at least one opportunity to participate in this research by completing a survey form, although a limited number of hikers had up to four opportunities to participate. For example, some walkers were personally approached by the researcher in addition to being invited to complete a survey form by both the two commercial ferry operators and the shuttle bus operator, whilst other hikers may not have utilised the shuttle bus service nor encountered the researcher during their walk. Despite the fact that both walking tracks attract international visitors and that questionnaires were only printed in English, this does not appear to have unduly disadvantaged their participation in the survey. This is evidenced by the participation of respondents from 18 different countries, including representatives from nations where English is not spoken as a first language (Section 6.3.1).

6.2.6 Reasons for non-participation

Since the researcher was not present when the majority of hikers completed their walk the reasons for non-participation in this survey remain largely unknown. The overwhelming majority of hikers who were personally approached by the researcher were generally extremely enthusiastic about completing a survey and only one declined the offer of a survey citing a dislike of James Cook University.

6.2.7 Rejection of surveys

The majority of survey forms were completed correctly with minimal missing responses in all sections. While a total of 627 surveys were returned to the researcher, four (0.6%) had to be rejected. Three surveys were rejected because of inadequate completion of questions (< 50% of survey questions) while another survey was rejected because it was received after the cut-off date. This left a total of 623 usable questionnaires for analysis, with 226 originating from the Mt Bartle Frere Track and 397 from the Thorsborne Trail.

6.3 RESPONDENT CHARACTERISTICS

6.3.1 Place of residence

Place of residence data was requested from respondents to enable the respective proportions of local residents, domestic tourists and international tourists to be determined. In addition to this descriptive profiling of respondents, place of residence data also allowed for an exploration of the relationship of this parameter to other variables. Hikers living outside of Australia were classified as ‘international tourists’, while those living within Australia were divided into ‘local residents’ and ‘domestic tourists’ on the basis of their post code. All visitors residing within post codes that adjoined the Wet Tropics bioregion were categorised as locals while all other Australians who nominated a post code that did not adjoin the bioregion were regarded as domestic tourists. A number of Australian residents failed to provide a post code and were grouped within an ‘other’ category.

Table 6.2 presents *place of residence* data which indicates that both walking tracks were used by local, domestic and international visitors. The majority of respondents were domestic tourists (37.8%), closely followed by local residents (33.7%), while international tourists (21.3%) comprised less than one quarter of all respondents. Comparative statistics confirmed that there were significant differences between the proportions of respondents who resided within Australia or overseas (Chi-square, d.f = 1; x^2 = 3.933; P = 0.047). The Mt Bartle Frere Track had a relatively higher proportion of local (38.1%) and international respondents (25.7%), than was the case for the Thorsborne Trail. Conversely domestic tourists were more prevalent on the Thorsborne Trail (37.8%) than was the case on the Mt Bartle Frere Track (29.6%).

Table 6.2 Characteristics of respondents.

	Combined Data		Mt Bartle Frere		Thorsborne Trail	
	N	**%**	**N**	**%**	**N**	**%**
Place of residence						
Local residents[1]	210	33.7	86	38.1	124	31.2
Domestic tourists [2]	235	37.8	67	29.6	168	42.3
International tourists [3]	133	21.3	58	25.7	75	18.9
Other [4]	45	7.2	15	6.6	30	7.6
Total	623	100	226	100	397	100
Gender						
Male	357	57.3	145	64.2	212	53.4
Female	266	42.7	81	35.8	185	46.6
Total	623	100	226	100	397	100
	N = 623		N = 226		N = 397	
Age (Mean ± Standard Error)	35.2 ± 0.521		36.3 ± 0.975		34.6 ± 0.647	
	N	**%**	**N**	**%**	**N**	**%**
Education (highest level)						
Primary	13	2.1	4	1.8	9	2.3
Secondary	129	20.7	45	19.9	84	21.2
Tertiary A	108	17.4	43	19.0	65	16.4
Tertiary B	372	59.8	134	59.3	238	60.1
Total	622	100	226	100	396	100
Level of physical fitness						
Extremely fit	34	5.5	14	6.3	20	5.1
Very fit	234	37.8	90	40.2	144	36.4
Somewhat fit	324	52.3	110	49.1	214	54.2
Somewhat unfit	25	4.1	9	4.0	16	4.1
Very unfit	2	0.3	1	0.4	1	0.2
Extremely unfit	0	0	0	0	0	0
Total	619	100	224	100	395	100

[1] Local residents = respondents who reside at an Australian post code that is within or adjoins the Wet Tropics bioregion
[2] Domestic tourists = respondents who reside at an Australian post code that is not within or adjoining the Wet Tropics bioregion
[3] International tourists = respondents who reside overseas
[4] Other = respondents who reside within Australia but did not supply a post code

A total of 133 completed survey forms were received from international tourists (Table 6.2). *Country of residence* data was subsequently analysed to determine where the majority of overseas respondents live (Appendix 9). The analysis revealed that the majority of respondents using the two tracks under investigation resided in the United States (25.6%), Germany (19.5%) and the United Kingdom (13.5%). Other countries with five or more survey respondents included Canada (8), France (8), the Netherlands (8), New Zealand (7) and Spain (5). International tourists from the United States (21), Germany (7) and the United Kingdom (6) were most prevalent on the Mt Bartle Frere Track, while visitors from Germany (19), the United States (13) and the United Kingdom (12) were most common on the Thorsborne Trail.

6.3.2 Gender

Survey respondents were asked to indicate their *gender* to assist in developing a profile of long-distance walking track users in the Wet Tropics region, and to enable the relationship of *gender* to other variables to be subsequently investigated. Table 6.2 indicates that of 623 returned questionnaires, 266 were completed by females (42.7%) and 357 were completed by males (57.3%), with these differences being statistically significant (Chi-square, d.f = 1; x^2 = 6.813; P = 0.009). Although male respondents were more numerous than female respondents on both walking tracks, the Thorsborne Trail had a higher proportion of female respondents (46.6%) than did the Mt Bartle Frere Track (35.8%).

6.3.3 Age

Survey respondents were asked to provide their *age* in years. The youngest respondent was nine and the oldest was 70, with the median age being 32 years. A total of 16 surveys were completed by children (respondents aged less than 15 years old) with three of these from the Mt Bartle Frere Track and the remaining 13 from the Thorsborne Trail. Surveys completed by younger children were carefully checked to ensure that they were completed in a consistent and credible manner. Table 6.2 indicates that the mean age of all respondents was 35.2 years with the mean age of respondents from the Mt Bartle Frere Track (36.3) being somewhat older than that of Thorsborne Trail respondents (34.6), although mean age differences between tracks were not statistically significant (t-test, d.f = 617; t = 1.544; P = 0.123). The average age of male respondents (36.1) was somewhat older than that of female respondents (34.0) but gender age differences were not statistically significant (t-test, d.f = 617; t = 1.944; P = 0.052).

Age data were subsequently recoded into one of seven classes (Figure 6.1) to enable gender/age distribution comparisons to be made within and between tracks. A majority of respondents (54%) were between 16-35 years. Males hiking the Mt Bartle Frere Track were more likely to be between 26-35 years while females were more likely to be between 16-25 years. On the Thorsborne Trail both males and females were more likely to be aged between 26–35 years.

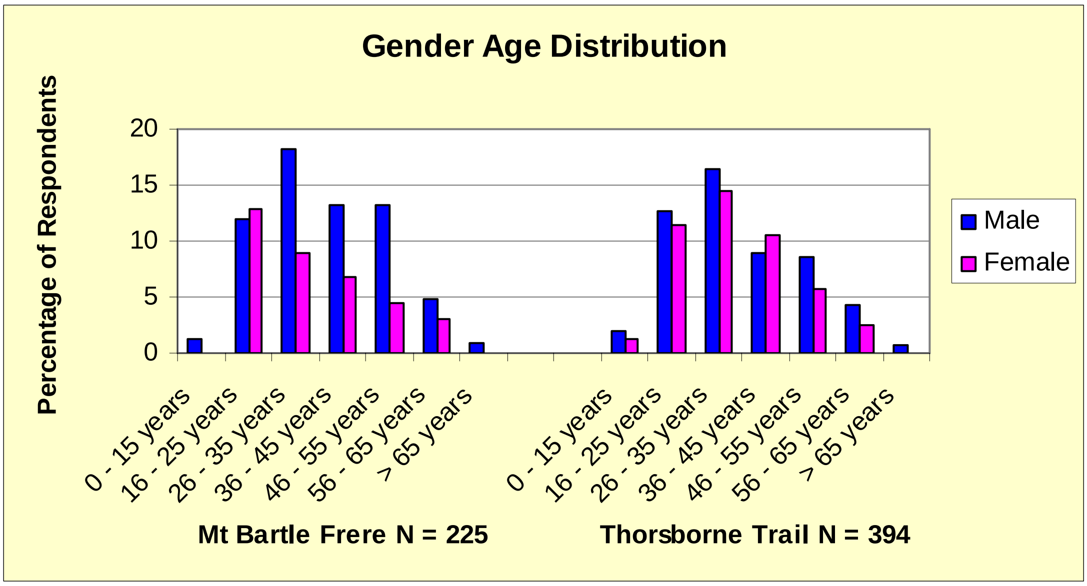

Figure 6.1 Gender age distributions for each walking track.

6.3.4 Education

Survey respondents were asked to nominate the highest level of formal *education* that they had completed from a list of four possible choices [Primary (1-8 years school), Secondary (9-12 years school), Tertiary A (technical or further educational institution) and Tertiary B (university)]. Table 6.2 indicates that over three-quarters of all respondents completed some tertiary education with approximately 60 percent having completed formal education at a university (Tertiary B). An additional 17 percent completed formal education at a technical or further educational institution (Tertiary A). Almost 21 percent of all walkers completed secondary school only while the remaining two percent only completed primary school. Respondent education levels were not significantly different between the two tracks (Chi-square, d.f = 3; x^2 = 0.873; P = 0.832).

6.3.5 Perceived level of physical fitness

Respondents were asked to provide a self-assessment of their *physical fitness* by selecting one of six predetermined response categories ranging from ‘extremely fit’ to ‘extremely unfit’. Table 6.2 suggests that the vast majority of respondents believed that they were either ‘somewhat fit’ (52.3%) or ‘very fit’ (37.8%), with similar results obtained from both tracks. It should be noted that no respondent perceived themselves to be ‘extremely unfit’, and only one respondent on each track regarded themselves as being ‘very unfit’. Perceptions of physical fitness did not differ significantly between the two walking tracks (Chi-square, d.f = 4; x^2 = 1.758; P = 0.780), although comparisons of perceived levels of physical fitness revealed statistically significant differences between males and females (Chi-square, d.f = 4; x^2 = 18.222; P = 0.001). Males considered themselves to be more physically fit than did females on both walking tracks.

6.3.6 Long-distance walking track experience

Previous experience was quantified by asking respondents to indicate both the number of long-distance walks (walks requiring at least one overnight stay) they had previously completed, and the duration in days of the longest walk they had ever undertaken. These two variables were subsequently combined to form a composite score that reflected overall level of long-distance walking track experience (Table 6.3). Composite *level of experience* results suggest that only 15.4 percent of respondents had ‘no experience’ while 21.2 percent of respondents could be regarded as ‘extremely experienced’ long-distance walking track users. Composite mean results suggest that the Mt Bartle Frere Track attracts a higher proportion of less experienced hikers than the Thorsborne Trail with significant differences existing between the two tracks (Mann Whitney U = 165934.000; P = 0.035).

In excess of 52 percent of hikers on the Mt Bartle Frere Track and almost 49 percent of hikers on the Thorsborne Trail had previously completed six or more long-distance walks. However, the Mt Bartle Frere Track (18.2%) attracted more novices than the Thorsborne Trail (13.8%). Almost three quarters (74.9%) of all hikers had previously completed a walk of more than two days duration, while more than 30 percent had completed a walk that extended for a week or longer. The Mt Bartle Frere Track (33.6%) had a higher proportion of respondents who had never undertaken a walk of more than two days duration. Comparative statistics demonstrated that differences in the number of previous long-distance walks completed by respondents from each track were not significant (Chi-square, d.f = 5; x^2 = 5.757; P = 0.331), although differences in the duration of the longest walk ever undertaken by respondents from each track were significantly different (Chi-square, d.f = 3; x^2 = 19.541; P = 0.002). Of the 16 children (age <15) who completed a survey, 12 had either 'no experience' or 'little experience', while two were 'quite experienced'.

Table 6.3 Level of experience.

Questions 4 and 5.	**Combined Data**		**Mt Bartle Frere**		**Thorsborne Trail**	
	N	**%**	**N**	**%**	**N**	**%**
Number of previous long walks						
0	96	15.4	41	18.2	55	13.8
1-2	108	17.4	37	16.4	71	17.9
3-5	108	17.4	30	13.3	78	19.7
6-10	96	15.4	36	15.9	60	15.2
11-20	72	11.6	27	11.9	45	11.4
>20	142	22.8	55	24.3	87	22.0
Total	622	100	226	100	396	100
Longest walk ever completed						
< 1 day	95	15.3	43	19.0	52	13.2
1-2 days	61	9.8	33	14.6	28	7.1
3-4 days	128	20.6	50	22.1	78	19.8
5-6 days	147	23.7	39	17.3	108	27.4
7-8 days	68	11.0	23	10.2	45	11.4
>8 days	121	19.6	38	16.8	83	21.1
Total	620	100	226	100	394	100

Level of Experience (Composite)

1 = No Experience **3 = Some Experience** **5 = Very Experienced**
2 = Little Experience **4 = Quite Experienced** **6 = Extremely Experienced**

	No Experience					Extremely Experienced	
Number of Responses	*1 %*	*2 %*	*3 %*	*4 %*	*5 %*	*6 %*	*Mean ± Standard Error*
Total 620	15.4	13.6	19.0	19.6	11.3	21.2	3.6 ± 0.05
BF - 226	18.6	15.5	17.7	16.6	11.1	20.6	3.5 ± 0.08 *
TT - 394	13.5	12.5	19.7	21.3	11.4	21.5	3.7 ± 0.06 *

* = Significant differences ($P < 0.05$) exist between the two tracks as indicated by Mann Whitney *U* tests.

6.3.7 Logistical arrangements

Private walk or organised group

A distinction was made between respondents who planned and organised their own walks and those who hiked as part of an organised group such as an educational excursion or a bushwalking club activity. It should be noted that no commercial tour operators are permitted on the Thorsborne Trail and that the sole commercial tour operator previously servicing the Mt Bartle Frere Track ceased to operate just prior to the commencement of the survey period. Over 92 percent of all respondents planned and conducted their own walk with this proportion somewhat higher on the Thorsborne Trail (95.5%) than for the Mt Bartle Frere Track (87.6%). The types of organised groups identified were from the Smithfield State High School, the School for Field Studies, James Cook University and various bushwalking clubs.

Sources of information about the walking tracks

Substantial resources have been invested to ensure that visitors can readily obtain information about long-distance walking opportunities within the Wet Tropics region. This research provided an opportunity to determine which sources of long-distance walking track information were most widely used by hikers. Respondents were asked to reveal how they found out about the existence of the walking track they completed from a list of seven predetermined response categories plus an additional open ended 'other' category. During data analysis it became apparent that a high proportion of the open ended responses were from respondents who were local residents who had 'always known' about the existence of particular walking tracks, or were part of an organised school or university excursion that organised the walk for them. Consequently two additional categories were created for the presentation of results.

Both combined data and the individual results obtained from each location indicated that respondents were more likely to learn about the existence of long-distance walking tracks using *informal information sources* rather than *formal sources*. Combined data suggested the majority of respondents (55.3%) used informal information sources to locate their respective tracks, which included 'word of mouth' (40.8%), 'repeat visitors' (14.5%), and those who lived locally and had 'always known' (0.03%). Figure 6.2 depicts sources of information (multiple responses allowed) used by respondents from each track. Over half (51.6%) of all respondents from the Mt Bartle Frere Track learnt of the walk via 'word of mouth' (33.5%) or were 'repeat visitors' (18.1%). Less frequently utilised sources of information about the Mt Bartle Frere Track were 'travel guides or books' (16.3%), 'regional maps' (8.0%), 'North Queensland tourist information centres' (7.1%) and 'QPWS or WTMA brochures' (6.2%).

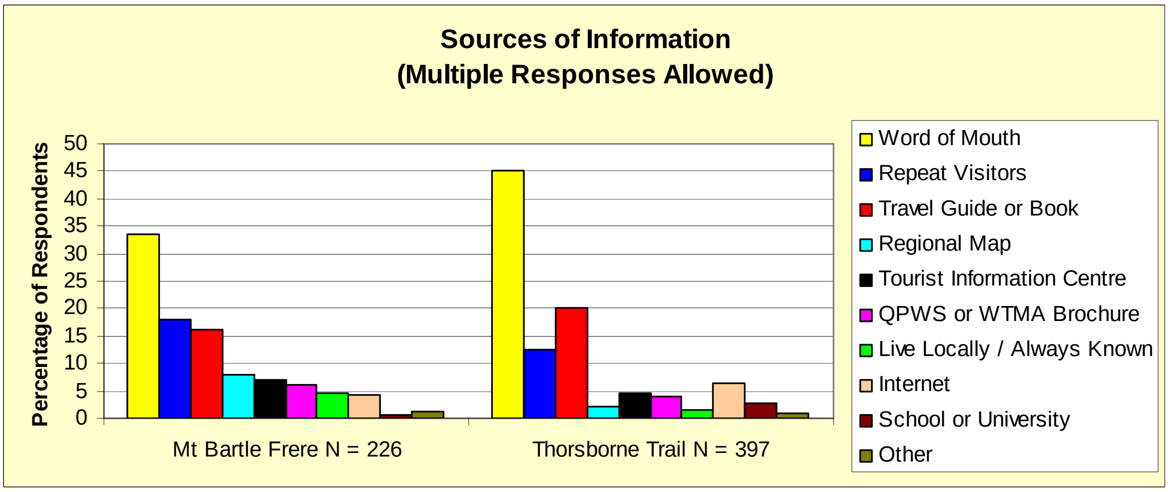

Figure 6.2 Sources of information (multiple responses allowed) about each track.

The most frequently cited sources of information about the Thorsborne Trail were ‘word of mouth’ (45.0%), ‘travel guides or books’ (20.1%), and respondents who were ‘repeat visitors’ (12.4%). The ‘internet’ (6.4%) and ‘North Queensland tourist information centres’ (4.5%) were less frequently utilised sources of information. The data in Figure 6.2 suggests that the Mt Bartle Frere Track appears to attract a higher proportion of respondents who have learnt about the walk because they live locally, whilst the Thorsborne Trail attracts more school or university excursions. Other sources of information about the existence of the two tracks included roadside signage, newspaper articles and church activities. Mann Whitney *U* tests were used to compare sources of information used by respondents from each track and demonstrated that statistically significant differences existed for ‘word of mouth’ (U = 40861.000; P = 0.009), ‘repeat visitors’ (U = 38192.500; P < 0.001), and ‘regional maps’ (U =40857.500; P < 0.001).

Group size

Respondents were also asked to indicate the number of adults and children (aged < 15) who walked as part of their group, which was later combined into *group size* data. Table 6.4 presents data on the number and percentage of groups of different sizes who completed either walking track as reported by respondents. It should be noted that Table 6.4 only refers to the number of individuals within each respondent’s own group and does not refer to the size of other parties the respondent encountered during their walk.

Table 6.4 Group size as reported by survey respondents from each track.

Number Within Group	Mt Bartle Frere		Thorsborne Trail	
	Number of Respondents	Percentage of Track Respondents	Number of Respondents	Percentage of Track Respondents
1	41	18.1	31	7.8
2	95	42.0	126	31.7
3 - 6	54	23.8	188	47.4
>6	36	16.1	52	13.1
Total	226	100%	397	100%

Modal data suggests that the most frequently reported group size on either walking track was two with 42.0 percent of respondents from the Mt Bartle Frere Track and 31.7 percent of respondents from the Thorsborne Trail walking with one other person. The Mt Bartle Frere Track had a higher proportion of respondents who walked alone (18.1%) compared to the Thorsborne Trail (7.8%), which has some potential implications for visitor safety given the high potential for serious injuries on this walking track. A distinction was made between respondents who walked as a member of either a medium sized group (3-6 members), or a large group (>6 members). Almost a quarter (23.8%) of respondents from the Mt Bartle Frere Track and almost half (47.4%) the respondents from the Thorsborne Trail indicated they had walked as a member of a medium sized group (3-6). The proportion of respondents who walked as a member of a large group (>6) was slightly higher on the Mt Bartle Frere Track (16.1%) than the Thorsborne Trail (13.1%). It is known from comments provided on surveys that many of the respondents who walked in groups of eight or more were often members of organised excursions by educational institutions and bushwalking clubs.

Duration of walk

Survey participants were asked to nominate the number of days they took to complete their walk as an indication of track usage patterns, although it should be reiterated that the Thorsborne Trail is substantially longer than the Mt Bartle Frere Track requiring a longer period of time to complete. Figure 6.3 indicates that a majority (70.4%) of respondents completed the Mt Bartle Frere Track within a day, while over a quarter (26.4%) of remaining hikers completed the walk within two days. Approximately 78 percent of hikers surveyed on the Thorsborne Trail completed their walk in either four or five days, while a further 14.6 percent of respondents took six or seven days to complete the walk. Thorsborne Trail respondents who reported only spending one or two days on their hike were unlikely to have completed the entire walk.

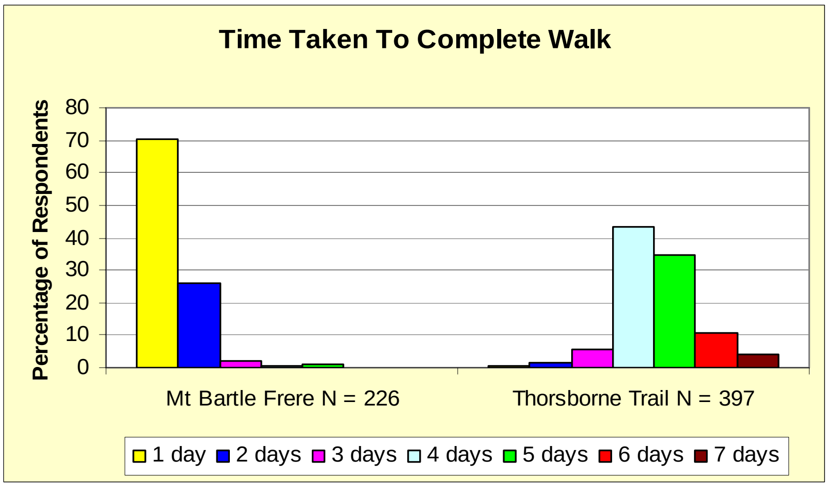

Figure 6.3 Number of days to complete each walk.

6.3.8 Motivations: reasons for undertaking each walk

In Question 15 (a-k) respondents were asked to evaluate 11 possible reasons for why they had chosen to undertake the particular walk that they completed and were also provided with an additional open ended 'other' category. Respondents were asked to rate each possible reason on a six-point multiple response scale ranging from 'not important' to 'very important'. A factor analysis (Appendix 10), which was used to test for the existence of inter-correlations among the 11 motivational items confirmed the existence of three distinct motivating factors (experiential, social, and activity-based). Kaiser's criterion or the eigenvalue rule was applied so only factors with eigenvalues of 1.0 or more were retained for further analysis and interpretation (Pallant, 2005).

The first factor identified five experiential-based motivations reflecting respondents need to experience various natural environmental phenomena including wilderness, natural features and scenery, wildlife and rainforest. The second factor identified three social-based motivations that reflected the extent to which respondents desired to interact with other visitors. The third factor identified three activity-based motivations which included their desire to partake in outdoor exercise, adventure and a new challenge. Composite scores for each of the three factors indicated that experiential-based reasons and activity-based reasons were the most important motivations for respondents undertaking either hike. Although the factor analysis suggested that it would have been possible to clump together related variables in multiple ways, three particular items (e, f, h) were combined to form a composite of social-based reasons that was consistent with the theoretical framework used in this research (Table 6.5). Significant differences existed between the two tracks for nine of the 11 motivations, and for both the experiential-based and social-based composites.

Table 6.5 Reasons for undertaking the walk.

Question 15 (a-l). Reasons for undertaking the walk

What are the most important **reasons for you undertaking this long-distance walk**?
For each item please circle the number that best reflects the level of importance to you.

1 = Not Important **2 = Slightly Important** **3 = Moderately Important** **4 = Important** **5 = Quite Important** **6 = Very Important**

Mt Bartle Frere / Thorsborne Trail / ***Experiential-based reasons*** / ***Social-based reasons*** / ***Activity-based reasons***	*Number of Responses*	*1 %*	*2 %*	*3 %*	*4 %*	*5 %*	*6 %*	*Mean ± Standard Error*
		Not Important					**Very Important**	
a) To experience rainforest *	222	5.0	6.3	13.1	19.8	23.9	32.0	4.50 ± 0.10
	391	3.8	9.0	14.6	27.6	21.2	23.8	4.26 ± 0.07
b) See natural features & scenery *	223	0.4	1.3	5.4	14.8	29.6	48.4	5.18 ± 0.07
	394	0.8	2.3	3.3	11.2	24.9	57.5	5.30 ± 0.05
c) View wildlife / bird watching	220	8.2	14.1	23.2	20.0	15.5	19.1	3.77 ± 0.11
	393	6.1	16.8	19.8	24.2	16.8	16.3	3.79 ± 0.07
d) To be in and enjoy wilderness *	224	0.4	0.9	6.3	13.4	28.6	50.4	5.22 ± 0.07
	394	0.8	1.3	2.5	7.1	21.6	66.8	5.48 ± 0.05
g) Experience peace & tranquility *	222	6.8	9.5	11.3	25.7	21.2	25.7	4.21 ± 0.10
	394	3.6	2.5	8.4	22.6	22.8	40.1	4.78 ± 0.07
Composite Scores (Experiential) *	Mt Bartle Frere Track Composite Score						4.58 ± 0.09	
	Thorsborne Trail Composite Score						4.72 ± 0.06	
e) Socialise with family / friends *	218	29.8	11.9	18.8	18.3	14.7	6.4	2.95 ± 0.11
	395	20.0	9.4	16.2	17.2	19.2	18.0	3.59 ± 0.09
f) To rest, relax and unwind *	220	16.8	10.0	20.5	21.4	14.5	16.8	3.60 ± 0.11
	394	10.2	6.9	12.4	24.4	19.0	27.2	4.16 ± 0.08
h) To get away from other people *	220	20.5	11.4	15.9	20.0	14.5	17.7	3.49 ± 0.12
	394	11.2	7.6	14.0	19.0	20.1	28.2	4.13 ± 0.08
Composite Scores (Social) *	Mt Bartle Frere Track Composite Score						3.35 ± 0.11	
	Thorsborne Trail Composite Score						3.96 ± 0.08	
i) A new challenge	224	8.5	7.1	7.1	19.6	22.3	35.3	4.45 ± 0.11
	394	8.1	4.8	6.9	17.8	25.6	36.8	4.58 ± 0.08
j) To get some outdoor exercise *	222	2.7	3.2	12.2	22.1	29.3	30.6	4.65 ± 0.09
	395	5.6	6.3	12.2	24.8	26.3	24.8	4.34 ± 0.07
k) For the adventure *	223	4.9	5.8	9.9	17.5	24.7	37.2	4.61 ± 0.10
	397	1.5	3.3	7.3	15.4	25.9	46.6	4.99 ± 0.06
Composite Scores (Activity)	Mt Bartle Frere Track Composite Score						4.57 ± 0.10	
	Thorsborne Trail Composite Score						4.64 ± 0.07	
l) Other (Refer Table 6.6)	51	0	0	2.0	7.8	15.7	74.5	5.63 ± 0.10
	53	0	0	1.9	3.8	17.0	77.4	5.70 ± 0.09

* = Significant differences (P < 0.05) exist between the two tracks as indicated by Mann Whitney *U* tests.

Analysis of the relationship between motivations and place of residence was interesting. Mean experiential, social and activity-based motivations were compared on the basis of respondents' country of residence to determine if Australian and international respondents had the same motivations for undertaking long-distance walks. An interesting finding was that mean scores derived from all experiential-based motivations were somewhat higher for international respondents (4.88) than was the case for Australian respondents (4.61). Conversely mean scores resulting from social-based motivations were considerably higher for Australian residents (3.85) than for international respondents (3.35), although activity-based motivations were similar.

Survey respondents had substantially different 'other' motivations for completing their respective walks. It should be noted that 'other' reasons for undertaking walks obtained the highest overall mean score from respondents for each walking track, which suggests that there are items which would need to be included in a future scale (Table 6.5). In Table 6.6 motivations in the 'other' category have been presented as experiential, social, educational and activity-based. The most frequently reported 'other' reasons for hikers to undertake the Mt Bartle Frere Track were activity-based (to climb the highest mountain in Queensland, fitness training), educational (to be part of a scientific excursion), and experiential (to see the views). For Thorsborne Trail respondents the most frequently reported 'other' reasons for undertaking the walk were experiential (obtain a new experience, escape the everyday), and social-based (family reasons, to have fun).

Table 6.6 'Other' reasons for undertaking this walk.

Question 15 (l). **Other specified reasons for undertaking this walk.**			
Mt Bartle Frere (N = 51)		Thorsborne Trail (N = 53)	
Activity (24) To climb the highest peak in Queensland (15) Fitness training (4) Take photographs (3) Swim (1) Clean up rubbish (1)	Experiential (11) To see the views (6) Gain hiking experience (2) To sleep in a tent (1) Love mountains (1) Be closer to God (1)	Activity (12) Fishing (3) Climb Mt Bowen / Mt Diamantina (3) Take photographs (2) Open coconuts (1) Swim in waterholes (1) Walk in World Heritage (1) To go on a famous walk (1)	Experiential (18) New experience (8) Escape the everyday (4) Fresh air (1) Unspoilt experience (1) See the beauty (1) Feel close to God (1) Milestone for life (1) See the stars at night (1)
Educational (9) Scientific excursion (7) Outdoor education (2)	Social (6) To have fun (5) Help out the group (1)	Educational (7) Outdoor education (3) Scientific excursion (2) School camp (2)	Social (15) Family reasons (7) To have fun (6) Meet new people (1) Wedding anniversary (1)
Other (1) To use National Parks so they are retained (1)		Other (1) To liaise with resort guests (1)	

6.3.9 Activities that hikers wanted to do but could not

Respondents were asked whether or not there were other activities that they had wanted to do during their long-distance walk but had been unable to do, and to specify the activity concerned (Question 12). Activities were then divided into groups according to the types of restrictions respondents had encountered (for example some activities were restricted by management regulations, whilst others were restricted by natural phenomena such as weather conditions). The main purpose in grouping this data was to examine what additional activities respondents would like to participate in and to determine the extent to which these were restricted by management. Table 6.7 provides a list of activities respondents had wanted to participate in and a categorisation of the types of restrictions they encountered.

On the Mt Bartle Frere Track a number of respondents indicated that they had wanted to either see or photograph the view from the top of the mountain but that they had been restricted by weather conditions (rain and cloud). A number of other respondents from the Mt Bartle Frere Track specified time as the restriction preventing them from climbing right to the summit or enabling them to stay longer, while yet others had wanted to see more wildlife. Respondents from the Thorsborne Trail most frequently reported ocean swimming as an activity that they had wanted to do but that this was not possible due to the presence of marine stingers during the period when their visit occurred. Another group of Thorsborne Trail respondents indicated that they had wanted to catch fish but that this was prohibited within freshwater locations within the National Park. It is important to note that a number of Thorsborne Trail respondents were restricted from doing particular activities by what can be categorised as management restrictions. For example a number of respondents had wanted to fish in freshwater streams or construct campfires but these activities were prevented by management regulations whilst other respondents indicated they had been unable to climb Mt Bowen as they could not obtain a permit.

Table 6.7 Activities that respondents wanted to do but could not do.

Question 12. Activities undertaken **Were there particular activities that you wanted to do on this walk that you were unable to do?**		**O** Yes **O** No If yes, please specify…………………………………..	
Mt Bartle Frere Track N = 225 Yes 30 (13.3 %) Listed Below No 195 (86.7 %)		Thorsborne Trail N = 397 Yes 97 (24.4 %) Listed Below No 300 (75.6 %)	
Types of Restrictions Upon Desired Activities		Types of Restrictions Upon Desired Activities	
Management Restrictions (1) Have a plaque at the summit to identify the view (1)	Weather Restrictions (16) See summit view (12) Photograph the view (4)	Management Restrictions (22) Go freshwater fishing (14) Build fires (5) Climb Mt Bowen (2) QPWS burning off (1)	Weather Restrictions (2) Swim in fresh water (2)
Nature Restrictions (3) See more wildlife (3)	Time Restrictions (5) Climb to the summit (3) Stay longer / Camp (2)	Nature Restrictions (43) Ocean swim – Stingers (32) See more wildlife (9) Rock climbing (1) Camp at Sunken Reef Bay but there was no fresh water (1)	Time Restrictions (24) Climb mountains (8) Stay longer (7) Climb Nina Peak (7) Do side walks (1) Sleep (1)
Other Restrictions (5) Swim but not enough fresh water (2) Climb big rocks (1) Look at rainforest structural changes (1) Not specified (1)		Other Restrictions (6) Not specified (4) Have a proper shower (1) Go rock climbing (1)	

6.4 APPRAISAL OF ENVIRONMENT AND MANAGEMENT

6.4.1 Appraisal of the natural environment

Hikers were asked for their appraisal of the condition, interest and appeal of the natural environment they encountered during the course of their long-distance walk by evaluating four statements using a six-point multiple response scale ranging from ‘strongly disagree’ to ‘strongly agree’ (Question 16: a-d). A factor analysis (Appendix 10) was performed on the four measures of appraisal of the natural environment and confirmed the existence of two factors that accounted for three quarters (75.8%) of all variance. The first factor (three items) related to respondent appraisal of the natural environment while the second factor (one item) was associated with the level of respondent concern for the natural environment (Table 6.8). Results suggest that most respondents positively appraised the natural environment along each track and were not concerned about the condition of the natural environment.

Table 6.8 Appraisal of the natural environment (condition, interest and appeal).

Question 16 (a – d). The condition and appeal of the natural environment

The following statements are about the **condition and appeal of the natural environment** associated with this walking track. Please rate how strongly you agree or disagree with each statement by circling the number that best reflects your level of agreement/disagreement.

1 = Strongly Disagree **3 = Mildly Disagree** **5 = Somewhat Agree**
2 = Somewhat Disagree **4 = Mildly Agree** **6 = Strongly Agree**

Strongly Disagree **Strongly Agree**

Mt Bartle Frere Track / Thorsborne Trail	*Number of Responses*	*1 %*	*2 %*	*3 %*	*4 %*	*5 %*	*6 %*	*Mean ± Standard Error*
a) The condition of the natural environment along this walking track appears to be good	226	0.4	1.3	1.8	8.8	38.5	49.1	5.31 ± 0.06
	397	0.3	1.3	0.8	6.0	39.8	51.9	5.39 ± 0.04
b) The natural environment along this walking track is interesting *	226	0.9	0.9	0.4	12.8	28.8	56.2	5.38 ± 0.06
	396	0.3	0.3	1.3	6.6	25.8	65.9	5.55 ± 0.04
c) The natural environment along this walking track is appealing in terms of attractions and scenic beauty *	223	0	0.9	4.5	20.2	29.1	45.3	5.14 ± 0.06
	395	0.3	0.5	1.3	8.1	22.5	67.3	5.54 ± 0.04
***Composite Scores (a, b, c)* ***	Mt Bartle Frere Track Composite Score						5.28 ± 0.06	
	Thorsborne Trail Composite Score						5.49 ± 0.04	
d) I am (not) concerned about the condition of the natural environment along this walking track #	222	10.4	8.6	14.4	16.2	25.7	24.8	4.13 ± 0.11
	394	9.4	9.9	12.2	11.2	27.2	30.2	4.27 ± 0.08

= Responses have been reverse coded and the word 'not' has been added.
* = Significant differences (P < 0.05) exist between the two tracks as indicated by Mann Whitney *U* tests.

The majority of respondents from both tracks agreed that the *condition* of the natural environment was good, in addition to being both *interesting* and *appealing*. Composite scores indicated that respondents from the Thorsborne Trail were more positive about the condition and appeal of the natural environment than their counterparts from the Mt Bartle Frere Track, with these differences being statistically significant (Table 6.8). When asked if they were concerned about the condition of the natural environment along each track respondents were ambivalent with the mean response being to 'mildly agree', although respondents from the Mt Bartle Frere Track were slightly more concerned about the condition of the natural environment than those from the Thorsborne Trail, but differences were not significant.

Hikers were asked to rate their perceptions of the extent of various biophysical impacts observed during the course of their walk using a six-point multiple response scale ranging from ‘extremely low’ to ‘extremely high’ (Question 16: e-k). The results presented in Table 6.9 suggest that respondents from both tracks perceived most biophysical impacts upon the natural environment to range between ‘somewhat low’ and ‘extremely low’. Mean responses from the Mt Bartle Frere Track indicated soil erosion and top soil loss was the most prevalent biophysical impact (3.03), followed by evidence of feral animals (2.50), and human vegetation damage (2.47). Hikers on the Thorsborne Trail perceived evidence of feral animals (2.68), human vegetation damage (2.55), and human litter (2.54) to be the most prevalent biophysical impacts. Respondents’ perceptions of the prevalence of soil erosion, weeds, litter, human body waste, and undesignated tracks were significantly different between the two tracks (Table 6.9).

Table 6.9 Appraisal of the natural environment (biophysical impacts).

Question 16 (e – k). Perceptions of the natural environment

Please rate your perceptions of the following aspects (where applicable) of the natural environment along this walking track. For each item please circle the number that best reflects the **prevalence of impacts**.

1 = Extremely Low **3 = Somewhat Low** **5 = Very High**
2 = Very Low **4 = Somewhat High** **6 = Extremely High**

Extremely Low **Extremely High**

Mt Bartle Frere Track / Thorsborne Trail	*Number of Responses*	*1 %*	*2 %*	*3 %*	*4 %*	*5 %*	*6 %*	*Mean ± Standard Error*
e) Soil – evidence of soil erosion and top soil loss along this walking track *	223	9.9	23.8	32.3	22.9	8.5	2.7	3.03 ± 0.08
	393	19.1	34.6	33.6	10.7	2.0	0	2.42 ± 0.05
f) Vegetation – evidence of vegetation trampling, breakages and other damage	224	16.5	37.1	30.8	13.8	1.8	0	2.47 ± 0.07
	396	15.2	35.6	32.3	14.6	1.8	0.5	2.55 ± 0.05
g) Weeds – the presence of weeds growing along this walking track *	215	33.0	32.1	25.1	8.4	1.4	0	2.12 ± 0.07
	378	40.2	39.4	14.8	3.7	1.9	0	1.88 ± 0.05
h) Feral animals – the presence of feral animals along this walking track	221	38.9	15.8	17.6	14.9	9.5	3.2	2.50 ± 0.10
	396	27.5	22.7	21.0	15.9	9.3	3.5	2.68 ± 0.07
i) Litter and rubbish – evidence of littering and rubbish along track *	224	42.0	33.5	17.0	6.3	1.3	0	1.92 ± 0.07
	396	20.7	32.3	27.5	12.4	5.8	1.3	2.54 ± 0.06
j) Human body waste – evidence of inadequate disposal of body waste *	224	52.2	29.9	9.4	5.8	1.8	0.9	1.78 ± 0.07
	395	63.0	23.8	8.4	3.3	0.8	0.8	1.57 ± 0.05
k) Undesignated tracks – evidence of short-cutting and informal social trails *	224	41.5	32.1	20.1	5.8	0.4	0	1.91 ± 0.06
	394	26.9	39.3	20.8	9.6	3.0	0.3	2.24 ± 0.05
Composite Scores (e – k)	Mt Bartle Frere Track Composite Score							2.25 ± 0.09
	Thorsborne Trail Composite Score							2.27 ± 0.04

* = Significant differences (P < 0.05) exist between the two tracks as indicated by Mann Whitney *U* tests.

6.4.2 Appraisal of the social environment

Hikers were also asked to appraise various aspects of the social environment that they encountered during the course of their long-distance walk by rating five statements using a six-point multiple response scale ranging from ‘strongly disagree’ to ‘strongly agree’ (Question 17: a-e). A factor analysis (Appendix 10) identified the existence of two factors that accounted for most of the variance (67.6%). The first factor identified four items relating to visitor numbers and behaviour (Table 6.10). The second factor centered upon whether or not other visitors were perceived to have behaved in an environmentally responsible manner towards the natural environment.

Table 6.10 Appraisal of the social environment.

Question 17 (a-e). The social environment

The following statements are about **other people** who also used this walking track. Please rate how strongly you agree or disagree with each statement by circling the number that best reflects your level of agreement/disagreement.

1 = Strongly Disagree **3 = Mildly Disagree** **5 = Somewhat Agree**
2 = Somewhat Disagree **4 = Mildly Agree** **6 = Strongly Agree**

Strongly Disagree **Strongly Agree**

Mt Bartle Frere Track / Thorsborne Trail	*Number of Responses*	*1 %*	*2 %*	*3 %*	*4 %*	*5 %*	*6 %*	*Mean ± Standard Error*
a) There were too many people using this walking track *	222	68.5	20.7	7.2	1.8	0.9	0.9	1.48 ± 0.06
	396	42.9	27.0	18.2	9.1	2.0	0.8	2.03 ± 0.06
b) There were too many people camped in the camping grounds along this walking track *	214	78.0	12.1	6.5	0.9	0.9	1.4	1.39 ± 0.06
	395	39.5	26.6	17.5	8.6	5.6	2.3	2.21 ± 0.07
d) The behaviour of some other visitors using this track detracted from my enjoyment of this walking experience *	215	71.6	18.6	4.2	2.3	1.4	1.9	1.46 ± 0.07
	394	56.3	25.1	8.1	5.6	2.5	2.3	1.80 ± 0.06
e) Some groups of people using this walking track were too large (too many people in one party) *	209	69.4	19.1	5.7	2.9	1.4	1.4	1.52 ± 0.07
	394	51.3	26.4	9.6	5.3	2.5	4.8	1.96 ± 0.07
Composite Scores (a, b, d, e) *	Mt Bartle Frere Track Composite Score							1.46 ± 0.06
	Thorsborne Trail Composite Score							2.00 ± 0.06
c) The behaviour of other visitors using this walking track has (not) been on the whole environmentally responsible #	215	31.2	38.6	10.7	2.3	4.7	12.6	2.48 ± 0.11
	394	36.5	34.0	11.9	5.1	6.1	6.3	2.29 ± 0.07

= Responses have been reverse coded and the word 'not' has been added.
* = Significant differences (P < 0.05) exist between the two tracks as indicated by Mann Whitney *U* tests.

Mean results suggest that respondents from both tracks were not unduly concerned about either the number or behaviour of other visitors although composite scores suggested that, while still in agreement, nevertheless respondents from the Thorsborne Trail were more concerned than was the case with respondents from the Mt Bartle Frere

Track with statistically significant differences (*) being recorded between tracks for all but one item (Table 6.10). There were more Thorsborne Trail respondents who believed that the behaviour of other visitors had detracted from their enjoyment of their walking experience. A majority of respondents from each track believed that the behaviour of other visitors had been environmentally responsible, with this being the only item that did not generate statistically significant differences between the two tracks.

6.4.3 Appraisal of the built environment

In Question 18 hikers were asked to rate the *adequacy* of existing visitor facilities associated with each walking track, while Questions 22 and 23 sought information about respondents' appraisal of the *standard of construction and maintenance* of these facilities. In each of the three questions respondents were required to use a six-point multiple response scale that enabled responses to be subsequently grouped to form composite scores for each track (Table 6.11).

Respondents from the Thorsborne Trail consistently reported significantly higher mean scores in their appraisal of the built environment than was the case for respondents from the Mt Bartle Frere Track, with statistically significant differences (*) recorded between the two tracks for every item (Table 6.11). A majority of respondents from both tracks (Mt Bartle Frere Track 79.9%; Thorsborne Trail 90.8%) rated existing visitor facilities positively (ranging from adequate to excellent), while almost twice as many respondents from the Thorsborne Trail (24.3%) rated existing facilities as 'excellent' compared to hikers from the Mt Bartle Frere Track (12.6%). Mean results suggest that respondents from the Thorsborne Trail were more satisfied with both the standard of construction and maintenance of facilities and infrastructure than were respondents from the Mt Bartle Frere Track.

Table 6.11 Built environment appraisal.

Questions 18, 22, 23. The built environment

Overall, how do you rate the adequacy of **existing visitor facilities** associated with this walking track?

1 = Totally Inadequate **3 = Somewhat Inadequate** **5 = Very Good**
2 = Very Inadequate **4 = Adequate** **6 = Excellent**

Totally Inadequate **Excellent**

Mt Bartle Frere Track Thorsborne Trail	*Number of Responses*	*1 %*	*2 %*	*3 %*	*4 %*	*5 %*	*6 %*	*Mean ± Standard Error*
18) Adequacy of existing visitor facilities associated with this track *	223	3.6	2.2	14.3	39.0	28.3	12.6	4.24 ± 0.76
	391	0.3	0.5	8.4	28.9	37.6	24.3	4.76 ± 0.48

Please rate how strongly you agree or disagree with each statement by circling the number that best reflects your level of agreement/disagreement.

1 = Strongly Disagree **3 = Mildly Disagree** **5 = Somewhat Agree**
2 = Somewhat Disagree **4 = Mildly Agree** **6 = Strongly Agree**

Strongly Disagree **Strongly Agree**

	Number of Responses	*1 %*	*2 %*	*3 %*	*4 %*	*5 %*	*6 %*	*Mean ± Standard Error*
22) Facilities and infrastructure associated with this walking track are well constructed *	205	3.4	6.8	11.7	32.7	32.2	13.2	4.23 ± 0.09
	392	0.5	2.8	7.1	22.4	40.1	27.0	4.80 ± 0.05
23) Facilities and infrastructure associated with this walking track are well maintained *	206	4.4	5.3	11.2	33.5	31.6	14.1	4.24 ± 0.09
	389	2.1	4.6	7.7	24.2	40.6	20.8	4.59 ± 0.06
Composite Scores (18, 22, 23) *	Mt Bartle Frere Track Composite Score						4.24 ± 0.31	
	Thorsborne Trail Composite Score						4.72 ± 0.20	

* = Significant differences (P < 0.05) exist between the two tracks as indicated by Mann Whitney *U* tests.

In Question 19 respondents were asked to indicate if the provision of *additional visitor facilities* would enhance their enjoyment of the particular walking track that they had completed (Table 6.12). A majority of respondents from both locations (Mt Bartle Frere Track 65.3%; Thorsborne Trail 56.3%) indicated that the provision of additional visitor facilities would not enhance their enjoyment of these long-distance walking tracks with mean results suggesting respondents from the Thorsborne Trail (2.63) were slightly more supportive of additional facilities than were respondents from the Mt Bartle Frere Track (2.50). Although proportionately more respondents from the Thorsborne Trail (32.9%) than the Mt Bartle Frere Track (26.6%) supported the establishment of additional facilities, comparative statistics confirmed that levels of support were not significantly different between tracks (Mann Whitney U = 41488.000; P = 0.321).

Table 6.12 Respondent support for the establishment of additional visitor facilities.

Question 19. The built environment

Would the provision of **additional visitor facilities** enhance your enjoyment of this walking track?

1 = No Definitely Not **3 = Don't Know** **5 = Yes Definitely**
2 = No Probably Not **4 = Yes Probably**

		No Definitely Not				**Yes Definitely**	
Mt Bartle Frere Track / Thorsborne Trail	*Number of Responses*	*1 %*	*2 %*	*3 %*	*4 %*	*5 %*	*Mean ± Standard Error*
Would additional visitor facilities enhance your enjoyment of this track? (Mt Bartle Frere Track)	222	22.5	42.8	8.1	15.8	10.8	2.50 ± 0.09
(Thorsborne Trail)	392	24.7	31.6	10.7	21.9	11.0	2.63 ± 0.07

In Question 20 respondents were asked to indicate what additional visitor facilities (if any) they would support either being established or increased on each walking track and were provided with a list of nine predetermined response categories (Figure 6.4), in addition to an open-ended 'other' category. Despite the fact that a majority of respondents from both locations had previously indicated that the provision of additional visitor facilities would not enhance their enjoyment of these walking tracks (Table 6.12), the vast majority of respondents from both tracks (Mt Bartle Frere Track 75.3%; Thorsborne Trail 83.9%) marked at least one of the nine preset response categories.

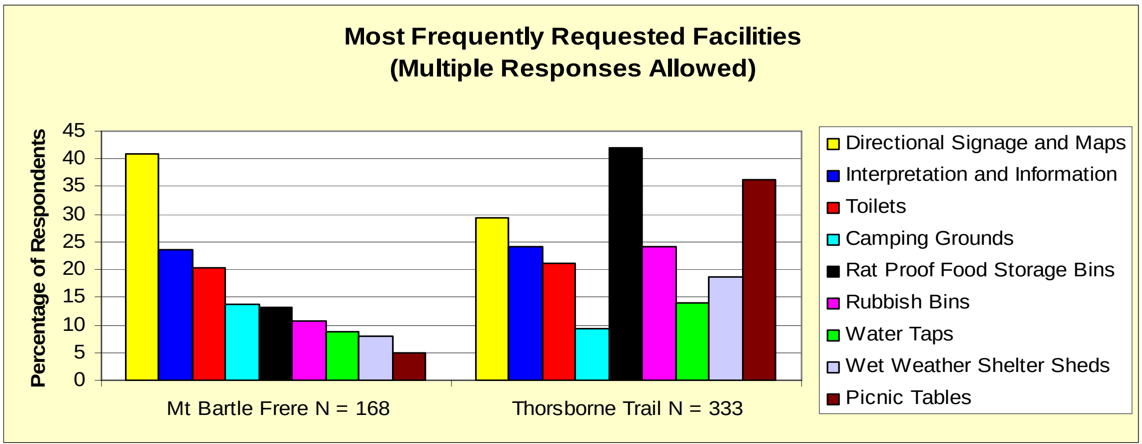

Figure 6.4 Visitor facilities that respondents most frequently indicated that they would like either established or increased along each walking track.

Results suggest that the facilities respondents from the Mt Bartle Frere Track most frequently requested were directional signage and maps (40.9%), interpretation and information (23.6%), and toilets (20.4%). Thorsborne Trail respondents most frequently requested rat proof food storage bins (41.9%), picnic tables (36.1%), and directional signage and maps (29.3%). Mt Bartle Frere Track respondents were more supportive of facilities related to visitor education and wayfinding, whilst Thorsborne Trail respondents were more supportive of facilities to enhance visitor amenity. Comparative statistics confirmed the existence of significant differences between the two walking tracks for five of the nine predetermined response categories (Table 6.13).

Table 6.13 Statistical comparisons of visitor facilities that respondents most frequently indicated that they would like either established or increased along each walking track.

Type of facilities	**Chi Square x^2**	**d.f.**	**Significance (P values)**
Directional signage and maps *	8.661	1	0.003
Interpretation and information	0.037	1	0.847
Toilets	0.023	1	0.879
Camping grounds	2.893	1	0.089
Rat proof food storage bins *	54.278	1	< 0.001
Rubbish bins *	16.962	1	< 0.001
Water taps	3.378	1	0.066
Wet weather shelter sheds *	12.985	1	< 0.001
Picnic tables *	75.000	1	< 0.001
* = Significant differences (P < 0.05) exist between the two tracks as indicated by Chi Square tests.			

Respondents from both walking tracks used the open-ended ‘other’ category in Question 20 to identify a range of additional visitor facilities they would like to see established or provided for each track. Responses were categorised into one of five subgroups relating to visitor safety, visitor wayfinding, visitor amenity, visitor education, and a ‘miscellaneous’ category. Facilities associated with wayfinding were the most frequently nominated ‘other’ facilities on both walking tracks (Appendix 11), suggesting that anxiety about becoming lost was a concern for many respondents. Additional facilities that Mt Bartle Frere Track respondents most frequently requested included track distance markers (9) and signage to indicate the location of camping grounds (4). Additional facilities most frequently nominated by Thorsborne Trail respondents included track distance markers (7), a separate south to north brochure and/or map (4), and signage identifying the names of beaches and creeks (3). It should be noted that track distance markers was the most frequently nominated ‘other’ facility that hikers on both walking tracks requested.

6.4.4 Perceptions of current track management

Respondents were asked to rate their perceptions of current track management using a six-point multiple response scale ranging from ‘strongly disagree’ to ‘strongly agree’ (Question 21). The results presented in Table 6.14 suggest that the vast majority of respondents from both locations were generally satisfied with current track management, although mean results suggest that respondents from the Mt Bartle Frere Track (4.53) were less satisfied than were respondents from the Thorsborne Trail (4.83). More than twice as many respondents from the Thorsborne Trail (31.0%) indicated that they ‘strongly agreed’ this track was well managed than was the case for the Mt Bartle Frere Track (14.5%). Statistically significant differences in respondent perceptions of current track management were recorded between the two tracks (Table 6.14).

Table 6.14 Perceptions of current track management.

Question 21. Current track management

The following statement is about **current track management**. Please rate how strongly you agree or disagree with this statement by circling the number that best reflects your level of agreement/disagreement.

1 = Strongly Disagree **3 = Mildly Disagree** **5 = Somewhat Agree**
2 = Somewhat Disagree **4 = Mildly Agree** **6 = Strongly Agree**

Strongly Disagree **Strongly**
Agree

Mt Bartle Frere Track / Thorsborne Trail	*Number of Responses*	*1 %*	*2 %*	*3 %*	*4 %*	*5 %*	*6 %*	*Mean ± Standard Error*
This walking track is well managed *	220	1.4	1.4	8.2	35.5	39.1	14.5	4.53 ± 0.07
	393	2.5	3.3	5.1	18.1	39.9	31.0	4.83 ± 0.06

* = Significant differences ($P < 0.05$) exist between the two tracks as indicated by a Mann Whitney *U* test.

6.4.5 Preferences for future management action

Successful management of long-distance walking tracks requires that managers periodically review the appropriateness of existing track management arrangements and if necessary introduce new initiatives. In Question 24 (a-g) hikers were asked to rate seven possible track management interventions using a six-point multiple response scale ranging from ‘strongly disagree’ to ‘strongly agree’, in order to gauge the level of visitor support. A factor analysis (Appendix 10) was performed on the various management interventions and confirmed that three factors accounted for a majority (64.0%) of the variance. The first factor grouped together five management interventions that related to *visitor management* (restriction of visitor numbers, limitations to group sizes, provision of more Rangers, education of visitors to reduce impacts, and provision of facilities to enable visitors to reduce their environmental impacts). The remaining two factors comprised one item each and were principally concerned with *site management* such as wayfinding (the provision of additional directional maps and signage), and disease control (the establishment of wash down facilities to prevent the spread of soil borne pathogens).

The results presented in Table 6.15 suggest that a majority of respondents from both tracks opposed four of the seven management interventions that they were asked to rate, with the introduction of wash down facilities to prevent the spread of soil borne pathogens receiving a high level of support, followed by the provision of visitor education to reduce impacts, and additional directional maps and signage to improve wayfinding. Mean responses suggest that respondents generally opposed any reduction to existing visitors numbers (Mt Bartle Frere Track 2.17; Thorsborne Trail 2.45), with respondents from the Mt Bartle Frere Track (2.83) also opposed to limiting the number of hikers in each party or group. Despite the fact that a limit of six hikers in each group is already in place on the Thorsborne Trail, over one-fifth (21.3%) of respondents ‘strongly agreed’ management should limit the number of people in each group on this track. It should be noted that the researcher personally witnessed examples of groups of walkers obtaining separate permits for the same dates but congregating into a preplanned larger group once on the Thorsborne Trail. Walkers from both tracks were generally not in favour of management providing more Rangers to enforce park regulations and visitor behaviour (Mt Bartle Frere Track 2.54; Thorsborne Trail 2.98), with 28.0 percent of respondents from the Mt Bartle Frere Track indicating that they 'strongly disagreed' with this suggestion. Statistically significant differences (*) were recorded between the two tracks for four of the possible track management interventions listed in Table 6.15.

Table 6.15 Perceptions of possible future track management interventions.

Question 24 (a-g). Future management of this walking track

The following statements are about the **future management** of this walking track. Please rate how strongly you agree or disagree with each statement by circling the number that best reflects your level of agreement/disagreement.

1 = Strongly Disagree **3 = Mildly Disagree** **5 = Somewhat Agree**
2 = Somewhat Disagree **4 = Mildly Agree** **6 = Strongly Agree**

Strongly Disagree **Strongly Agree**

Mt Bartle Frere Track / Thorsborne Trail	*Number of Responses*	*1 %*	*2 %*	*3 %*	*4 %*	*5 %*	*6 %*	*Mean ± Standard Error*
a) Management should reduce the number of people using this walking track *	215	38.6	22.8	27.0	8.8	1.9	0.9	2.17 ± 0.08
	392	31.1	24.7	20.9	15.8	5.4	2.0	2.45 ± 0.07
b) Management should limit the number of people in each group or party using this walking track *	214	28.0	17.3	15.9	23.4	9.3	6.1	2.83 ± 0.11
	394	16.5	12.9	13.5	18.5	17.3	21.3	3.70 ± 0.09
c) Management should provide more Rangers to enforce park regulations and improve visitor behaviour *	214	28.0	25.2	25.2	14.5	4.2	2.8	2.54 ± 0.09
	393	19.6	23.7	22.4	20.4	5.1	8.9	2.98 ± 0.08
e) Management should do more to educate visitors about how they can reduce their impacts on this environment *	220	5.5	9.5	17.7	27.3	17.7	22.3	4.06 ± 0.10
	391	8.4	13.3	17.9	30.2	16.4	13.8	3.73 ± 0.07
f) Management should provide more facilities along this track so that visitors can reduce their environmental impacts	219	19.2	19.6	22.8	22.4	10.0	5.9	3.00 ± 0.10
	391	16.9	18.2	22.8	22.3	11.3	8.7	3.19 ± 0.08
Composite Scores (a, b, c, e, f) *	Mt Bartle Frere Track Composite Score						2.92 ± 0.07	
	Thorsborne Trail Composite Score						3.21 ± 0.08	
d) Management should provide more directional maps and signage along this track (wayfinding)	219	15.1	16.0	8.7	23.7	15.1	21.5	3.70 ± 0.12
	393	14.8	18.1	17.0	22.1	12.5	15.5	3.45 ± 0.08
g) If management introduced wash down facilities to prevent the spread of soil borne diseases I would use them	216	5.1	5.1	8.3	16.2	23.6	41.7	4.75 ± 0.10
	385	4.7	4.9	9.9	18.7	20.0	41.8	4.69 ± 0.07

* = Significant differences ($P < 0.05$) exist between the two tracks as indicated by Mann Whitney *U* tests.

6.5 SATISFACTION AND OVERALL QUALITY OF EXPERIENCE

Respondents were asked to rate their level of satisfaction with their overall experience and to specifically identify factors that either enhanced or detracted from their enjoyment. Respondents were also asked to indicate whether or not they experienced various fears during their walk and to assess the level of physical difficulty presented by each walking track. Finally, respondents were asked if they would be prepared to undertake their respective hike again and if they would recommend it to others, before being provided with an opportunity to make any concluding remarks about their walk.

6.5.1 Satisfaction

Respondents were asked to reflect upon their overall long-distance walking experience by evaluating a number of statements using a six-point response scale ranging from ‘strongly disagree’ to ‘strongly agree’ (Question 25: a-f). A factor analysis (Appendix 10) was performed on the visitor satisfaction measures and confirmed that two factors accounted for a majority (72.4%) of the variance. The first factor grouped together three measures of satisfaction (Q25: a, b, d) that addressed enjoyment and value for money, while the second factor grouped together two measures of satisfaction (Q25: e, f) that considered a level of disappointment. Measures of satisfaction that were negatively worded were reverse coded to enable comparisons to be made among all items.

The results presented in Table 6.16 indicate that a majority of respondents from both tracks had a high level of satisfaction with their overall experience. While mean composite scores derived from enjoyment/value measures of satisfaction were virtually identical (Mt Bartle Frere 5.56; Thorsborne Trail 5.57), mean composite scores compiled from disappointment measures of satisfaction (Mt Bartle Frere 5.06; Thorsborne Trail 5.19) were significantly different between the two tracks, with Thorsborne Trail respondents being more satisfied with their experiences (Mann Whitney *U* test, $U = 39403.000$; $P = 0.038$). The proportion of respondents who ‘strongly agreed’ they were satisfied with their hiking experience was also substantially higher for the Thorsborne Trail (76.1%) than for the Mt Bartle Frere Track (61.9).

Table 6.16 Respondents' overall experience on each walking track.

Question 25 (a-f). Your overall experience of this walking track

The following statements are about your **overall experience** of this walking track. Please rate how strongly you agree or disagree with each statement by circling the number that best reflects your level of agreement/disagreement.

1 = Strongly Disagree **3 = Mildly Disagree** **5 = Somewhat Agree**
2 = Somewhat Disagree **4 = Mildly Agree** **6 = Strongly Agree**

		Strongly Disagree					Strongly Agree	
Mt Bartle Frere Track / Thorsborne Trail	*Number of Responses*	*1 %*	*2 %*	*3 %*	*4 %*	*5 %*	*6 %*	*Mean ± Standard Error*
a) Overall I am satisfied with my experience of this walking track *	226	0.4	0.9	0.9	1.3	34.5	61.9	5.55 ± 0.05
	397	0.3	0.3	0	3.0	20.4	76.1	5.71 ± 0.03
b) Using this walking track has been a special and enjoyable experience *	226	0.4	0	2.7	6.6	26.1	64.2	5.52 ± 0.05
	397	0.3	0.3	0.5	4.0	18.4	76.6	5.69 ± 0.03
d) This walk was well worth the money I spent (camping permits, transport costs, food etc.) *	215	0.5	0.5	2.8	2.8	20.9	72.6	5.61 ± 0.05
	396	1.8	2.5	3.0	10.6	19.7	62.4	5.32 ± 0.06
Composite Scores (a, b, d)	Mt Bartle Frere Track Composite Score						5.56 ± 0.05	
	Thorsborne Trail Composite Score						5.57 ± 0.04	
e) I was (not) disappointed with some aspects of this walk * #	223	0.4	4.9	18.4	12.1	28.7	35.4	4.70 ± 0.09
	396	2.3	4.3	11.1	11.4	27.8	43.2	4.88 ± 0.07
f) This walk (has not) failed to meet my prior expectations #	224	1.3	1.8	2.2	6.3	25.0	63.4	5.42 ± 0.07
	396	0.5	2.3	2.3	6.3	19.2	69.4	5.50 ± 0.05
Composite Scores (e, f) *	Mt Bartle Frere Track Composite Score						5.06 ± 0.08	
	Thorsborne Trail Composite Score						5.19 ± 0.06	

= Responses have been reverse coded and the words 'not' and 'has not' have been added.
* = Significant differences (P < 0.05) exist between the two tracks as indicated by Mann Whitney *U* tests.

The majority of respondents from both locations believed their walk had been a special and enjoyable experience (Table 6.16), although mean responses from the Thorsborne Trail were significantly higher than those from the Mt Bartle Frere Track (Mann Whitney *U* test, *U* = 39057.000; P = 0.001). A majority of respondents from both tracks were satisfied that their hike had been well worth the money they had spent (camping permits, transport costs, food etc.), with mean responses from the Thorsborne Trail significantly lower than those from the Mt Bartle Frere Track (Mann Whitney *U* test, *U* = 37226.500; P = 0.002). This result was most probably a consequence of the higher transport costs associated with the use of commercial ferries to access Hinchinbrook Island which do not apply when accessing the Mt Bartle Frere Track. Respondents from the Mt Bartle Frere Track were more likely to be disappointed with aspects of their hike or believe that their prior expectations had not been met than was the case for Thorsborne Trail respondents.

6.5.2 Predictors of satisfaction

Satisfaction levels were found to vary between genders on both walking tracks. Results from the Mt Bartle Frere Track suggested females (5.73) were significantly more satisfied than males (5.44) with this assessment confirmed by comparative statistics (Mann Whitney U test, U = 4787.500; P = 0.007). Results from the Thorsborne Trail also suggested females were somewhat more satisfied with their overall experience (5.74) than were males (5.69) although differences were not statistically significant in this instance (Mann Whitney U test, U = 18247.500; P = 0.108).

A simultaneous multiple regression analysis was used to investigate the extent of variance in respondent satisfaction (dependent variable) that could be explained for each walking track using a selection of independent variables. The independent variables used in each regression analysis included aspects of respondents' *demographic characteristics*, their *appraisals of the natural, built* and *social environments*, and their *perceptions of current track management*. A number of composite variables were also included in each regression. Fifteen independent variables were common to the analysis on each walking track, but one additional variable (*value for money*) was included in the Thorsborne Trail regression. Since the vast majority of hikers completing the Thorsborne Trail needed to travel to and from Hinchinbrook Island via commercial ferries, it was believed that *value for money* should be included as a potential predictor of satisfaction for this track only, since there are no comparable costs associated with completing the Mt Bartle Frere Track. A number of respondents also specifically identified the cost of the ferries as a factor that had detracted from their enjoyment of the Thorsborne Trail (Section 6.5.3). In addition to continuous data, the analysis also used two dichotomous independent variables (*gender* and *place of residence*). Appendix 12 includes a list of all variables used in the regression analysis for each walking track.

Following the regressions, unstandardised beta coefficients (B), standardised beta coefficients (β), part correlation coefficients (Part F), and significance levels were reported for the top five variables on each walking track, in addition to summary model statistics (Table 6.17). Standardised beta (β) coefficients were used to compare variables since variables are then compared using the same scale (Pallant, 2005). Standardised beta coefficients were ranked from highest to lowest (ignoring negative signs) to determine which variables made the strongest unique contribution to explaining the dependent variable, once the variance explained by other variables in the model was controlled for (Pallant, 2005). When squared, part correlation coefficients provide an indication of the unique contribution that each variable makes to the total R squared value after any shared variance is removed thereby revealing how much R squared would be reduced by if this variable was not included in the model (Pallant, 2005). The R squared value produced by a multiple regression ultimately indicates the proportion of variance in the dependent variable that is explained by the model while the Adjusted R square statistic corrects this value to provide a better estimate of the true population value and is often reported for small population sizes (Pallant, 2005). In this test the significance levels reveal which variables make a statistically significant *unique* contribution to the multiple regression equation (Pallant, 2005).

Table 6.17 Simultaneous multiple regression analyses used to identify predictors of visitor satisfaction (dependent variable) for each walking track.

Model Summary - Mt Bartle Frere Track (N = 226) R = 0.414 R Square = 0.171 or 17.1% (proportion of variance explained by the model) R Square Adjusted = 0.100				
Five Highest Predictors of Satisfaction	**B**	**β**	**Sig.**	**Part F**
Composite natural environment appraisals **	0.076	0.217	0.009	0.182
Education *	0.144	0.171	0.027	0.153
Group or party size	0.027	0.152	0.067	0.127
Gender	0.210	0.139	0.077	0.122
Perceived level of physical fitness	-0.137	-0.131	0.080	-0.121
Model Summary – Thorsborne Trail (N = 397) R = 0.628 R Square = 0.394 or 39.4% (proportion of variance explained by the model) R Square Adjusted = 0.367				
Five Highest Predictors of Satisfaction	**B**	**β**	**Sig.**	**Part F**
Value for money ***	0.164	0.313	0.000	0.287
Composite natural environment appraisals ***	0.089	0.282	0.000	0.232
Adequacy of current track management **	0.074	0.148	0.002	0.129
Extent of physical difficulty experienced **	0.103	0.122	0.005	0.115
Composite experiential-based motivations	0.011	0.081	0.122	0.063
***p < 0.001 ** p < 0.01 * p < 0.05 Dependent variable – Respondent satisfaction				

Multiple regression model summaries suggested that 17.1 percent of variation in respondent satisfaction on the Mt Bartle Frere Track and 39.4 percent of variation in the satisfaction of respondents using the Thorsborne Trail were explained respectively. As neither regression was able to explain a majority of variance in respondent satisfaction for either walking track, caution should be exercised in the interpretation and extrapolation of these results. It is probable that weather conditions would have been another significant influence upon the satisfaction of respondents from both locations, especially on the Mt Bartle Frere Track where a number of respondents utilised open-ended questions to lament the lack of views from the summit due to overcast or rainy weather conditions (Section 6.5.3).

Respondents' *appraisal of the natural environment* was the highest ranked independent variable for the Mt Bartle Frere Track and was the second highest ranked predictor of satisfaction on the Thorsborne Trail being statistically significant on both walking tracks. This result suggests that this variable may have the potential to be used to predict satisfaction on other long-distance walking tracks within the Wet Tropics region and beyond, although the predictive value of this variable would need to be trialed much more extensively before any results could be extrapolated beyond these two tracks, especially in view of concerns expressed above about the low proportion of variance explained by each regression analysis used in this research. *Education* was found to be another significant influence upon the satisfaction levels of respondents using the Mt Bartle Frere Track, with hikers with higher levels of education tending to have higher levels of satisfaction with their experience on this track. *Value for money* was found to be the best predictor of satisfaction among respondents using the Thorsborne Trail, although satisfaction levels were also significantly influenced by their *appraisal of the natural environment*, their perceptions of the *adequacy of current track management*, and the *extent of physical difficulty* they experienced.

It should be noted that all regressed variables summarised in Table 6.17 were positively correlated with satisfaction with the exception of respondents' *perceived levels of physical fitness* on the Mt Bartle Frere Track. A negative correlation suggests that hikers with high levels of physical fitness tend to have lower levels of satisfaction with this walk than do hikers with lower levels of physical fitness. One possible explanation for this negative correlation is that hikers with lower levels of physical fitness may thrive upon the challenge of climbing the highest mountain in Queensland, while respondents with high levels of physical fitness may be disappointed by the lack of challenge and physical difficulty that they experience.

6.5.3 Factors that increased or enhanced enjoyment

Respondents were asked if there had been particular aspects of their experience on each walking track that had increased or enhanced their enjoyment, and to specify what those factors were (Question 26). Over two thirds of respondents from each track (Mt Bartle Frere Track 67.3%; Thorsborne Trail 68.6%) identified particular factors that had increased their enjoyment during their long-distance walk, with multiple responses permitted from each respondent (Appendix 13). To assist with the analysis all responses were initially categorised as being associated with either the biophysical setting (natural and built environments) or the psychosocial setting (social and psychological environments), with responses further subcategorised into one of four environments.

Approximately half of all responses identified *aspects of the natural environment* as having enhanced enjoyment (Mt Bartle Frere Track 50.6%; Thorsborne Trail 50.0%) with remaining responses being reasonably evenly distributed among the built, social and psychological environments associated with each track (Appendix 13). Scenic beauty and landscape diversity was the most frequently cited aspect of the natural environment that had enhanced enjoyment on each track (Appendix 13). Respondents were highly polarised in relation to *aspects of the built environment* that had increased their enjoyment. A number of respondents from the Mt Bartle Frere Track indicated the lack of visitor facilities along the walk had enhanced their enjoyment, whilst the facilities that were provided were identified as having enhanced the enjoyment of other respondents (Appendix 13). The opposite trend occurred on the Thorsborne Trail where the number of respondents who indicated their enjoyment had been enhanced by visitor facilities substantially outnumbered those who believed their enjoyment had been increased by what they perceived to be minimal facilities along the track (Appendix 13). The *aspect of the social environment* that was most frequently cited was the number of people respondents had encountered on each track, while the *aspect of the psychological environment* that was most frequently cited were the activities respondents had participated in during their hike. It should be noted that hikers nominated different activities on each walk with rock climbing most frequently cited by respondents from the Mt Bartle Frere Track whilst swimming was the mostly commonly cited activity among Thorsborne Trail respondents (Appendix 13).

6.5.4 Factors that decreased or detracted from enjoyment

Respondents were asked if there had been particular aspects of their experience on each walking track that had decreased or detracted from their enjoyment, and to specify what these were (Question 27). Approximately half of all respondents from each walking track (Mt Bartle Frere Track 47.3%; Thorsborne Trail 55.4%) identified particular factors that had decreased their enjoyment during their long-distance walk (Appendix 14). Responses were categorised as being associated with either the natural, built, social, or psychological environments.

Factors related to the natural environment (Mt Bartle Frere Track 42.2%; Thorsborne Trail 40.6%) were most frequently cited as having detracted from respondents' enjoyment of either walking track, with the most commonly cited aspects being weather conditions, and biting insects, leeches or rats (Appendix 14). Although only one third of all questionnaires originated from the Mt Bartle Frere Track, the number of respondents who identified aspects of the built environment as having detracted from their enjoyment was higher on the Mt Bartle Frere Track than the Thorsborne Trail. Respondents from the Mt Bartle Frere Track most frequently cited a lack of facilities and/or track route markers as having detracted from their enjoyment (Appendix 14). This result suggests that respondents from the Mt Bartle Frere Track were polarised in relation to the adequacy of the built environment. Aspects of the built environment most commonly cited by Thorsborne Trail respondents were a perceived lack of maintenance of the track and/or facilities, and a perceived lack of facilities and/or track route markers (Appendix 14). Littering by other walkers was the most frequently cited aspect of the social environment on both walking tracks, although a number of respondents from the Mt Bartle Frere Track also nominated the inadequate disposal of human body waste, whilst Thorsborne Trail respondents also cited the number of people they encountered within campgrounds (Appendix 14). The aspect of the psychophysiological environment that was most commonly cited on the Mt Bartle Frere Track was the physical pain, discomfort, exhaustion and injuries that hikers endured while completing the walk, while Thorsborne Trail respondents most frequently cited the cost of the ferries (Appendix 14).

6.5.5 Experiences of fear

Respondents were provided with six predetermined response categories identifying possible fear-inducing scenarios and asked to indicate if they had experienced any of these during the course of their walk (Question 28). Results presented in Table 6.18 suggest that respondents from the Mt Bartle Frere Track were slightly less fearful than their Thorsborne Trail counterparts. The three most frequently reported fear-inducing scenarios at both sites were ‘being injured’, ‘being harmed by wildlife’, and ‘becoming lost’. It should be noted that a number of Thorsborne Trail respondents specifically referred to the presence of crocodiles and box jellyfish within estuaries and oceans associated with the trail and specifically raised concerns about the adequacy of track marking when walking the trail from south to north in response to other survey questions. Fear of being harmed by another person or being the victim of vandalism or theft were negligible on both walking tracks, although both fears were more prevalent among hikers who used the Mt Bartle Frere Track (Table 6.18). Statistically significant differences were only recorded between the two tracks for fear of being harmed by wildlife (Chi-square, d.f = 1; x^2 = 17.741; P < 0.001) and fear of vandalism and theft (Chi-square, d.f = 1; x^2 = 5.000; P = 0.025).

Table 6.18 Fear-inducing scenarios reported by respondents from both walking tracks.

Question 28. Which of the following **fears** (if any) did you experience during your walk? (Multiple responses allowed)				
Fear-inducing scenarios	**Mt Bartle Frere Track** N = 226		**Thorsborne Trail** N = 397	
	N	**%**	**N**	**%**
Fear of being injured	59	26.1	122	30.7
Fear of becoming lost	24	10.6	48	12.1
Fear of being harmed by wildlife *	23	10.2	95	23.9
Fear of vandalism and theft *	7	3.1	3	0.8
Fear of being harmed by another person	3	1.3	2	0.5
* = Significant differences (P < 0.05) exist between the two tracks as indicated by Mann Whitney *U* tests.				

Comparisons of fear were also made between males and females using combined data from both locations to determine if there were gender differences in respondents' perceptions of fear. The fears that were most frequently acknowledged by respondents of either gender were fear of being injured (males 26.6%; females 32.3%), fear of being harmed by wildlife (males 14.0%; females 25.6%), and fear of becoming lost (males 10.6%; 12.8%), suggesting that females were consistently more fearful than males. Fear of vandalism and theft, and fear of being harmed by another person were negligible for both genders. Significant differences were recorded between males and females in relation to fear of being harmed by wildlife (Chi-square, d.f = 1; x^2 = 13.263; P < 0.001).

Perceptions of fear were also compared between males and females who had walked alone to determine if being unaccompanied influenced perceptions of fear for either gender. A total of 72 hikers or 11.5 percent of all respondents from both tracks indicated they had walked alone, comprising 61 (84.7%) males and 11 (15.3%) females. Fears that were most commonly reported by solo hikers were a fear of being injured (males 36.1%; females 54.5%), a fear of being harmed by wildlife (males 16.4.0%; females 36.4%) and a fear of becoming lost (males 23.0%; females 27.3%). Fear of vandalism and theft was not reported by any solo hikers, whilst fear of being harmed by another person was only reported by one female. These results suggest that unaccompanied respondents were much more fearful than hikers who walked in the company of at least one other person.

6.5.6 Perceptions of physical difficulty

Hikers were asked to rate the level of physical difficulty they experienced during their walk from a list of six predetermined response options ranging from ‘extremely easy’ to ‘extremely difficult’ (Question 29). Mean results of perceptions of physical difficulty presented in Table 6.19 appear to support the widely held belief that the Mt Bartle Frere Track is the more physically challenging of the two walks. A majority of hikers from both tracks (Mt Bartle Frere Track 52.0%; Thorsborne Trail 68.2%) assessed their walk as ‘somewhat difficult’, with the proportion of respondents who believed their walk had been either ‘very difficult’ or ‘extremely difficult’ almost three times higher on the Mt Bartle Frere Track (43.0%) than on the Thorsborne Trail (14.9%). Respondents’ perception of the level of physical difficulty they experienced was highly correlated with their perceived level of physical fitness (Table 6.2). The extent of correlation was significant on the Thorsborne Trail (Spearman’s Rank Order Correlation -0.106; P = 0.036), but was not statistically significant on the Mt Bartle Frere Track (Spearman’s Rank Order Correlation 0.130; P = 0.054).

Table 6.19 Perceptions of physical difficulty.

Question 29. Physical difficulty

Which of the following best describes the degree of **physical difficulty** associated with this walk?

1 = Extremely Easy **3 = Somewhat Easy** **5 = Very Difficult**
2 = Very Easy **4 = Somewhat Difficult** **6 = Extremely Difficult**

Extremely Easy **Extremely**
Difficult

Mt Bartle Frere Track / Thorsborne Trail	*Number of Responses*	*1 %*	*2 %*	*3 %*	*4 %*	*5 %*	*6 %*	*Mean ± Standard Error*
Extent of physical difficulty associated with completing this walking track * (Mt Bartle Frere Track)	223	0.4	0.4	4.0	52.0	32.7	10.3	4.47 ± 0.53
Extent of physical difficulty associated with completing this walking track * (Thorsborne Trail)	390	0	3.1	13.8	68.2	12.3	2.6	3.97 ± 0.35

* = Significant differences (P < 0.05) exist between the two tracks as indicated by Mann Whitney *U* tests.

6.5.7 Intentions to complete the walk again or recommend to others

Respondents were asked about their willingness to either undertake their respective walk again in the future or to recommend it to others. Results presented in Appendix 15 suggest that the vast majority of respondents from both tracks would be willing to undertake their hike again (Mt Bartle Frere Track 90.1%; Thorsborne Trail 87.3%), or would recommend the track to others (Mt Bartle Frere Track 98.2%; Thorsborne Trail 98.9%). It can be assumed that respondents would not be willing to recommend a walking track to others if they had not had at least a satisfactory experience. Respondents who indicated they were unwilling to either repeat their hike or recommend it to others were asked to provide their reasons. These were subsequently divided into two groups on the basis of whether or not the reasons provided were the result of dissatisfaction with the particular walking track completed or the result of external factors such as logistical constraints (Appendix 15). Respondents who expressed an unwillingness to repeat their respective walks more frequently cited external factors (Mt Bartle Frere Track 56.5%; Thorsborne Trail 67.3%), rather than dissatisfaction with the actual walk. The reasons provided by respondents as to why they were unwilling to recommend their respective walks are also listed in Appendix 15 but provide few insights given the extremely low number of responses received.

6.5.8 Temperature and weather conditions

Respondents were asked to rate both the temperatures (hot, warm or cool) and weather conditions (sunny, overcast or raining) that they experienced during the course of their walk. Whenever multiple responses were received from the same respondent these were recorded as variable conditions (Appendix 16).

6.6 DISCUSSION

6.6.1 Introduction

In a recreational setting such as a long-distance walking track there are a number of environmental and psychological variables which influence the way in which a visitor responds to such a setting both behaviourally and psychologically. In this part of the research the focus was to explore psychological responses using the human-environment transactional model as the overarching *theoretical and analytical framework*. The application of this model allowed for the conceptualisation of what and where interactions occurred and provided an insightful picture of the nature and quality of those interactions. From an applied management perspective these results have immediate implications for both *site* and *visitor management,* and longer term implications for monitoring and evaluating change over time. Such comprehensive baseline data clearly provides the critical first step of any monitoring program. Strategic visitor monitoring in this form has previously been identified as inadequate or non-existent within most Australian protected areas (Gardner, 1994). *Previous research* findings have, where relevant, been presented for comparative purposes. It must be reiterated however that no long-distance walking track results exist for the Wet Tropics region. Of the relevant research that does exist, the vast majority has occurred within the temperate zone.

6.6.2 Key profile characteristics of long-distance walking track users

Rather than revisiting all of the results presented, the emphasis here is on discussing those *key profile characteristics* to emerge from this research which are particularly informative to *site* and *visitor management* and/or are of *theoretical relevance.* This discussion of the results also addresses the third research question outlined below.

RQ3. What is the profile of visitors (with respect to demographics, logistic arrangements, motivations) using selected long-distance walking tracks within the Wet Tropics region?

6.6.2.1 Key demographic characteristics

Place of residence

Place of residence is a key demographic characteristic providing interesting and important information that contributes to the development of an informative profile of hikers, that is, one which is instructive to *visitor management.* While there is a range of possible applications of place of residence information, of particular interest to this research is the implication this has for information dissemination, a common but very important indirect technique for managing visitors. From this perspective, a number of research findings are particularly relevant.

Firstly, the finding that local residents comprise a substantial proportion of visitors who use both tracks (Table 6.2) highlights the importance of identifying appropriate strategies for how and where regulatory, interpretive and management information is conveyed and disseminated within an *ex situ* context. Associated with the geographic proximity of local hikers to the sites is their familiarity with the landscape, physical and climatic conditions of the area, connections with others, and a greater tendency for multiple/repeat visits, all of which provides an important information base for them to draw on. This may well result in such users ignoring critical regulatory and management information either in an *ex situ* or *in situ* context because it is embedded within information designed specifically for the unfamiliar visitor (international, domestic), and/or that management agencies use *ex situ* information dissemination strategies which do not reach the local user.

Contrary to expectations, the Mt Bartle Frere Track had the highest proportion of international tourists, which again has implications for information dissemination because this is a site with minimal *ex situ* or *in situ* regulatory, interpretive and management information. All hikers – local, domestic and international – are therefore dependent on informal sources of information. However, unlike local users, international visitors have limited opportunity to become adequately informed and so would be more reliant on track relevant information provide by management agencies. It was originally anticipated that international tourists would be more prevalent on the Thorsborne Trail which has developed an international reputation as one of Australia's preeminent walking tracks (Roe, 2004), in addition to being located in close proximity to the coastal town of Cardwell, a well established backpacking destination.

One possible explanation for the proportionately higher number of international visitors completing the Mt Bartle Frere Track is that the Thorsborne Trail requires a greater commitment of time, money and resources (camping and cooking equipment), in addition to being dependent upon the availability of camping permits. Consequently, many international visitors who had not made prior arrangements to hike the Thorsborne Trail may have been prohibited from doing so and hence taken up the opportunity to walk elsewhere in the Wet Tropics. Given these findings, there is the need to stress the importance of carefully considering where visitors come from (their place of residence) in order to develop specific, tailored information dissemination strategies that are more likely to be effective in achieving the outcome most desired.

Place of residence findings also highlight the importance for local residents of the immediate landscape as a place for recreational activities, a fact often overlooked by management agencies and the tourism industry. This is particularly evident in the information strategies used by these agencies, which is predominantly designed to capture the ‘outside’ visitor (international, domestic). Not only do local residents live and work within this World Heritage landscape they actively engage with it. This finding is consistent with previous research undertaken at ten popular recreational sites within the Wet Tropics World Heritage Area. Bentrupperbäumer and Reser (2002) reported comparable proportions of local residents (34%) and domestic tourists (38%) to the current study, although the proportion of international tourists (31.3%) was higher than that recorded for long-distance walkers in the current research (21.3%). This finding suggests that international tourists visiting the Wet Tropics region are probably more likely to visit popular day-use sites than undertake a long-distance walk, which could be a reflection of the increased time and resource commitment required for a long-distance walk.

Education

Education has emerged as another key demographic characteristic that provides valuable information about the profile of long-distance walkers. Whilst education data has a number of potential applications for *visitor management*, two research findings are particularly relevant.

The most salient finding to emerge in relation to education is that long-distance walkers tend to be more highly educated than visitors who frequent more accessible day-use recreation sites within the Wet Tropics region. Educational data compiled from visitors surveyed within the Wet Tropics World Heritage Area revealed that 40.9 percent of respondents had completed a university education (Bentrupperbäumer and Reser, 2002), which is 20 percent lower than was recorded for long-distance hikers in the current research (Table 6.2). Although it is not clear why long-distance walkers are more highly educated than other recreational users within the Wet Tropics region, a similar finding was made in New Zealand where backcountry hikers were found to be much more likely to have either a degree or a postgraduate qualification in comparison to members of the wider population (Kearsley *et al*. 1998). Regardless of the reasons for this difference it has potential implications for *visitor management* in terms of interpretation and information provision. For instance, these highly educated long-distance walkers would not only be capable of reading quite detailed and scientifically sophisticated interpretive material but are more likely to be interested in this level of detail. They may also be more likely to obey management regulations because they understand the relationship between their activity and the biological consequences. Managers may need to consider providing more in-depth interpretive messages for this recreational segment in order to maximise indirect *visitor management* opportunities to influence both behaviour and experience.

Another important finding to emerge from the current research was that educational levels reported by long-distance walkers are commensurate with levels reported for long-distance hikers in other locations. For example, surveys conducted with 970 visitors using backcountry trails in New Zealand during 1995-96 revealed that 69 percent had completed a tertiary education with 21 percent of these also possessing a postgraduate qualification (Kearsley *et al*. 1998). Similar results were obtained by

Morin *et al*. (1997) who reported that approximately 70 percent of visitors to Nuyts Wilderness in Western Australia had completed some tertiary education, while Lucas (1990) found that between 60-85 percent of visitors to different wilderness areas in the United States had obtained a tertiary education. This finding suggests that long-distance walking is an activity that universally attracts visitors with high levels of education regardless of the geographical location and provides further confirmation that managers should carefully consider the nature and quality of the information provided.

Extent of previous long-distance walking experience

Level of long-distance walking experience data provided by respondents is of particular interest because it has both theoretical and applied management implications and confirms previous research findings that have been made in other locations. Four aspects of previous experience data are particularly deserving of discussion.

The principal research finding from each study location was that the vast majority of respondents were experienced users of long-distance walking tracks (Table 6.3). This experience data tells us something about the *importance* of this recreational activity to long-distance hikers as they *repeatedly* engage in this activity. The fact that almost a quarter of respondents (22.8%) had completed more than 20 long-distance walks requiring them to stay overnight provides evidence of their commitment to regularly participate in this recreational activity. This experience data also suggests long-distance walking is an activity which provides the challenges and conditions that generate significant personal benefits for those who participate, benefits which are clearly regularly sought after. The fact that almost one-fifth (19.6%) of respondents had completed a walk of longer than eight days in duration indicates that many hikers also make a substantial commitment of time to accommodate their passion for long-distance walking.

The fact that respondents from the Thorsborne Trail were found to be slightly more experienced than their counterparts from the Mt Bartle Frere Track has been attributed to hikers being able to complete the latter walk within one day which appears to have resulted in more ‘first-time’ walkers undertaking this track (Table 6.3). Such information is considered to be particularly relevant from a *site management* perspective. As has been previously suggested (Section 2.5.3.5), experienced walkers are more likely to have the physical and mental preparedness and practical skills to undertake long-distance walks in a competent manner. Consequently, highly experienced walkers are likely to have lower requirements for wayfinding infrastructure (track marking and directional signage) than inexperienced hikers who are undertaking their first long-distance walk. One implication of this finding is that management should seek to avoid a proliferation of track marking and signage to help ensure that wayfinding infrastructure is appropriate to the needs of the *majority* of visitors who are experienced walkers. Nevertheless, the fact that over 15 percent of all respondents were undertaking their first long-distance walk (higher on Mt Bartle Frere) suggests that track marking and directional signage will still need to meet a minimum standard to maintain the safety of all hikers.

The high prevalence of previous experience among respondents from both tracks also has implications from a *visitor management* perspective. Such highly experienced hikers may tend to be more knowledgeable of what constitutes appropriate behaviour during a walk on the basis that they will have had greater opportunity to learn about minimal impact walking and camping techniques during previous hikes. Consequently experienced users may require less 'education' by management in relation to their behaviour within the setting. However, a contrary argument can also be constructed that some experienced walkers may assume that they 'know it all' and feel less constrained in their behaviour than do inexperienced hikers. It is also likely that highly experienced walkers will have higher expectations in relation to the level of detail that is included within interpretive materials provided by management in relation to biological and cultural information. Accordingly, appropriate *visitor management* requires that management consider the level of experience profile of visitors when designing interpretive resources.

The finding that the vast majority of respondents using these two long-distance tracks in the Wet Tropics have high levels of previous experience is consistent with previous research. Recent surveys conducted with hikers using long-distance walking tracks in New Zealand revealed that most are highly experienced with 52 percent indicating they walked at least three times each year, while a further 36 percent walked at least once every year (Kearsley *et al.* 1998), although hikers using both the Heaphy Track

(Cessford, 1997a) and the Tongariro Circuit Track (Cessford, 1997b) were found to be far less experienced. Similarly most backcountry hikers to wilderness areas in the United States have high levels of previous experience (McFarlane *et al*. 1998).

6.6.2.2 Logistic arrangements

Information concerning logistic arrangements made by long-distance walkers has particular relevance to protected area mangers from both *site management* and *visitor management* perspectives. Two components of the findings found to warrant further discussion were sources of information and group size.

Sources of information

A key research finding made in relation to sources of information used was that most respondents relied upon *informal* strategies, in particular word of mouth or previous experience, that is, they were repeat visitors. As a consequence, they may not have had an opportunity to review *formal* information sources until such time as they reached the start of the walking track in the case of the Mt Bartle Frere Track, or either boarded ferries to Hinchinbrook Island or viewed the introductory video at the Cardwell Reef and Rainforest Information Centre in the case of the Thorsborne Trail. While it is deemed compulsory for Thorsborne Trail hikers to view a short minimal impact walking video prior to commencing their hike, the researcher personally encountered a number of survey respondents who had not viewed the video. These findings clearly have implications for *visitor management*, emphasising the importance of providing sufficient *on-site* management, regulatory and interpretive material at both locations given many visitors may not have had previous exposure to such information.

In addition, the fact that most respondents relied upon *informal* information sources, in particular word of mouth, to obtain information about long-distance walking tracks raises questions about the accuracy and adequacy of the information they may have been provided with. In the event that prospective walkers obtained inaccurate or unclear information about the extent of visitor facilities, environmental conditions, safety and regulatory advice at sites this may have implications with respect to their expectations, quality of experience and ultimately safety if they are not sufficiently well prepared.

Furthermore, if hikers have inadequate or inaccurate information about requirements within a protected area they may be more likely to behave inappropriately resulting in biophysical and social impacts. Similarly, if walkers have acquired inaccurate information about protected area regulations they may inadvertently engage in illegal activities such as freshwater fishing, accessing prohibited areas, lighting fires or feeding wildlife.

The findings also align with previous research conducted within the Wet Tropics World Heritage Area, which found that a high proportion of users were either repeat visitors (35.3 %), or had used word of mouth (30.2%) to locate their site (Bentrupperbäumer and Reser, 2002). Since the results obtained in these studies indicate that the majority of visitors using outdoor recreation sites within the Wet Tropics region do not rely upon formal organised information sources (such as visitor information centres, tourist brochures, and the internet), this should have implications for both the level of resources allocated to the provision of these information sources and for the methods used by protected area managers to distribute interpretive and regulatory messages to visitors.

Group size

From an applied management perspective research findings made in relation to group size have implications for both *site management* and *visitor management*. In particular, group size has important consequences for site layout and design (*site management*), quality of experience including, for example, recreational conflict and experiences of fear (*visitor management*), and visitor safety (*site* and *visitor management*).

A key research finding made in relation to group size (Table 6.4) was that groups of two were the most common party size on both long-distance walking tracks. This finding has particular *site management* implications and should be considered during any planned redevelopment of camping grounds associated with both study sites or when planning the layout and design of the built environment associated with other long-distance walking tracks within the Wet Tropics region. An appropriate site layout and design should reflect the fact that long-distance hikers are more likely to be walking in groups of two. Hence, managers should seek to provide a higher proportion of small, discrete camping nodes that are configured for single tents, although the provision of a few larger sites to accommodate medium sized groups (3-6) should be considered if available space permits. Whilst a higher than anticipated proportion of respondents walked in groups of ten or more, groups of this size are generally not appropriate within camping grounds on long-distance walking tracks and therefore no specific attempt should be made to accommodate such larger parties when designing the layout of sites. Rather, an appropriate site layout can actively discourage this inappropriate grouping.

An especially interesting finding made in relation to the size of groups using the Thorsborne Trail was that more than 13 percent of respondents (Table 6.4) indicated that they had walked in a group of seven or more, despite management attempting to limit the size of groups to six (Section 3.4.6). Anecdotal evidence obtained via informal conversations with respondents suggested that some groups of walkers circumvented management restrictions by making separate bookings as multiple small groups and then amalgamated into preplanned larger groups upon arrival at Hinchinbrook Island. This finding has particular relevance for *visitor management* indicating that current strategies are inadequate. Managers need to develop new techniques and strategies to prevent the current practice which would be made easier given they have the support of a majority of respondents who want them to limit the number of people in each group or party (Table 6.15), and given the presence of large groups was identified as an aspect of the social environment that was of concern to respondents (Table 6.10), or detracted from the enjoyment of some experiences (Appendix 14). Possible strategies to prevent the formation of large groups on the Thorsborne Trail might include restricting the number of hikers permitted to commence the walk each day, giving priority to permit applications from small groups (1-3), or giving priority to permit applications from different geographical locations. Although results indicated that large groups also traversed the Mt Bartle Frere Track, respondents were much more likely to complete the walk in one day (Figure 6.3), which reduced the potential for recreational conflict within camping grounds.

Another important finding in relation to group size was that a substantial proportion of all respondents hiked alone (Table 6.4), which has implications for visitor safety, and ultimately *visitor management*. Of particular concern is the fact that almost one in every five respondents from the Mt Bartle Frere Track was unaccompanied. Given the remote and physically challenging nature of this track, and the capacity of weather conditions to rapidly deteriorate on the mountain, this finding has important implications for the management agency responsible for the safety of visitors within the park. In the event that an unaccompanied hiker is either injured or becomes lost, they are more vulnerable than would be the case if they were accompanied by at least one other person. For example, an unaccompanied hiker is likely to face increased time delays before the alarm is raised and assistance arrives. This finding emphasises the need for managers to ensure that route marking is adequate to minimise the risk of solo hikers getting lost and requiring rescue, especially since walkers are not required to provide management with notification that they are using the track unless camping overnight. This result also highlights the necessity for interpretive material and signage to make prospective walkers aware of the potential safety risks associated with walking alone. Individual hikers using the Thorsborne Trail are less of a concern for management as ferry operators fulfill a valuable early warning role by reporting overdue walkers who fail to meet prearranged departures from the island. Nevertheless, management may need to review interpretation in order to encourage individual hikers using the Thorsborne Trail to make other parties they encounter at camping grounds aware of their planned future movements.

6.6.2.3 Motivations: Reasons for undertaking the walks

The findings on visitor motivations to undertake these two long-distance walks provide an interesting perspective on the nature of the human-environment transaction as it occurs in the setting.

Experiential-based motivations in general provided the most important incentive for respondents to undertaken and complete either hike (Table 6.5). The fact that respondents from both tracks rated *experiential-based* reasons (such as the enjoyment of wilderness, opportunities to experience peace and tranquility, obtain solitude etc.) as most important suggests that both *visitor management* (regulation of visitor use and behaviour, signage and interpretation) and *site management* (extent of facilities, site layout and design etc.) need to be compatible with the experiential objectives of the majority of walkers.

An important finding made in relation to this experience-based motivation was that 'enjoyment of wilderness' was rated as the most important reason for hiking for respondents from both tracks (Table 6.5). This finding clearly has implications from a *site management* perspective suggesting that wherever possible managers should seek to retain wilderness attributes on both tracks and avoid the development of inappropriate or excess facilities that are not compatible with this motivation. From a *visitor management* perspective the finding suggests that substantial increases in visitor numbers should be avoided on both tracks to minimise the sense of loss of 'wilderness'. Small groups of hikers will generally be more appropriate if walkers are to continue to have opportunities to enjoy wilderness. Given the emphasis on experience-based motivations, regional protected area managers may wish to consider adopting an *experiential opportunity spectrum* approach to the planning and management of long-distance walking tracks to ensure that potential hikers have access to a spectrum of walking experience opportunities within the region (Bentrupperbäumer and Reser, 2002). Such an approach is similar to a ROS planning framework but would require that both *site management* and *visitor management* are adjusted to the type of experiences long-distance walkers seek.

The results obtained align to a large extent with previous research which found that a high number of day visitors nominated experiential-based reasons (such as the opportunity to experience nature, view natural features and scenery, rest and relax, experience tranquility) as their principal motivations to visit (Bentrupperbäumer and Reser, 2002). These findings suggests that most visitors who access natural area recreation sites within the Wet Tropics region are motivated by a desire to obtain experiential opportunities, regardless of the nature of their principal recreational activity.

The motivations of respondents who used long-distance walking tracks in the current study have a number of similarities with previous research reported by Kearsley *et al*. (1998) following surveys with 970 hikers who used backcountry trails in New Zealand during 1995-96. In the New Zealand study backcountry walkers rated experiential-based motivations (including to see scenic beauty and naturalness, enjoy the outdoors, encounter wilderness) highest, followed by a range of activity-based motivations (such as to face the challenges of nature, undertake physical exercise). As with the current study within the Wet Tropics, New Zealand hikers rated social-based motivations (specifically to meet new people and make friends) as their least important reason for walking (Kearsley *et al*. 1998). These findings appear to suggest that long-distance hikers have predominately similar motivations for walking regardless of their geographical location.

In spite of the emphasis on experience-based reasons, this research has revealed that long-distance walkers have a range of motivations for undertaking such walks (Table 6.5), which has relevance from both a regional protected area management planning perspective and from the perspective of managing individual walking track settings. Results suggest that some hikers using the Mt Bartle Frere Track have regarded the attributes of the Wet Tropics region as largely incidental, or at best an aesthetically pleasing setting in which to obtain physically challenging exercise. Likewise, some Thorsborne Trail respondents appear to have primarily undertaken their walk in order to socialise with family and friends which suggests that some hikers merely regard the trail as an attractive destination in which to socialise.

A particularly interesting finding was the relationship between place of residence and visitor motivations for long-distance walking. International respondents were found to place greater importance upon the nature-based aspects of their long-distance walk, than did Australian residents. This was possibly a consequence of Australian residents, and more particularly local residents, being more familiar with the natural environment within the Wet Tropics region and having less logistical constraints to make repeat visits and thereby enjoy the nature of the region at regular intervals. Conversely, many international respondents may have regarded their hike as a once in a lifetime opportunity to *experience* the Australian natural environment. The fact that social-based motivations were rated more highly by Australian residents, than was the case for international respondents, is illustrative that a number of Australians, and more likely local residents, regard the natural environment along each walk as an appealing setting and the activity itself as an opportunity to conduct their social activities.

The relationship between respondent motivations (Table 6.5) and their level of experience (Table 6.3) was also very informative. This relationship was tested via a *case study* (Appendix 17) that calculated mean values for the highest ranked motivation on each track (*to be in and enjoy wilderness*), according to *level of experience* data. While all respondents, regardless of level of experience, rated this motivation higher, nevertheless the more experienced the hiker the higher their motivation score for ‘enjoy wilderness’. Clearly, the more a hiker is exposed to or participates in this type of recreational activity, the more they appreciate and seek out the ‘wilderness’ encounter.

6.6.3 Visitor appraisal of environments and track management

Respondent appraisal of the natural, social and built environments associated with each walking track, and their evaluation of the management of these environments provides an informative insight into human responses to the environments they encounter. Key findings that are particularly instructive to *site* and *visitor management*, or are of *theoretical relevance* are discussed within the context of the fourth research question.

RQ4. How do visitors perceive the natural, built and social environments associated with the two long-distance walking tracks being examined, and the management of these environments?

6.6.3.1 Natural environment appraisal

Respondent appraisal of the natural environment (both in terms of condition and appeal, and perception of biophysical impacts) represents an essential source of information for better understanding the quality and possible outcome of the human-natural environment encounter.

A particularly important finding was that, in general hikers appraisal of the natural environment encountered during their long-distance walk was highly positive in terms of being *interesting* and *appealing* (Table 6.8). Respondents’ positive appraisal of the natural environment associated with each track is encouraging from a *visitor management* perspective. Such a high level of appraisal would suggest that these aspects of the natural environment have fulfilled hikers’ expectations for a rewarding and positive encounter and is very likely to positively influence other aspects of their hiking experience. Given their prime desire was ‘to be in and enjoy wilderness’ and ‘to see natural features and scenery’ this outcome was highly desirable for the management agencies involved as these positive appraisals of the natural environment were likely to result in positive behavioural responses.

Appraisal of the natural environment was higher among respondents from the Thorsborne Trail than was the case for the Mt Bartle Frere Track (Table 6.8). This finding can be interpreted using the 'landscape preference theory' (Kaplan and Kaplan, 1989) and suggests that respondents from the Thorsborne Trail encountered a higher proportion of natural environments that were to their liking. It should be reiterated that the natural environment associated with the Thorsborne Trail contains far greater natural diversity in terms of vegetation types, topography, and water features than is the case for the Mt Bartle Frere Track (Chapter 3).

Another interesting finding was that most respondents on both walking tracks considered the *current prevalence of biophysical impacts* to be low (Table 6.9). There are two possible explanations for this. One is that many of the impacts were not evident to the untrained eye and even to the trained eye without sophisticated measurement techniques. Secondly, such impacts were in fact quite low when objectively measured. Whatever the reality, hikers perceptions of these impacts is what counts when developing *visitor management* strategies such as identifying and linking visitor behaviour to impact outcomes. For example, it would be advisable for management agencies to closely monitor and if possible reduce the prevalence of impacts that have been identified as being of concern to visitors on each track, regardless of whether they consider these impacts to be problematic. Respondents from the Mt Bartle Frere Track rated soil erosion, feral animals and human vegetation damage as the three most prevalent biophysical impacts, while Thorsborne Trail respondents regarded feral animals, human vegetation damage and human litter as being most prevalent on their track. Soil erosion and feral animals are primarily *site management* issues that may require a range of site specific management interventions, whilst human vegetation damage and human litter are best addressed using *visitor management* strategies such as education and interpretation programs to achieve behaviour change.

Respondent perceptions of the prevalence of biophysical impacts (Table 6.9) provides for some interesting comparisons with other results. Previous research conducted both overseas (for example, Roggenbuck *et al*. 1993; Shafer and Hammitt, 1995; Lynn and

Brown, 2003), and with day-use visitors within the Wet Tropics region (for example, Moscardo, 1997; Bentrupperbäumer and Reser, 2000) has also identified human vegetation damage and human litter as the biophysical impacts that visitors were most concerned about, and suggests that visitors are particularly sensitive to the presence of these two highly visible forms of degradation regardless of the recreational setting. Conversely, although feral animals were considered to be one of the most prevalent impacts on both long-distance walking tracks, they were less of a concern to visitors who used intensively managed day-use sites in the Wet Tropics region (Bentrupperbäumer and Reser, 2002). This is most likely an indication that feral animals are more numerous in remote areas only accessed by long-distance hikers, in comparison to highly accessible day-use sites.

6.6.3.2 Social environment appraisal

Respondent appraisal of the social environment encountered during their hiking experience has important implications for *visitor management* and for understanding the nature and consequences of recreational conflict.

The fact that a majority of respondents from both locations formed positive appraisals of the social environment (Table 6.10) suggests most walkers were satisfied with both the presence and behaviour of other visitors they encountered during their experience. Nevertheless, negative encounters were reported indicating some level of recreational conflict was experienced, particularly from the Thorsborne Trail. Dissatisfaction with the social environment was found to be primarily due to crowded camping grounds and meetings with larger groups. These findings are important from a *visitor management* perspective because they present Thorsborne Trail managers with an opportunity to intervene to modify these aspects of the social environment that are contributing to recreational conflict.

The finding that in excess of one in every six respondents from the Thorsborne Trail believed there were *too many people in the camping grounds* (Table 6.10) suggests hikers were not sufficiently dispersed. Since the location where encounters occur has an important influence upon perceptions of crowding and ultimately satisfaction, this finding suggests that managers need to seek to minimise visitor encounters within camping grounds both through improved site layout and design, and via better regulation of the flow of walkers between available camping grounds. A possible solution may be to only allow visitors to hike the Thorsborne Trail in one direction, which would help avoid unwanted trail encounters with other groups and also reduce the likelihood of walkers congregating within the same camping ground despite walking in opposite directions. An alternative strategy would be for management to provide prospective walkers with information about trail usage levels in order to ensure they have realistic expectations about the probability of sharing camping grounds with other hikers (Roggenbuck, 1992). This finding confirms previous research which has demonstrated that visitors to wilderness areas tend to be more accepting of encounters with groups along trails than within a camping ground, most probably due to the brevity of trail encounters (Roggenbuck *et al*. 1993; Morin *et al*. 1997).

Despite still comprising a relatively low proportion, the fact that approximately one in eight respondents from the Thorsborne Trail indicated that *some groups were too large* (Table 6.10) confirms that some hikers experienced recreational conflict as a consequence of encounters with large groups. Since negative appraisal of the social environment can detract from the overall quality of human-environment transactions this indicates that management needs to consider implementing strategies to enforce the current limit of six members per group. Possible *visitor management* strategies might include establishing a strictly enforced limit on the number of hikers allowed to commence the trail on any one day, numbering camp sites at each camping ground and administering site bookings for particular groups on specified dates, and giving preference to permit applications from parties that are obviously comprised of less than six members, such as couples. The presence of large groups was also a concern to some respondents from the Mt Bartle Frere Track although it is much more difficult to regulate group size at this location since access to the track is more accessible. The results obtained are consistent with previous research which has found that visitors are generally more tolerant of meeting multiple small groups than they are of meeting the same numbers of people in one large group (Tarrant *et al*. 1997), and suggests that wherever possible *in situ* interpretation should encourage hikers to complete both walks in smaller groups.

The fact that twice as many respondents from the Mt Bartle Frere Track as from the Thorsborne Trail ‘strongly agreed’ that some other visitors had not displayed *environmentally responsible behaviour* (Table 6.10) may be a reflection of the reduced management presence along that track in terms of signage and interpretation. This finding suggests there is a need for some additional *visitor management* on the Mt Bartle Frere Track which might include the provision of more *in situ* interpretation and signage at trackheads and at camping grounds to encourage hikers to behave responsibly towards the setting. In particular, hikers from the Mt Bartle Frere Track appear to require better education in relation to the disposal of litter and human body waste. One possible explanation for respondents from the Thorsborne Trail being more likely to exhibit *environmentally responsible behaviour* was that most hikers were required to view an interpretative video before commencing their walk which may have resulted in improved behaviour. This would be consistent with previous research which has demonstrated that the provision of educational information to prospective visitors can generate enhanced behaviour throughout their experience (Mason, 2005).

6.6.3.3 Built environment appraisal

Respondent appraisal of the built environment (both in terms of perception of existing facilities and support for additional facilities) represent important information sources for managers that can assist them to better understand how visitor infrastructure can influence the quality of human-built environment encounters.

The fact that a majority of respondents from both tracks rated the existing built environment as adequate (Table 6.11), and indicated that the provision of additional visitor facilities would not necessarily enhance their enjoyment of each walk (Table 6.12), suggest that the existing built environment is working well and enabling positive encounters with the natural environment. An appropriate built environment should not distract visitors from their primary goal of experiencing the natural environment. Most hikers considered the built domain to have a less significant role in relation to their overall hiking experience than the natural environment, which is consistent with their primary motivations ‘to be in and enjoy wilderness’ and ‘to see natural features and scenery’ (Section 6.6.2.3) and further emphasises the significance of the natural environment as the most important influence upon quality of experiences (Section 6.6.3.1).

Notwithstanding this finding, built environment appraisal has some potential implications for future *site* and *visitor management* on each track. Firstly, findings tend to suggest that current facilities are adequate to satisfy the expectations of most hikers and the provision of additional facilities is not justified from the perspective of management seeking to improve the quality of visitor experiences. Nevertheless, the provision of additional visitor facilities may still be justified in order to achieve other *site management* objectives such as enhancing visitor safety and combating biophysical impacts (Chapter 5). The findings also have some potential repercussions for *visitor management* in that interpretation may need to better describe the extent of the built environment in order to reduce the current level of dissatisfaction that results for a minority of hikers.

A somewhat contradictory finding was that although most respondents indicated that the provision of additional visitor facilities would not necessarily enhance their enjoyment (Table 6.12), a majority still signaled they would support the establishment or an increase in at least one visitor facility (Figure 6.4). These slightly ambiguous results appear to suggest that visitor facilities were sufficient to enable the enjoyment of both long-distance walking tracks for most respondents, although a majority of hikers would still welcome the addition of more facilities if management were to provide these. The fact that respondents from the Mt Bartle Frere Track were more likely to support the establishment of additional facilities to enhance *wayfinding* was most probably related to perceived inadequacies with the current standard of track marking. Conversely, the fact that respondents from the Thorsborne Trail were more likely to support additional facilities to enhance *amenity* appears to confirm earlier suggestions that some respondents primarily undertake this walk in order to socialise in an attractive destination (Section 6.6.3.2).

Although previous research has found that more experienced wilderness users tend to prefer more natural sites with less visitor facilities (McFarlane *et al*. 1998), this has not been borne out in the current study. Level of experience data (Table 6.3) showed that Thorsborne Trail hikers tend to be slightly more experienced than hikers using the Mt

Bartle Frere Track, yet this research found that respondents from the Thorsborne Trail were more supportive of management establishing additional visitor facilities such as rat proof food storage bins and picnic tables (Figure 6.4). One possible explanation for this result is that although the Thorsborne Trail tends to attract more experienced hikers, many are motivated by social-based reasons and would therefore welcome the establishment of facilities that improve their comfort.

As it was anticipated that level of experience (Table 6.3) would substantially influence preferences for additional visitor facilities (Figure 6.4), the relationship between these two variables was tested using a *case study* (Appendix 18) whereby combined *level of experience* data was cross-tabulated with respondent support for additional *directional signage and maps*, which was the item of visitor infrastructure that received the highest overall level of support from respondents. The case study indicated that respondents who were 'extremely experienced' in the use of long-distance walking tracks were much more likely to reject the need for additional directional signage and maps along tracks. A likely explanation for this finding was that more experienced respondents wished to retain the wilderness nature of their experience and comprised a higher proportion of 'purists' (Stankey, 1973). Despite this finding it was interesting to note that 'very experienced' walkers were the segment of hikers most likely to support improved wayfinding infrastructure (Appendix 18). This was somewhat contrary to expectations because it was originally anticipated that hikers with either 'no experience' or 'little experience' would be the segment of respondents who would be most likely to support the establishment of additional directional signage and maps on each track.

6.6.3.4 Track management

Visitor perceptions of track management are important from a human-environment perspective because they provide insights into how hikers view the capability and performance of the management agency responsible for the track in question. In the event that visitors are dissatisfied with track management this may reflect wider dissatisfaction with aspects of the natural, built and social environments encountered within the setting.

Most respondents were found to approve of *current track management* although Thorsborne Trail respondents were significantly more supportive than their counterparts from the Mt Bartle Frere Track (Table 6.14). This finding was most likely related to the Thorsborne Trail having a more visible management presence in terms of visitor facilities, signage, and interpretation along the trail although this concept was not explored in the current research. Despite the fact that a majority of respondents considered current track management to be adequate, many indicated that the management of both tracks could be enhanced through the implementation of a range of additional management interventions. This was an important finding from an applied management perspective because it suggests there is scope for improvement in the way the tracks are currently managed.

Respondents from both tracks were found to support a range of *possible management interventions* (Table 6.15). One particularly important finding was that respondents were strongly supportive of management introducing washdown facilities to prevent the spread of soil borne diseases. They also supported the provision of more education to enable visitors to reduce their biophysical impacts. These findings present managers with an opportunity to introduce new initiatives that will help to prevent additional biophysical impacts associated with each track with little risk of alienating track users. The introduction of washdown facilities is more relevant to the Mt Bartle Frere Track where a soil borne pathogen (*Phytophthora cinnamomi*) that causes tree dieback exists (Gadek and Worboys, 2002).

Another interesting finding was that respondents from both tracks expressed a preference for more *visitor management* (particularly education) rather than more *site management* (facilities) to reduce biophysical impacts. Although respondents were especially supportive of management providing additional education, with the exception of washdown facilities they were not generally in favour of more site infrastructure being established to assist them to reduce their impacts (Table 6.15). One possible explanation for this finding was that many respondents may prefer to retain the ‘wilderness character’ of their experience rather than see the development of a plethora of site facilities. This finding was somewhat contrary to results obtained in Warren National Park in Western Australia where a majority of visitors indicated their support for additional site facilities to assist them to reduce their biophysical impacts (Smith and

Newsome, 2002). Given that respondents from both tracks generally opposed the provision of extra Rangers to enforce regulations and improve visitor behaviour (Table 6.15), many hikers appear to believe these outcomes can be best accomplished using *indirect management strategies*, rather than needing to revert to direct regulation and enforcement.

6.6.4 Satisfaction and overall quality of experience

Visitor satisfaction with recreational experiences conducted within natural protected areas is important to the conservation of those areas. From a human-environment transactional perspective it is important that visitors enjoy positive recreational experiences within protected areas, since the quality of their interactions with the recreation setting can ultimately influence behaviour (Reser and Bentrupperbäumer, 2001). The results obtained have generated a number of findings of relevance to the final research question.

RQ5. How satisfied are visitors with their experience of hiking the two long-distance walking tracks under investigation and what specific factors enhance or detract from the quality of their experience?

6.6.4.1 Satisfaction

The fact that respondents were generally satisfied with their long-distance walking experiences (Table 6.16), and would be willing to complete their respective hikes again and/or recommend them to others (Table 6.19) were positive findings. They are also consistent with the notion of humans deriving physiological and psychological benefits from outdoor recreation experiences (Ulrich, 1979; Wilson, 1984; Reser and Scherl, 1988; Kaplan and Kaplan, 1989).

Interestingly, hikers who used the Thorsborne Trail were generally more satisfied with their overall experiences than was the case on the Mt Bartle Frere Track (Table 6.16). One possible explanation for this finding was that the increased natural diversity associated with the Thorsborne Trail enhanced satisfaction consistent with the landscape preference model (Kaplan and Kaplan, 1989). This interpretation appears to be credible given that Thorsborne Trail hikers encounter a much greater diversity of ecosystem types including both marine and terrestrial environments, and walk varied topography with a greater abundance of freshwater features (Chapter 3). The Mt Bartle Frere Track is also predominantly comprised of a vegetation type and structure (rainforest with a dense understorey) that humans have a low preference for (Kaplan and Kaplan, 1989).

The research findings obtained were consistent with previous research that has demonstrated that the natural environment is an important influence upon satisfaction in outdoor recreation settings. The ‘condition and appeal of the natural environment’ was the single best predictor of visitor satisfaction among hikers using the Mt Bartle Frere Track, and the second best predictor on the Thorsborne Trail (Table 6.17). Previous research conducted with visitors to day-use sites in the Wet Tropics made similar findings with ‘positive symbolic associations with the natural environment’ (Lines, 1999), and the ‘perceived attractiveness of the natural environment’ (Bentrupperbäumer and Reser, 2000) being significant predictors of satisfaction levels. Research conducted with visitors to three provincial parks within Ontario, Canada also established that satisfaction was closely correlated with perceptions of wilderness quality (Sop Shin and Jaakson, 1997), and effectively demonstrates that the importance of the natural environment as an influence upon satisfaction is not confined to the Wet Tropics region. These comparisons further suggest that visitor satisfaction with natural protected areas is inherently linked to appraisal of the natural environment regardless of the geographical location, duration of visit, and nature of recreational activity.

The finding that ‘value for money’ was lowest among Thorsborne Trail respondents (Table 6.16) was not surprising since hikers using the trail need to pay substantially higher travel costs in order to access the start of their walk. Given that a number of respondents from the Thorsborne Trail indicated the cost of the ferries had detracted from their enjoyment (Appendix 14), it is likely that ferry prices were a critical influence upon their perceptions of value for money. Another factor that may have contributed to this finding was that most respondents from the Mt Bartle Frere Track completed their walk within one day (Figure 6.3), and consequently did not incur camping permit fees.

6.6.4.2 Factors that enhanced or detracted from enjoyment

Factors that were found to either enhance (Appendix 13) or detract (Appendix 14) from enjoyment among long-distance walkers have many similarities with previous research findings reported for visitors to day-use areas in the Wet Tropics World Heritage Area. Bentrupperbäumer and Reser (2000) found that natural environment attributes such as ‘natural beauty’, ‘views’, ‘rainforest flora’, ‘water’, and ‘wildlife’ tended to enhance enjoyment, along with activities like ‘swimming’ and ‘walking’. Factors that were likely to detract from enjoyment of day-use sites were ‘too many people’, ‘the wildlife (for example leeches and mosquitoes)’, ‘the weather’, and ‘litter’ (Bentrupperbäumer and Reser, 2000). These results suggest a high degree of commonality exists among factors that either enhance or detract from the quality of recreation experiences within the Wet Tropics region, regardless of the recreation setting and type of activity.

A number of factors that were identified as detracting from enjoyment (Appendix 14) could be addressed via various *site management* interventions, although some other aspects are clearly beyond the capacity of managers to remedy (for example, weather conditions and biting insects). A number of concerns that detracted from enjoyment could be remedied by managers via site specific works to combat soil erosion, improved maintenance of site infrastructure, the establishment of additional track route markers and signage, and control programs for feral animals and weeds. Respondents from both tracks also made a number of site specific suggestions concerning the provision of additional visitor facilities and information (Appendix 11) that would address some of the factors that detracted from their enjoyment.

A number of other factors that were identified by respondents as having detracted from their experiences (Appendix 14) are best addressed using *visitor management* strategies. For instance, a number of Thorsborne Trail respondents raised concerns about the presence of burnt vegetation which has resulted from management conducting prescribed burns, and a perceived lack of freshwater during the dry season. Both of these concerns could be at least partly addressed through the provision of additional information to prospective hikers prior to the commencement of their walk. A number of respondents also cited various aspects of the social environment as having detracted from their enjoyment including the number of other people encountered in camping grounds, the size of some groups, and the inappropriate behaviour of some visitors, in particular littering and the inadequate disposal of human body waste. As has previously been discussed in some detail (Section 6.6.3.2), many of these concerns require particular *visitor management* strategies to combat such as improving the flow of hikers between available camping grounds, limiting the size of groups, and providing better education.

6.6.4.3 Experiences of fear

A number of findings were made in relation to differences in the perception of fear between tracks, between accompanied and unaccompanied hikers, and between genders that warrant discussion given that fear can function as a behavioural constraint.

Despite the fact that Thorsborne Trail respondents were found to be consistently more fearful than hikers who used the Mt Bartle Frere Track (Table 6.18), overall satisfaction levels were still higher on the Thorsborne Trail (Table 6.16). Although fear is typically considered to be a negative emotion that can detract from the overall quality of visitor experiences (Henderson and Bialeschki, 1993), this has not been borne out in the current study. Rather, this finding suggests that whilst Thorsborne Trail respondents were more likely to experience fear this did not overly diminish the quality of their experiences.

It was shown that unaccompanied hikers were generally more fearful than hikers who walked in the company of at least one other person (Section 6.5.4). A likely explanation for the increased prevalence of fear among unaccompanied walkers was that they were fully aware of the increased vulnerability associated with hiking on their own. This finding has some potential *visitor management* implications because it suggests managers may need to invest additional effort and resources to discourage visitors from walking alone and ensure that interpretation accurately documents potential risks to visitors so that they commence their hikes fully informed.

Fear of being harmed by another person was the least commonly reported fear for respondents from both locations (Table 6.18) regardless of whether they were accompanied or walking alone. This finding suggests that most hikers using long-distance walking tracks in the Wet Tropics region are not at all fearful of encounters with other hikers. This discovery was contrary to findings made during previous research conducted with solo hikers to wilderness areas in the United States where the most commonly reported fear for both males and females was a fear of being harmed by another person, specifically a male (Coble *et al*. 2003).

Female long-distance walkers were found to be consistently more fearful than males, regardless of whether they were accompanied by another person or walking alone (Section 6.5.5). This finding was anticipated because long-distance hikers often have to traverse extremely remote locations, potentially exposing them to harmful situations. One likely explanation is that females were more likely to have been socialised to be wary of placing themselves in risky locations (Henderson and Bialeschki, 1993), and therefore may have been acutely aware of their vulnerability. Nevertheless, despite the fact that females were more likely to have experienced fear than males, this does not appear to have adversely impacted upon their enjoyment, as females were found to be more satisfied than males with their overall quality of experience (Section 6.5.1).

The fact that many respondents from both locations indicated they had experienced various fears can be viewed either positively or negatively from a *visitor management* perspective. On the one hand managers may be pleased to learn that many respondents were fully aware of the potential for them to be *harmed by wildlife* (crocodiles, snakes, marine stingers etc.), as this may have translated into more cautious behaviour. Similarly, the fact that many respondents feared *being injured* or *getting lost* during their walk may also be viewed positively by management as this may result in hikers taking fewer risks, thereby reducing the chance that they require rescue or assistance. On the other hand managers may be concerned about the reasonably high prevalence of fear reported by respondents as this suggests that some hikers may have been unduly fearful to an extent where they could not relax and fully enjoy their experience.

6.6.4.4 Perceptions of physical difficulty

It was not surprising that perceptions of physical difficulty were significantly higher among respondents from the Mt Bartle Frere Track (Table 6.19) given the steep terrain that exists along both routes to the summit. Since previous research has demonstrated that visitors who perceive a recreational activity as being too strenuous or providing an excessive level of physical difficulty can have lower levels of enjoyment and ultimately reduced satisfaction levels (Talbot and Kaplan, 1986), the increased perceptions of physical difficulty reported by hikers from the Mt Bartle Frere Track may have contributed to the lower satisfaction scores at this location (Table 6.16).

Perceptions of physical difficulty (Table 6.19) do not appear to have been related to variable levels of physical fitness since perceived levels of physical fitness were not significantly different between the two tracks (Section 6.3.5). Nevertheless, it was possible that variations in perceptions of physical difficulty were influenced by levels of previous experience in the use of long-distance walking tracks. The fact that a higher proportion of respondents from the Mt Bartle Frere Track had either ‘no experience’ or ‘little experience’ at long-distance walking (Table 6.3) may have meant they were less mentally and physically prepared to undertake an extended walk, thereby heightening their perceptions of physical difficulty. This finding has potential implications from a *visitor management* perspective and emphasises that interpretation and signage need to provide prospective hikers with accurate information about the topography and level of physical difficulty they will encounter so they form realistic prior expectations.

6.7 SUMMARY

This chapter has reported the results of a survey that assessed the psychosocial experiences of 623 hikers using two long-distance walking tracks within the Wet Tropics region. Results have enabled the development of a profile for long-distance walking track users and suggest that hikers were more likely to be highly educated Australian males, who regarded themselves as having a reasonable level of physical fitness and substantial experience in the use of such tracks. Word of mouth was the most frequently cited information source used by hikers to locate their walk, although a relatively high proportion of respondents were repeat visitors. A majority of respondents cited experiential-based motivations for walking, although activity-based reasons also rated strongly.

Most respondents formed largely positive appraisals of the natural, built and social environments they encountered and were generally satisfied with current management arrangements on each track. Respondents from both locations believed that the condition of the natural environment was good, although soil erosion, vegetation damage and feral animals were the biophysical impacts of most concern. A majority of respondents from both tracks indicated that the provision of additional visitor facilities would not enhance their overall enjoyment but most also indicated at least one aspect of the built environment that they would like to see improved or increased. Respondents from the Thorsborne Trail were more likely to be concerned about aspects of the social environment than their counterparts from the Mt Bartle Frere Track, in particular the number of people encountered within camping grounds.

A majority of respondents from both tracks were found to have a high level of satisfaction with their overall experience and most would be willing to undertake their walk again or recommend it to others. Aspects of the natural environment were most frequently nominated as having either enhanced or detracted from overall satisfaction levels. Respondents perceived the Mt Bartle Frere Track to have a higher degree of physical difficulty than was the case for the Thorsborne Trail.

The results presented in this chapter provide protected area management agencies with an opportunity to review the adequacy of current track management, whilst also providing valuable baseline data suitable to facilitate longitudinal monitoring of the experiences of track users at regular intervals in the future. Results can be cautiously extrapolated to other long-distance walking tracks within the Wet Tropics region, provided that site specific factors are taken into consideration.

CHAPTER 7 – SYNTHESIS

7.1 INTRODUCTION

Long-distance walking tracks present many challenges for researchers which have undoubtedly contributed to the lack of previous research undertaken within the Wet Tropics region. In particular, these outdoor recreation settings are often geographically remote, extensive in length, and are used by relatively small numbers of visitors. Notwithstanding important ethical issues, behavioural observations of long-distance walkers are inherently difficult due to the linear nature of the tracks, often resulting in researchers needing to interpret visitor behaviour from physical evidence left behind in the setting (for example litter, human vegetation damage, exposed mineral soil etc.).

Despite the challenges presented, it is argued that long-distance walking tracks provide an important research avenue. Long-distance walking provides one of the few ways to experience much of the Wet Tropics World Heritage Area, particularly core wilderness areas. The superlative attributes of the natural environment in combination with the recent opening of additional long-distance walking track infrastructure (refer Chapter 1) also means the Wet Tropics region is well placed to become an internationally renowned destination for long-distance hiking similar to Tasmania and New Zealand. Such a development would potentially generate a range of social and economic benefits for regional communities throughout the Wet Tropics region. However, for this to be sustainable it is critical that long-distance walking tracks be managed appropriately, both from the perspective of mimimising biophysical impacts upon the natural environment and maintaining the quality of hiking experiences. In order for management to be effective, it will need to be adequately informed by sound research.

This research has sought ways to improve our knowledge and understanding of human-environment encounters within a long-distance walking track context through a multidisciplinary approach. It has attempted to obtain insights into visitor activity and behaviour through combined analysis of *biophysical impacts* (which in part represent physical manifestations of visitor behaviour or human behavioural responses to the environment), and *psychosocial experiences* (which provide insights in relation to hikers' psychological responses to the environments encountered). The thesis began with a series of research questions which were subsequently addressed in Chapter 5 (biophysical impacts) and Chapter 6 (psychosocial experiences).

This chapter seeks to provide a synthesis of this dissertation and is presented in three main sections, with six objectives that are discussed in sequential order.

Human-environment transactional model revisited (Section 7.2)

Recognition of the importance of the nature and quality of people-environment encounters led to the adoption of a theoretical and analytical framework aimed at improving understanding of these encounters. The first section of this chapter addresses three objectives that relate to the use of the human-environment transactional model and initially seeks to review the use of the model as a framework for assessing the behaviour and experiences of visitors using long-distance walking tracks. This is followed by a conceptual mapping exercise that explores the contributions various environments or domains appear to make to recreational experiences within different settings. The section concludes with a succinct summary of how this research has confirmed and extended aspects of the human-environment transactional model.

Objective 1 To review the role of a human-environment transactional model as an assessment framework for analysing biophysical impacts and psychosocial experiences of visitors using long-distance walking tracks. (*Section 7.2.1*)

Objective 2 To undertake conceptual mapping to compare the contribution that different domains within human-environment transactional models make to experiences within different outdoor recreation settings. (*Section 7.2.2*)

Objective 3 To clearly articulate the scientific contribution this research has made to the human-environment transactional model. (*Section 7.2.3*)

Resistance and resilience revisited (Section 7.3)

This section revisits the concepts of *resistance* and *resilience* and considers the interaction among setting attributes, visitor use, biophysical impacts, and management intervention within the context of long-distance walking tracks.

Objective 4 To identify key factors that influence resistance and resilience within a long-distance walking track setting. (*Section 7.3.1*)

Applied site and visitor management (Section 7.4)

Due to the applied nature of the research it was felt that this project would be incomplete without an attempt to develop some general principles for the management of long-distance walking tracks within the Wet Tropics region, and site-specific recommendations for both the Mt Bartle Frere Track and the Thorsborne Trail. As a consequence, the third section of the chapter has two objectives which seek to explore those biophysical impact and psychosocial experience findings which are particularly relevant from an applied management perspective.

Objective 5 To identify general principles that may assist future management of long-distance walking tracks within the Wet Tropics region. (*Section 7.4.1*)

Objective 6 To provide evidence-based site-specific management recommendations for the Mt Bartle Frere Track (*Section 7.4.2*) and the Thorsborne Trail (*Section 7.4.3*).

7.2 HUMAN-ENVIRONMENT TRANSACTIONAL MODEL REVISITED

7.2.1 Evaluating the use of human-environment transactional models

As previously noted (Chapter 2), human-environment transactional models consider humans as one component of an environmental transaction (Scherl, 1991), and are characterised by dynamic reciprocity and mutual causation resulting in simultaneous exchanges between the environment and an individual with consequences for both (Bonnes and Secchiaroli, 1995). The human-environment transactional model used in this research (Figure 2.2) was specifically developed by Bentrupperbäumer and Reser (2000, 2002) to explain the reciprocal interactions that take place between visitors and the respective environments or impact domains encountered within outdoor recreation settings. Their model conceptualises visitors interacting with both a biophysical setting (natural and built environments) and a psychosocial setting (social and psychological environments) (Bentrupperbäumer and Reser, 2002). Whilst the model has previously been shown to provide an appropriate methodological and theoretical framework with which to investigate the experiences of visitors using intensively managed day-use areas within the Wet Tropics World Heritage Area (Reser and Bentrupperbäumer, 2005), the current research represents the first attempt to apply the model within a long-distance walking track context which represent vastly different recreation settings.

It has been suggested that the natural resource impacts of most importance to protected area managers ‘are those that signal threatening or negative consequences of impacting events or processes’ and that the identification of these events and processes is where sustainability, biophysical impact assessment, and assessments of the human dimension come together (Reser and Bentrupperbäumer, 2005. p. 237). The fact that these authors are clearly suggesting that the human dimension (visitor experiences, appraisal, and perceptions) should be considered as an integral component of any attempt to achieve sustainable natural resource management indicates an awareness of the contribution this research avenue can make. As a consequence a human-environment transactional approach necessarily entails the simultaneous assessment of biophysical impacts (impact on environment) and psychosocial experiences (impact on people) to enable a more holistic exploration of impact parameters.

Field based measurements of biophysical impacts and visitor perceptions of impacts represent equally valid sources of knowledge within a human-environment transactional approach to protected area management. Given the known linkages that exist between quality of experience and behaviour (Kuss *et al*. 1990), and the fact that perceptions of biophysical impacts are known to detract from satisfaction (Buckley and Pannell, 1990; Farrell and Marion, 2001), it can be argued that visitor perceptions of impacts are what really matters for management as this will ultimately influence visitor behaviour within a setting with potential sustainability implications. Although visitors may not necessarily be accurate barometers of the extent of impact that is occurring at a site (Marion and Lime, 1986; Hillery *et al*. 2001), and may perceive the extent of impacts differently to managers (Martin *et al*. 1989), these concerns should remain subservient to their potential to act as an early warning system for management. Once managers become aware that visitors are concerned about the prevalence of biophysical impacts at a site this should ideally trigger appropriate management intervention. Similar arguments can be made in relation to visitor appraisal of the adequacy of other aspects of *site management* (such as maintenance standards for walking tracks and related facilities, adequacy of track marking etc.) and *visitor management* (including visitor numbers, group size, the behaviour of other visitors, the extent of compliance with regulations etc.). The human judgments formed by visitors in relation to factors that adversely impact upon quality of experience thus become an integral component of monitoring programs.

The use of human-environment transactional models enables researchers to quickly distinguish between the biophysical and psychosocial settings when investigating the visitor experience. As both the biophysical (natural and built) and social settings simultaneously influence the quality of experiences within a setting, this can cause confusion over the origin of underlying concerns (Reser and Bentrupperbäumer, 2005). This can be exacerbated by the fact that some environmental impact assessment practitioners perceive social and psychological impact assessments to be ‘messy, unmeasurable, and reasonably trivial’ (Reser and Bentrupperbäumer, 2005. p. 243).

Fortunately, the strategic design of research utilising the theoretical framework provided by a human-environment transactional approach enables the collection of data in relation to visitor appraisal of each of the four domains that exist within the model. This approach has helped to eliminate confusion and ensured that results were able to be attributed to the particular environment to which they rightfully belonged. For instance, if a segment of visitors formed positive appraisals of the biophysical setting but still indicated that they had obtained negative experiences overall, this indicates that they were most probably dissatisfied with aspects of the psychosocial setting.

Advantages of transactional models over traditional visitor planning frameworks

Although traditional frameworks such as the Recreation Opportunity Spectrum (ROS), Limits of Acceptable Change (LAC), and Visitor Impact Management (VIM) approaches have assisted management and monitoring within some protected areas, their overall uptake and implementation in Australia has been reasonably limited for reasons that have been previously discussed (Chapter 2). By way of revision, the failure to implement traditional visitor planning frameworks has typically resulted from a lack of commitment by decision makers, a lack of resources (biophysical and social data, money etc.), confusion about their purpose and applicability, or a lack of agreement among stakeholders about decisions which is often required prior to implementation (Newsome *et al*. 2002).

It can be argued that human-environment transactional models have a number of advantages over traditional visitor planning frameworks that have been borne out in the current research. Traditional planning frameworks have been largely influenced by biophysical and conservation considerations, and have predominantly used techniques drawn from the natural sciences and neglected social science techniques (Reser and Bentrupperbäumer, 2005). In particular, traditional approaches fail to adequately investigate the *nature of encounters* that take place between visitors and the environment within a protected area, which is arguably critical to their management (Reser and Bentrupperbäumer, 2005). In contrast, transactional models provide greater acknowledgement that the ‘environment’ also includes the human dimension, and that ‘impact’ includes impacts upon visitor experiences (Reser and Bentrupperbäumer, 2005).

Transactional models appear to be more ‘visitor centered’ and attribute greater importance to the experiences of visitors than do traditional approaches. In particular, transactional models provide greater scope for use of human judgments about the current condition and welfare of particular recreational settings than do traditional management frameworks such as VIM. Although VIM entails field assessments of social impact indicators and emphasises that interrelationships exist between impacting processes and visitor experiences, it fails to adequately address the actual nature and quality of individual experiences, and the interdependent nature of biophysical and psychosocial impacts (Reser and Bentrupperbäumer, 2005).

The utility of transactional models for long-distance walking track research

The human-environment transactional model used in this research was specifically designed for use within outdoor recreation settings (Bentrupperbäumer and Reser, 2000), although it has previously only been applied to intensively used (and managed) day-use areas. Nevertheless, the model appears to be highly flexible and capable of being adapted to other recreation settings such as long-distance walking tracks with low visitor numbers and minimal management intervention. As a consequence this research has confirmed the merit of conceptualising long-distance walking experiences within a human-environment transactional framework and has also verified that categorising visitor experiences in this manner has merit. Use of the model has both extended knowledge of the nature and quality of human-environment encounters and facilitated more informed recommendations to management.

The simultaneous assessment of biophysical impacts (impact on environment) and psychosocial experiences (impact on people) within the human-environment transactional model enabled a more holistic exploration of the events, processes, and impacting behaviors that occurred within these two recreation settings. For instance, the integration of impact and experience data within the model generated 'cross-sectional snapshots' of visitor encounters that enabled identification of cross-linkages between visitor behaviour and impacts as evidenced by physical traces left within the setting.

An undoubted benefit of utilising this particular transactional model is the fact that it was able to produce findings for researchers and managers that were not easily obtained using other methodologies. In particular, this mode of inquiry has provided specific insights in relation to environmental concerns that were perceived as threats by long-distance hikers. Likewise, the model appears to have illuminated particular concerns held by hikers in relation to various aspects of the social environment that appear to have been oblivious to managers. By conceptualising visitor experiences within the four impact domains this research has been able to pinpoint those that exert the greatest influence upon the overall quality of experience of long-distance walkers.

7.2.2 Conceptual mapping of human-environment transactions

A conceptual mapping exercise was undertaken to demonstrate how human-environment transactions vary within different outdoor recreation settings. In the exercise a generic transactional model was progressively modified to illustrate the changing contribution that the various environments or domains make to the quality of visitor experiences within both intensively managed day-use areas with high numbers of visitors and more extensive long-distance walking tracks with low numbers of visitors and a reduced management presence.

Generic outdoor recreation setting

The generic concept map depicts quality of experience being influenced by the four environments that comprise the basis of the human-environment transactional model used in this research (Figure 7.1). Double-headed arrows have been used to symbolise the reciprocal nature of impacts while the various domains are uniformly sized to symbolise that each environment makes an equal contribution to quality of experience within this hypothetical setting. Although it provides a useful starting point, the generic concept map is undoubtedly misleading due to the divergent and sometimes conflicting motivations that visitors have for accessing different outdoor recreation settings. Concept maps therefore need to be tailored to reflect visitor appraisal of the natural, built, and social environments within the particular recreation settings to which they relate.

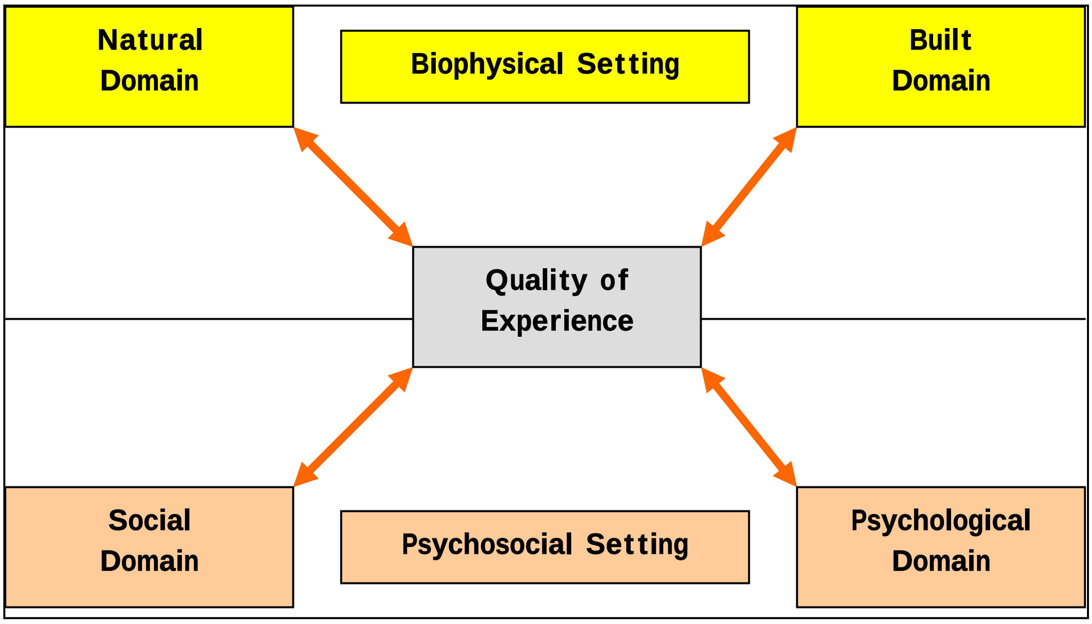

Figure 7.1 Concept map for a generic outdoor recreation setting.

Although aspects of the psychological domain (such as prior expectations, previous experience, motivations) undoubtedly also influence visitor experiences within different recreational settings, it is uncertain to what extent this might vary between long-distance walking tracks and intensively managed day-use areas. As a consequence the relative importance of the psychological domain has been depicted as remaining constant throughout the conceptual mapping progression.

High visitation day-use site

High visitation day-use sites in the Wet Tropics World Heritage Area (for example, popular picnic, swimming, and camping areas) reflect the increased importance of two environmental domains, the social and the built. Equated with high visitation is clearly the potential for considerable social interaction both positive (social engagement), and negative (crowding), and biophysical impact. As a consequence such day-use sites are generally intensively managed through the provision of extensive built infrastructure which provides the physical mechanisms for controlling, directing, and influencing visitor behaviour. Many visitors to such intensively managed day-use sites therefore tend to expect to be provided with (and be able to utilise) a range of facilities including car parks, toilets, barbecues, picnic tables, shelter sheds, signage, and information within the setting, and that the built environment will be designed in a way to minimise social conflict, enhance positive social interaction, and decrease biophysical impact. A conceptual map was developed for such day-use sites as a way of diagrammatically representing the increased importance, and perhaps dominance, of these two environmental domains in such contexts (Figure 7.2). Intensively used day-use sites dramatically alter the social domain encountered by visitors who are forced to interact with high numbers of other users, potentially resulting in recreational conflict.

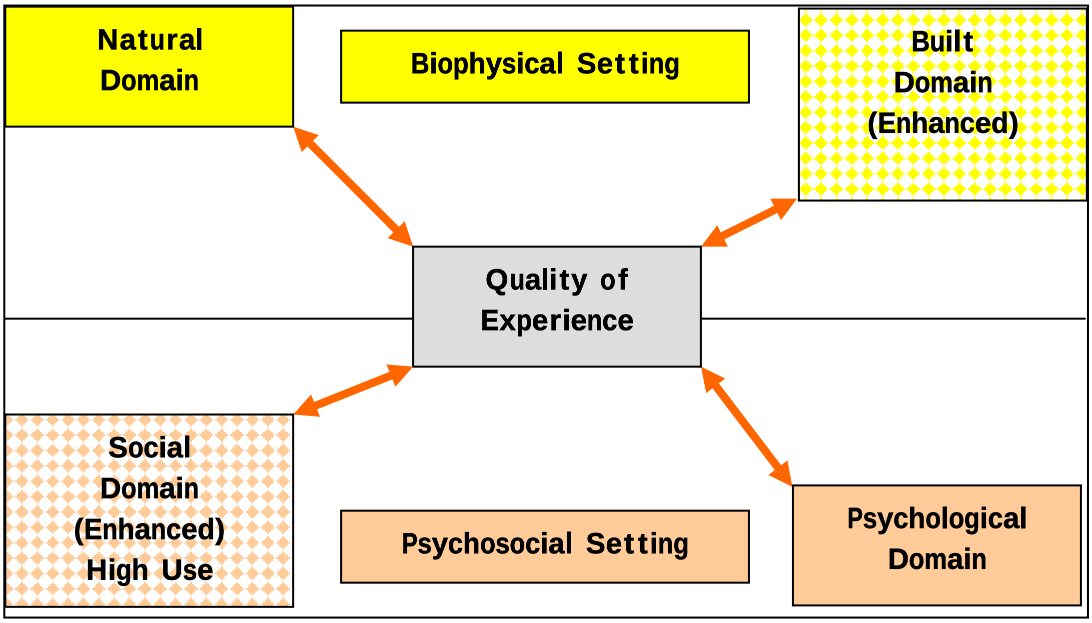

Figure 7.2 Concept map for an intensively managed high visitation day-use area.

On the other hand, the natural domain is presented as unchanged (Figure 7.2), with many visitors in this setting considering it as an aesthetically pleasing backdrop in which to socialise (Valentine and Cassells, 1991; Pearce and Moscardo, 1994). Natural environment attributes such as wilderness, wildlife, and perceived naturalness may become largely incidental to some visitors' experiences at popular swimming holes and picnic areas.

Despite the pre-eminence of the social domain, it is anticipated that visitors to day-use areas will be more accepting of the social conditions they encounter within this setting than encountered on long-distance walks. As day-use area visitors are likely to have an expectation that they will need to share popular destinations with a number of other visitors, it is probable that they will be more tolerant of the presence and behaviour of others at a site unless the number and activities of other users within a setting violates their prior expectations and results in perceptions of crowding. This is not intended to suggest that social conditions are not important influences upon the quality of experience of visitors using day-use sites within the Wet Tropics region as this has previously been demonstrated to be of great importance to visitors (Bentrupperbäumer and Reser, 2002). Rather it is suggested that the social environment is *comparatively less important* to the overall quality of experience within day-use settings in comparison with long-distance walking track settings.

Long-distance walking tracks

In contrast to high visitation day-use settings, long-distance walks provide the opportunity for a solitary (social), wilderness (natural) experience as evident in this research. The relative contribution of the built environment as an influence upon quality of experience was substantially lower among visitors using long-distance walking tracks in comparison with the significance attributed to the natural and social environments. As previously discussed, appraisal of the natural environment was the best predictor of respondent satisfaction on both tracks (Table 6.17). Respondents from both locations also most frequently identified aspects of either the natural or social environments as having increased their enjoyment (Table 6.18) during their long-distance walk. Analysis of the factors that detracted from respondent enjoyment revealed that aspects of the natural environment were again the most frequently cited issues on either track (Table 6.19). The fact that long-distance walkers sought a different type of experience and were provided with (and presumably expected to encounter) considerably fewer visitor facilities and infrastructure than would have been the case within an intensively managed day-use site also suggests that the built environment was somewhat incidental to hikers experiences on either track.

A conceptual map for long-distance walking tracks was developed based upon results obtained in the current study (Figure 7.3). In this concept map the built environment is depicted as being smaller in size than the other three domains to demonstrate the reduced contribution it makes to the experiences of long-distance hikers, while the importance of both the natural and social domains have been enhanced to symbolise their increased weighting.

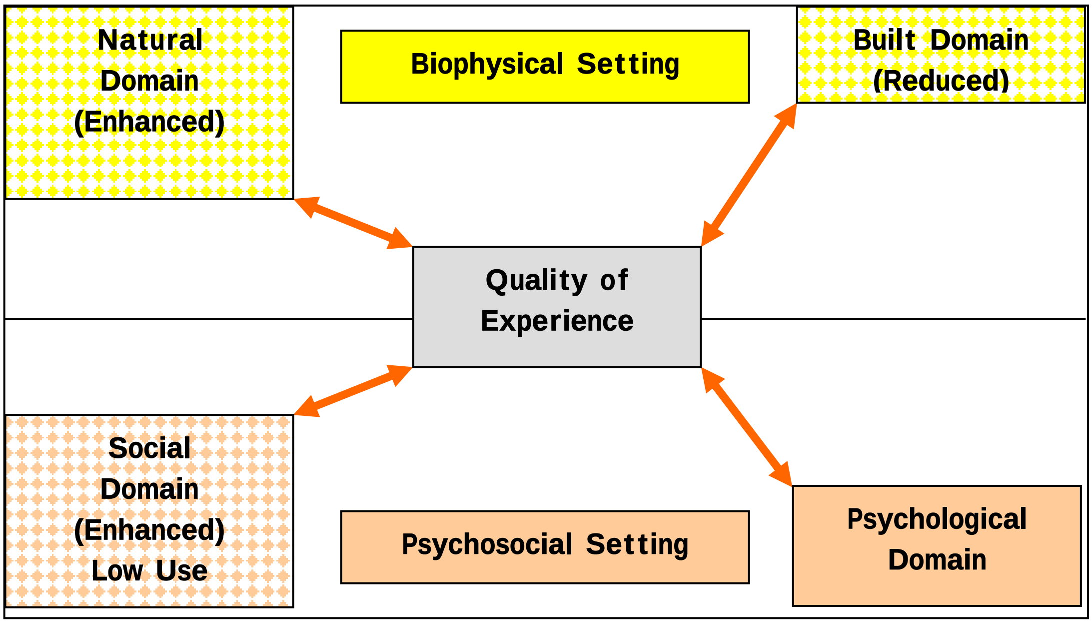

Figure 7.3 Concept map for a long-distance walking track.

7.2.3 Research contribution of and to the human-environment transactional model

As noted previously (Chapter Two), there are a number of key conceptual, theoretical and methodological aspects associated with the human-environment transactional model, all of which make it highly suited to the realization of this research. In turn this research has contributed in a number of ways to our understanding of human-environment transactions in natural settings in general, and in particular within the context of recreational activities such as long-distance walking in world significant natural environments. It must be noted that while the advancement of the human-environment transactional model was not a primary objective of this research, nevertheless it is evident that this research has made some contributions to theoretical and methodological applications. Key aspects that are particularly noteworthy in their contribution as evident in this research include *multidisciplinarity*, *simultaneous assessment*, *multidimensionality*, *reciprocity and interconnectedness*.

Multidisciplinarity

Multidisciplinarity and as such the incorporation of conceptual, theoretical and methodological perspectives from a number of key disciplines in the social and natural sciences were considered fundamental to this human-environment transactional model.

The research contribution of and to the model of this key aspect has been notable for a number of reasons.

1. The disciplines of recreational ecology and natural resource management for example, have provided the important concept of *impact on environment* and the theory of 'resistance and resilience' as a way of exploring and understanding those impacts. The research in turn has validated the use of the theory of 'resistance and resilience' in the assessment of biophysical impacts in the context of long-distance walking tracks. The sustainability of such settings, particularly in tropical regions, depends on the capacity of such environments to both withstand and recover from impacts.
2. Additionally, the disciplines of leisure science, human and behavioural geography, and environmental psychology have provided relevant theoretical and methodological approaches for an assessment of *impacts on people*. Behavioural and experiential analyses of these impacts have been identified in all of these disciplines as being particularly important to understanding human-environment encounters. The research in turn has confirmed the significance of people's experience in such settings and the relevance of theories such as 'landscape preference', 'attention restoration', 'behaviour constraint', for example, as being particularly relevant in understanding those encounters.

Simultaneous Assessment

A key methodological and theoretical aspect of the human-environment transactional model has been the *simultaneous assessment* of the biophysical and psychosocial impacts on the basis that this allows for a more holistic exploration of events, processes, and impacting behaviours. This in turn provides a more meaningful understanding of what is happening in the landscape to both the environment and people and why, at the actual time of the encounter. In the context of long-distance walking tracks, such a simultaneous assessment has contributed to our understanding of human-environment transactions and hence the model in a number of ways. For example:

1. In general, an assessment of the biophysical setting within which encounters occurred has provided for a more meaningful interpretation of human behaviour and experience. In the absence of such a contextual assessment the behaviours and experiences (as self-reported by hikers) have little meaning and prohibit spatial and temporal comparative analyses.

2. More specifically, a focus on elements of the biophysical assessment clarifies particular behaviour/experience/biophysical impact linkages, for example, littering.

Multidimensionality

A third key aspect of the human-environment transactional model is one that emphasises the *multidimensional* nature of such transactions, that is, that people-environment encounters within outdoor recreation settings can be conceptualised as being responsive to four domains (natural, built, social, and psychological). The following research contributions of and to the model were identified in a long-distance walking track setting.

1. The use of the model has advanced the analytic process by clearly identifying a structure in which to conduct the analysis and place results.
2. The framework allows for replication in terms of comparative analysis within different recreation settings such as intensively managed day-use areas and more extensive long-distance walking tracks.
3. The transactional model provides for replication over time (longitudinal studies), which facilitates monitoring and evaluation of changes within a temporal dimension.
4. The research demonstrates that use of a thematic approach to the analysis of impact and experience data within the four domains of the human-environment transactional model provides for the standardisation of methodology.
5. While in this research each of the four domains have been identified as having relevance to understanding both the nature and quality of these transactions, of particular significance is the *natural* domain. In other recreational contexts this may well be very different.

Reciprocity and Interconnectedness

The *reciprocal* nature of the interactions between people and their environment and their *interconnectedness* is also acknowledged as a key aspect of the human-environment transactional model. People impact on the environment which in turn impacts on people. In the outdoor recreational setting an understanding of this is particularly important. This research has verified the interconnectedness of impact parameters when visitors interact with both the biophysical and psychosocial settings at a recreational site. The following examples illustrate how this research has contributed to our understanding of such transactions and hence to the human-environment transactional model.

1. The integration of impact and experience data within the human-environment transactional model can enable cross-linkages to be made between visitor behaviour and visitor impacts, as evidenced by physical traces (manifestations of behaviour) left within the setting. For example, evidence of inappropriate visitor behaviour was recorded on both tracks in the form of human litter and intentional environmental damage.
2. Dissatisfaction with aspects of the social environment, such as perceived crowding within camping grounds, was shown to result in hikers camping in inappropriate areas, thereby extending the biophysical impact ‘footprint’. The interconnectedness of human behaviour/experience/biophysical impact was clearly identified in this instance.
3. Since linkages exist between quality of experience and visitor behaviour, this research has reaffirmed the importance of providing visitors with positive and satisfying encounters with recreational settings in order to reduce the prevalence of biophysical impacts as a result of inappropriate behaviour and thereby promote sustainability.

Practical Applications of the Human-Environment Transactional Model

In addition to the many scientific contributions made via use of the human-environment transactional model, use of the model has also provided a number of practical benefits as follows:

1. Use of a human-environment transactional model enabled findings to be conceptualised in a form that was readily accessible and understandable for management.
2. Results confirm that the reciprocal impacts of the setting (natural, built, and social environments) upon the experiences of recreational users (impact upon people) are just as important for management to understand as the impacts visitors have upon the setting (impact upon environment). This is based upon the premise that these environments are a source of stimulation that can ultimately result in altered behaviour and changed outlooks (Magnusson and Törestad, 1992; Bechtel, 1997).

3. Use of a human-environment transactional approach to protected area management can provide managers with an early warning system and trigger management intervention to address biophysical impacts in response to visitor concerns (as identified by psychosocial experience assessments) well before problems might be revealed using a purely natural science approach (biophysical impact assessments).
4. Findings made in relation to motivations suggest that for many respondents 'experiencing wilderness' was an integral reason for their long-distance walk. Many also perceived the retention of 'wilderness attributes' to be important based upon their attitudes towards any extension of the built environment. Such findings should have immediate relevance to managers of long-distance walking tracks within the Wet Tropics region.

7.3 RESISTANCE AND RESILIENCE REVISITED

The *resistance* and *resilience* of outdoor recreation settings, in particular long-distance walking tracks, is the result of complex interactions that take place among setting attributes, visitor activity, biophysical impacts, and management intervention. As has been previously described (Chapter 2), the resistance and resilience characteristics of recreational settings are in part products of their natural environmental attributes (soil and vegetation type, climate etc.), with tropical rainforest considered to possess low resistance and high resilience (Table 2.4). Nevertheless, different locations within an area of tropical rainforest will posses dissimilar capacity to both resist and recover from visitor impacts.

It is important to note that managers have considerable capacity to influence the resistance and resilience of long-distance walking tracks through their initial selection of a suitable track alignment, layout and design of the setting, and through ongoing management over time. Managers can initially help to promote resistance by locating walking tracks on durable surfaces (such as well drained stable soils and locations with a high prevalence of rocks), or within vegetation types that are more likely to withstand visitor impact (refer Table 2.8). It is also important that layout and design promote site legibility and are congruent with the needs of anticipated visitors so as to discourage inappropriate behaviour such as short-cutting to access facilities. Managers can also encourage site resistance through ensuring appropriate standards of construction including retention of canopy cover, mimimising track widths, and ensuring adequate track drainage.

Managers need to take a long-term perspective when establishing a management regime for a newly developed long-distance walking track to ensure that visitation levels and their associated activities are sustainable and that the natural setting has at least some period of respite to recover from impacts. Since the nature and timing of visitation can influence setting resistance and resilience, it is important that these are considered when planning for an influx of hikers. It is also important that appropriate visitor management strategies are put in place prior to opening a newly constructed long-distance walking track to the public, since later attempts to impose restrictions upon activities, visitor numbers, and group size will be likely to encounter greater opposition. The provision of suitable educational and interpretive resources that promote minimal impact hiking and camping should accompany the development of new walking track infrastructure to reduce impacts from the outset.

Ideally managers need to be able to rapidly respond to biophysical impacts as they arise which requires the establishment of an ongoing monitoring program. Regular monitoring of biophysical impacts can result in the early detection of problems provided that responsive indicators are chosen. Exposed mineral soil, exposed tree roots, organic litter depth, and seedling density were found to be useful indicators of spatial variations in trampling impacts in the current study, whilst track width, exposed mineral soil, and seedling density were the most useful indicators of seasonal variations in trampling impacts. It is also considered important that mangers monitor hikers' psychosocial experiences given the nexus that exists between satisfaction, behaviour, and biophysical impacts. Figure 7.4 presents a schematic summary of key stages and processes that typically occur during the evolution of an outdoor recreation setting which have the potential to impact upon both resistance and resilience.

Time	*Natural setting attributes*	Topography Vegetation type Soil type Rocks Climate Seasonality Canopy cover	***Resistance and resilience***
			
	Management intervention (establishment of recreation setting) 	Suitable location for track Setting layout and design Track construction Provision of facilities Wayfinding Interpretation and signage Initial management regime	
	Recreational use 	Visitor numbers Timing of visitation Visitor activities Visitor satisfaction Visitor behaviour Recreational conflict	
	Biophysical impacts upon natural setting 	Track widening Exposed mineral soil Exposed tree roots Vegetation damage Reduced organic litter Soil erosion / Social trails Human litter / body waste	
	Management intervention (ongoing management and monitoring) 	Site management (e.g. track maintenance) Visitor management (e.g. interpretation) Monitoring (*impacts* and *experiences*)	

Figure 7.4 Influences upon outdoor recreation setting resistance and resilience.

7.4 APPLIED MANAGEMENT IMPLICATIONS

Assessments of *biophysical impacts* and *psychosocial experiences* provide protected area managers with complimentary data sources that can be used to better inform their management. Such information allows managers of recreational settings to protect natural ecosystems while simultaneously providing for their recreational use (Kuss and Graefe, 1985). Simultaneous evaluations of both biophysical impacts and psychosocial experiences provide managers with a cross-sectional summary of impacts and experiences at a given point in time. Both methodologies represent equally valid information sources for management agencies and should form part of an integrated tool kit that mangers can utilise to better manage outdoor recreation settings, and are especially relevant within a long-distance walking track setting.

The results obtained in the current research represent baseline data suitable for the commencement of a longitudinal monitoring program to enable managers to determine if, when, and in what context biophysical impacts and psychosocial experiences change over time. In addition, these results comprise the only systematically recorded impact and experience data collected on long-distance walking tracks within the Wet Tropics region prior to the advent of Cyclone Larry in March 2006. Consequently, the data collected in the current study assumes even greater importance because it provides managers with important baseline information with which to assess the extent of track damage and recovery rates following the cyclone. Optimum use of data collected in this research requires that both managers and visitors are able to function as triggers for management intervention when either biophysical or psychosocial conditions decline below standards that are considered acceptable to either party.

7.4.1 General recommendations for the management of long-distance walking tracks

This biophysical and psychosocial research has implications at a wider geographical scale than the two long-distance walking tracks that were investigated in the current study. The results from this research can be cautiously extrapolated to inform the future management of other long-distance walking tracks within the Wet Tropics region, and possibly beyond. Findings from the current research have enabled the development of a number of general recommendations to guide the future management of other long-distance walking tracks in the Wet Tropics region. Due to the extensive nature of long-distance walking tracks and the types of experiences that are sought within these recreation settings, intensive *site management* is not generally feasible due to cost and aesthetic considerations (Turton, 2005; Turton and Stork, 2006). As a consequence these recommendations place greater emphasis upon *visitor management* as the preferred strategy to both reduce impacts and enhance visitor experiences. These evidence-based recommendations are initially summarised in Table 7.1 and are then outlined below in more detail according to the various domains to which they relate.

Table 7.1 General long-distance walking track management priorities.

Natural environment	Built environment	Social environment	Psychological environment	
Seek to maintain visual amenity and landscape integrity along tracks Undertake weed and feral animal control programs Undertake remedial action in relation to soil erosion and human vegetation damage Regularly monitor trampling impacts upon natural attributes	Establish washdown facilities on upland tracks Ensure adequate wayfinding facilities (signage and markers) Minimise track widths and maximise canopy retention during construction Site design should achieve a high degree of 'congruence' between users and the setting	Minimise visitor perceptions of crowding by use of appropriate site layout and design Periodically review the adequacy of site management to ensure it encourages appropriate behaviour and reduces conflict among visitors	Seek to establish a diversity of walking track infrastructure in the region (varied difficulty, terrain, vegetation types, facility provision, visitor numbers) Aim to maintain the 'wilderness character of most long-distance walking tracks as the 'enjoyment of wilderness' is the primary reason many hikers complete them	*Site management*
Introduce wet season closures to both prevent impacts and assist recovery Seek to concentrate visitor activity to minimise the spatial distribution of impacts	Provide interpretation to assist hikers to reduce impacts Provide interpretive resources on-site Ensure interpretive resources are appropriate for walker profile	Impose restrictions upon the size of groups Distribute hikers between available camping grounds on more popular walks to reduce encounters Educate hikers about appropriate behaviour towards others	Adopt an 'Experiential Opportunity Spectrum' approach to interpretation and marketing of walking experiences within the region Monitor the quality of visitor experiences at regular intervals	*Visitor management*

Natural environment

1. Appraisal of the natural environment is the primary influence upon visitor satisfaction on long-distance walking tracks. It is therefore recommended that management seek to maintain the quality of natural environment attributes associated with long-distance walking tracks in terms of visual amenity, apparent naturalness, and landscape integrity.
2. Some biophysical impacts such as track widening and social trails appear to be more prevalent during the annual wet season. It is therefore recommended that management consider introducing wet season closures on long-distance walking

tracks and accompanying access roads. Wet season closures would have additional benefits for upland walking tracks that are susceptible to the spread of soil borne pathogens such as *Phytophthora cinnamomi* and frog chytrid fungus.

3. Visitors were particularly concerned about highly visible biophysical impacts such as litter, soil erosion, human vegetation damage and feral animals. It is therefore recommended that management take action to reduce the prevalence of these impacts via the implementation of remedial action and control programs.
4. Strategies that concentrate long-distance walkers within a defined geographical space such as mimimising the physical dimensions of track widths, camping grounds and lookouts can help to reduce the extent of the natural environment that is ‘sacrificed’ in conjunction with visitors’ activities. It is therefore recommended that management seek to concentrate visitor activity in order to confine the area that is subjected to impacts.
5. It is recommended that wherever possible long-distance walking track widths are kept to a minimum in order to reduce linear barrier effects.
6. It is recommended that canopy connectivity be maintained above long-distance walking tracks to deter the growth of weeds and reduce soil erosion.
7. It is recommended management mmonitor the condition of natural environment attributes (soil, vegetation, water and wildlife) at periodic intervals.

Built environment

1. Visitors were highly supportive of washdown facilities to prevent the spread of soil borne pathogens. It is therefore recommended that management consider establishing washdown facilities on upland walking tracks throughout the region.
2. Visitors were generally highly supportive of site management interventions that enhance wayfinding such as track markers and locational signage. It is therefore recommended that long-distance walking tracks within the region be well marked to help ensure visitor safety.
3. It is recommended that visitors be provided with good quality interpretation and educational resources to assist them to minimise their biophysical and psychosocial impacts upon long-distance walking tracks in the region.
4. A majority of visitors appear to have used informal information sources (word of mouth, were repeat visitors or local residents etc.) to locate long-distance

walking tracks in the region. It is therefore recommended that management primarily provide *on-site* interpretive materials, as many long-distance walkers may not have accessed formal information sources prior to commencing their walks.

5. Visitors using long-distance walking tracks within the region tend to be highly educated, highly experienced and comprise a mix of local residents, domestic and international tourists of varying age and levels of physical fitness. It is therefore recommended that management take the diverse profile of visitors into consideration when developing new interpretive materials.

Social environment

1. Visitors are particularly concerned about large groups on long-distance walking tracks. It is therefore recommended that management impose restrictions upon the size of groups utilising regulated long-distance walking tracks within the region. This may be achieved in conjunction with the development of an experiential opportunity spectrum.
2. Visitors are particularly concerned about the number of other people they encounter in camping grounds on long-distance walking tracks. It is therefore recommended that management consider introducing initiatives to better distribute visitors among available camping grounds on long-distance walking tracks with high levels of visitation. This may require the introduction of campsite allocation systems.

Psychological environment

1. Since visitors have a variety of motivations for undertaking long-distance walks, it is recommended that managers endeavor to provide a spectrum of walking opportunities within the region that encompass different ecosystem types, different levels of physical difficulty, different levels of visitor infrastructure, and walks with different social conditions such as regulated visitor numbers and group sizes etc. This might be best achieved by adopting an ‘Experiential Opportunity Spectrum’ approach to planning and management of long-distance walking tracks.
2. It is recommended that managers be aware that many long-distance hikers possess high levels of previous experience, well defined prior expectations, and

both the psychological and physical preparedness to complete a long-distance walk. This knowledge can be used to inform various aspects of site and visitor management such as the adequacy of wayfinding and interpretation programs.

3. It is recommended that managers introduce integrated monitoring programs on various long-distance walking tracks within the region to assess whether hiker psychosocial experiences change over time.

7.4.2 Site-specific management recommendations for the Mt Bartle Frere Track

The following recommendations are specific to the Mt Bartle Frere Track and are presented according to the four impact domains.

Natural environment

Issue	**Recommendations**
Seasonal closures	1. It is recommended that managers give consideration to introducing wet season closures for this track to reduce the potential for soil erosion, track widening, social trails, and the further spread of soil borne pathogens.
Track maintenance	2. It is recommended that managers consider improving drainage on the section of track between the carpark at the western trackhead and Bobbin Bobbin Falls to combat track widening associated with muddy track sections. 3. It is recommended that managers periodically cut and remove fallen trees from the designated track surface following the end of the wet season to reduce the proliferation of social trails as hikers attempt to detour fallen obstacles. 4. Visitors were concerned about the extent of soil erosion associated with this track. It is therefore recommended that managers investigate the feasibility of stabilising badly eroded sections of track in proximity to the summit.

Issue	Recommendations
Vegetation damage	5. Visitors were concerned about the extent of human vegetation damage along this track. It is therefore recommended that managers attempt to better educate visitors about the importance of keeping to the defined track to prevent damage to shrubs and seedlings, to refrain from carving their names on trees near the summit, and to avoid breaking branches from vegetation.
Weeds	6. It is recommended that managers undertake eradication programs to control the limited infestations of weeds, in particular Lantana (*Lantana camara*) and Giant Bramble (*Rubus alceifolius*) that exist within tableland forest and lowland forest near both ends of the track.
Feral animals	7. Visitors were concerned about the prevalence of feral animals (especially feral pigs) along this track. It is therefore recommended that managers attempt to control populations of feral pigs, particularly within tableland forest at the start of the western route to the summit.

Built environment

Issue	**Recommendations**
Provision of visitor facilities	1. A majority of respondents believed existing facilities were adequate or better than adequate, and that additional facilities would not enhance their enjoyment of this walk. It is recommended that any additional facilities established along this track be carefully designed and for the purposes of either reducing biophysical impacts or enhancing visitor safety. 2. It is recommended that washdown facilities (with accompanying interpretation) be established on this track to help prevent the spread of soil borne pathogens.

3. It is recommended that managers construct a toilet facility in close proximity to the Top Western camping ground to reduce the potential for contamination of the only water supply at this location. In the event that financial resources prohibit the construction of a toilet, managers need to consider establishing signage at this location to encourage visitors to dispose of human body waste appropriately.

Setting layout and design

4. Almost half of all respondents walked in a group of two. It is therefore recommended that any future campground development or expansion provide a high proportion of sites suitable for two person tents.

Wayfinding

5. Since almost one in every five visitors walked this track alone, it is recommended that track directional signage be upgraded to both improve wayfinding and enhance the safety of unaccompanied hikers, particularly on the western route.
6. A number of visitors indicated they would support the installation of kilometre distance markers. Distance markers have already been established on the eastern route to the summit and it is recommended that they also be established on the western route to improve visitor safety.
7. It is recommended that a locational sign be provided at the Northwest Peak to assist visitor orientation.
8. It is recommended that a locational sign be provided at the Top Western camping ground to assist visitor orientation.

Education and interpretation

9. Due to the high prevalence of hikers who relied upon informal information sources to locate this track, it is recommended that interpretive messages be predominately provided on-site at trackheads to maximise uptake of critical information by visitors.

10. Given this high proportion of unaccompanied hikers who walk this track, it is recommended that any future revision of the current track brochure specifically attempt to encourage hikers to walk with at least one other person.
11. It is recommended that managers consider providing a brochure at the respective trackheads to educate visitors about minimal impact camping and hiking techniques.
12. It is recommended that visitors be provided with information about native rats and the need to hang food overnight, particularly at Big Rock camping ground.

Social environment

Issue	Recommendations
Encounters with other hikers in camping grounds	1. Some respondents appear to have had unrealistic expectations about the likelihood of encountering other walkers, both on the track and within camping grounds. It is therefore recommended that interpretive material be progressively updated to inform visitors about annual levels of track use and the likelihood of encounters.
Size of groups encountered	2. Some respondents appear to have had unrealistic expectations about the likelihood of encountering large groups. It is therefore recommended that interpretive material be progressively updated to inform visitors about the possibility that they will encounter large groups.

Psychological environment

Issue	Recommendations
Level of experience	1. The majority of respondents from the Mt Bartle Frere Track were experienced users of long-distance walking tracks. It is therefore recommended that managers be aware that most hikers possess the physical and psychological preparedness to undertake this walk.
Motivations	2. Hikers' motivations for walking this track were primarily experiential-based reasons (to experience wilderness and to see natural features and scenery). It is therefore important that managers endeavour to retain the 'wilderness character' of the walk and avoid developing excessive visitor facilities along the route except as outlined above.

7.4.3 Site-specific management recommendations for the Thorsborne Trail

The following recommendations are specific to the Thorsborne Trail and have been categorised as belonging to each of the four impact domains.

Natural environment

Issue	Recommendations
Seasonal closures	1. It is recommended that managers continue the current practice of wet season closures between February and March to reduce the potential for soil erosion, track widening and social trails. It should be noted that the Thorsborne Trail is currently closed for these two months due to safety concerns related to visitors having to cross flooded creeks, rather than any conscious attempt to reduce biophysical impacts.

Track maintenance	2. The Thorsborne Trail is widely regarded as the pre-eminent long-distance walking track in the Wet Tropics region. It is therefore recommended that more emphasis be placed upon track maintenance in order to reduce the prevalence of biophysical impacts, including fallen trees, low overhanging branches, living vegetation encroaching onto the track, human litter, and soil erosion.
	3. It is recommended that managers periodically cut and remove fallen trees from the designated track surface to reduce the proliferation of social trails resulting from hikers attempting to detour obstacles. There was a high prevalence of social trails in the vicinity of North Zoe Creek which appeared to be a consequence of hikers avoiding fallen trees and in some cases confusion over the location of the track.
Feral animals	4. Visitors were concerned about the prevalence of feral animals (especially feral pigs) along this track. It is therefore recommended that managers continue to attempt to control populations of feral pigs, particularly in proximity to camping grounds at both Zoe Falls and Mulligan Falls.
Vegetation damage	5. Visitors were concerned about the extent of human vegetation damage along this track. It is therefore recommended that managers attempt to better educate visitors about the importance of keeping to the defined track surface to prevent trampling of shrubs and seedlings, and to refrain from breaking branches from vegetation when attempting to obtain freshwater supplies.
Information provision	6. Visitors were concerned about perceived damage to vegetation along this track associated with fires that were deliberately lit by management. It is therefore recommended

	that managers be more proactive at informing visitors about the reasons and importance of controlled burning operations. This might be best achieved via provision of information to the commercial ferry operators servicing the island.
Habituated native wildlife	7. There appears to be a population of habituated native rats at Mulligan Falls camping ground that seek food from campers at that location. It is recommended that hikers be provided with more information about food storage and additional education to encourage them not to feed native rats.

Built environment

Issue	**Recommendations**
Provision of visitor facilities	1. A majority of respondents believed existing facilities were adequate or better than adequate, and that additional facilities would not enhance their enjoyment of this walk. It is therefore recommended that additional facilities be primarily established along this track for the purposes of either reducing biophysical impacts or enhancing visitor safety. 2. It is recommended that the current practice of providing visitor log books within rat proof storage bins at each major camping ground be continued to enhance safety. However, log books need to be replaced at more regular intervals as they were frequently full which reflects poorly on managers. 3. It is recommended that at least one additional rat proof food storage bin be provided at the Mulligan Falls camping ground. Hiker's inability to securely store food within the only available storage bin may be contributing to the 'rat problem' at this location. The lack of rat proof food storage facilities at this location has also resulted in substantial damage to trees within the camping ground as hikers have

	attempted to hang food and packs from branches using fishing line, ropes, wire, nails etc.
Setting layout and design	4. Approximately one-third of respondents walked in a group of two. It is therefore recommended that any future campground development or expansion provide a high proportion of sites suitable for two person tents.
Wayfinding	5. It is recommended that managers review the adequacy of track directional signage for hikers walking the trail in a south to north direction as this has been identified as a concern to many visitors walking the trail in this direction. 6. It is recommended that managers periodically undertake track maintenance in a south to north direction instead of the usual north to south route as this may have masked problems with wayfinding referred to above.
Education and interpretation	7. Although a high proportion of respondents relied upon informal information sources (for example, word of mouth) to locate this track, the current practice of communicating interpretive messages via video (Without a Trace) appears to be reasonably effective. Nevertheless, it is recommended that managers seek to ensure that all prospective hikers view the video as the researcher personally encountered a number of visitors who had not had an opportunity to view it. 8. It is recommended that the 'Prohibited Access Area' sign on the north-eastern bank of Diamantina Creek (the side closest to Zoe Falls) be relocated, reorientated or revised as it is potentially dangerous. A number of respondents specifically nominated this sign as being extremely confusing. 9. It is recommended that interpretive material be progressively updated to inform visitors about annual levels of track use and the likelihood of encounters with other hikers as some

respondents had unrealistic prior expectations.

Social environment

Issue	Recommendations
Visitor numbers	1. Despite the level of latent demand that exists for additional permits to walk the trail, it is recommended that the current limit of 40 visitors on the trail at any one time remain unchanged under current management arrangements. 2. The current limit of 40 visitors on the trail at any one time could be increased slightly if visitors were more evenly distributed between available camping grounds and the potential for trail encounters was also reduced. 3. Visitor numbers could be increased slightly if hikers were better distributed between camping grounds through initiatives like making the trail ‘one directional’ to reduce the potential for on-trail encounters between groups (the direction hikers are permitted to walk could be alternated at three or six monthly intervals to cater for repeat visitors who desire to experience the trail from the opposite direction). 4. Visitor numbers could be increased slightly by the introduction of a campsite booking system allocating hikers to specific campsites within specific camping ground for particular nights.
Encounters with other hikers in camping grounds	5. One in every six respondents was concerned about the number of other visitors encountered in camping grounds. It is therefore recommended that managers seek to better distribute hikers between available camping grounds. This might be achieved by the introduction of a campsite booking system so that hikers are allocated to specific campsites within specific camping ground for particular nights.

6. Concerns about numbers of visitors within camping grounds might be overcome by strictly regulating the number of visitors permitted to commence the walk on any given day.
7. Concerns about numbers of visitors within camping grounds might be overcome by making the trail ‘one directional’ to reduce ‘bottlenecks’ where different groups converge upon camping grounds from different directions.

Size of groups encountered

8. One in every eight respondents was concerned about the size of some groups they encountered on this walk. Anecdotal evidence also suggests that some visitors circumvent the current restrictions upon group size. In particular, some large groups have applied for permits as multiple small groups and then amalgamated into one pre-planned large group upon arrival on Hinchinbrook Island. Concern about the size of groups might be overcome by enforcing a daily limit upon the number of hikers permitted to commence the trail from either end.
9. Concern about the size of groups might be overcome by reviewing the current online permit booking system to better regulate the quota of permits available on any given day.
10. Concern about the size of groups might be overcome by reviewing the current ‘discretionary’ practice of allowing larger groups (such as school groups and clubs) of hikers to walk the trail.

    Concern about the size of groups might be overcome by giving priority to permit applications from smaller groups over larger groups whenever possible.

Psychological environment

Issue	**Recommendations**
Level of experience	1. The majority of respondents from the Thorsborne Trail were experienced users of long-distance walking tracks. It is therefore recommended that managers be aware that most hikers possess the physical and psychological preparedness to undertake this walk.
Motivations	2. Hikers' motivations for walking this track were primarily experiential-based reasons (to experience wilderness and to see natural features and scenery). It is therefore important that managers endeavour to retain the 'wilderness character' of the walk and avoid developing excessive visitor facilities along the route except as outlined above.

7.5 SUMMARY

This research has demonstrated that a human-environment transactional model can be an effective theoretical and analytic framework for investigating the biophysical impacts and psychosocial experiences of hikers using long-distance walking tracks. It has also highlighted the interconnectedness of impact parameters when visitors interact with both the biophysical and psychosocial settings at a recreational site. Concept maps have demonstrated how visitor experiences are influenced by different domains within various recreation settings, whilst influences upon resistance and resilience were considered from a recreational impact perspective. The chapter concluded with general recommendations that, if adopted, will enhance for future management of long-distance walking tracks within the Wet Tropics region and made a series of site-specific recommendations for both the Mt Bartle Frere Track and the Thorsborne Trail.

CHAPTER 8 – CONCLUSIONS

8.1 INTRODUCTION

All use of natural areas by visitors contributes impacts (Liddle, 1997; Hammitt and Cole, 1998; Newsome *et al*. 2002), and all natural environments impact either positively or negatively on visitors (Bentrupperbäumer and Reser, 2000; Reser and Bentrupperbäumer, 2001). The challenge for management therefore becomes how best to minimise the scale and intensity of resultant biophysical impact so as to ensure long-term sustainability of the setting, and how best to maximise the opportunities for visitors to experience the setting in a positive way? Managed appropriately, long-distance walking has the potential to be one of the most sustainable forms of natural area tourism. Long-distance hikers, by the very nature of their activity and mode of travel, are specialists in low impact visitation since they utilise neither vehicles, horses, mountain bikes, nor other modes of transport capable of generating severe impacts over a short period of time. Nevertheless, this research has demonstrated that hiking within natural areas does cause some biophysical impacts. It would therefore appear to be critical that managers have access to appropriate research to better inform *site* and *visitor management* so that long-distance walking tracks are managed in a manner that maximises their long-term sustainability.

As has been previously outlined, long-distance walking tracks located within tropical rainforest environments represent a neglected research avenue (Wet Tropics Management Authority, 2001; Turton, 2005). The current dissertation has sought to help remedy this situation and represents the first systematic attempt to assess *biophysical impacts* and *psychosocial experiences* associated with visitor use of long-distance walking tracks in the Wet Tropics region. This project also comprised one of the first known attempts to conduct *simultaneous* evaluations of impacts and experiences on long-distance walking tracks within Australia.

This concluding chapter is presented is three sections. Initially the chapter summarises the principal findings from the research. These are followed by a summary of the possible limitations of the study. The chapter concludes with recommendations for future research. All sections are presented as numbered points to both enhance clarity and provide readers with the option to easily reference from the respective lists.

8.2 PRINCIPAL RESEARCH FINDINGS

The principal findings from this research are outlined below. These are not listed in order of importance, but rather reflect the structure of the thesis.

Biophysical impacts

1. This research has demonstrated that rapid assessment methodology represents a relatively quick and cost-effective means of adequately assessing biophysical impacts associated with extensive outdoor recreation settings such as long-distance tracks.

2. Whilst biophysical impacts were evident along both long-distance walking tracks investigated, these do not currently threaten ecosystem integrity.

3. Most biophysical impacts were extremely localised and were predominantly confined to the immediate tread zone, with control zones providing the reference point for the identification of (relevant) impacts. Impacts were more prevalent within areas where hikers congregate such as camp grounds, lookouts and swimming holes.

4. Vegetation type and topography were found to be important influences upon the distribution and severity of biophysical impacts along long-distance walking tracks.

5. Minimal seasonal variation in biophysical impacts was recorded on either track, although some results support the introduction of wet season closures to promote recovery and ultimately ecosystem resilience.

Psychosocial experiences

6. Most long-distance walkers were motivated by experiential-based reasons to undertake their hike, in particular ‘to be in and enjoy wilderness’.

7. Appraisal of the natural environment appeared to be the most important influence upon visitor experiences, and was the best predictor of overall satisfaction.

8. The majority of long-distance hikers formed positive appraisals of the natural, built, and social environments they encountered.

9. Although most hikers were generally satisfied with the way tracks are currently being managed, a majority would support the introduction of a range of additional management interventions.

10. Most respondents reported high levels of satisfaction with their hiking experiences, although many identified specific factors that had detracted from their enjoyment.

11. Human-environment transactional models have been shown to represent an appropriate theoretical and analytical framework within which to assess biophysical impacts (impact on environment) and psychosocial experiences (impact on people) associated with long-distance walking tracks.

12. Human-environment interactions associated with long-distance walking tracks have the potential to generate either positive or negative experiences for hikers and reinforce previous findings in relation to impact-behaviour linkages.

13. Effective long-distance walking track management requires the strategic use of a combination of *site* and *visitor management* techniques to both prevent biophysical impacts and enhance the quality of psychosocial experiences.

8.3 LIMITATIONS OF THIS RESEARCH

Possible limitations of the current research are as follows:

Biophysical impact assessments

1. Although results from both locations were presented together throughout the thesis, comparisons of results between the two tracks were not the primary focus. Rather, caution should be exercised when making comparisons of results between the two tracks due to variations in site-specific factors (for example, soil and vegetation types, topography, weather conditions at the time of sampling, site and visitor management) at each location.

2. It was not possible to determine the extent of pre-existing or cumulative impact that already existed from previous years of visitation. Consequently, the results reported in this research included impacts that would have been the result of decades of visitation to both sites.

3. Wet and dry season sampling of biophysical impacts were undertaken within approximately six months of each other which may not fully reflect inter-annual seasonal variations in environmental conditions. It would also have been preferable to replicate both wet and dry season sampling over a period of some years to ensure that results were representative of annual variations in background environmental conditions.

4. Interpretations of results obtained from the Mt Bartle Frere Track were limited by the fact that actual visitor numbers were not known. Whilst the number of visitors who acquired permits to camp was known, the number of hikers who completed the walk within a day was unable to be accurately determined.

5. Some environmental indicators (for example, extent of canopy cover, exposed tree roots) were not sufficiently rigorous to detect seasonal variations due to the short period that elapsed between replicated sampling.

Psychosocial experience assessments

1. The validity of comparisons made between results obtained on each of the two tracks was limited by the varied site-specific factors that existed at each location. Although results were compared and contrasted between the two tracks some caution should be exercised in their interpretation due to variations in site and visitor management including the nature and extent of biophysical impacts, numbers of walkers, and extent of infrastructure and information provision.

2. The research may have benefited from the researcher undertaking site specific inventories of the extent and condition of visitor infrastructure (the built environment) on each track. While data was collected on the condition of both the natural and social environments, no systematic attempt was made to assess the condition of the built environment which would have enabled a more in-depth exploration of the influence of this domain.

3. Notwithstanding ethical constraints, this research may have benefited from some structured behavioural observations of hikers at high-activity nodes such as camp grounds, swimming holes, and lookouts. Such observations could have been used to help understand behavioural responses to the setting. An alternative approach would have been to conduct structured interviews with a cross-sectional sample of hikers to obtain additional insights.

8.4 RECOMMENDATIONS FOR FUTURE RESEARCH

It is recommended that additional research be conducted within the following areas:

1. Additional biophysical impact assessment work is required to investigate ‘cumulative impacts’ associated with long-distance walking track use. Such research would ideally examine the impacts of trampling at different temporal intervals to ascertain resilience.

2. It would be useful to determine if there are attenuation effects upon biophysical impacts associated with distance along long-distance walking tracks. In particular, it would be valuable to know whether impacts are more prevalent within peripheral or core areas associated with tracks.

3. Periodic assessment of psychosocial experiences on both long-distance walking tracks investigated would be insightful because this would enable longitudinal monitoring of experiences against the baseline data presented here.

4. Longitudinal monitoring to assess the impact of Cyclone Larry upon psychosocial experiences on both long-distance walks investigated.

5. Further exploration of the concept of fear within natural recreation areas would be insightful. In particular, it would be interesting to explore the intensity of the fear response in relation to a number of variables including gender, place of residence, level of experience, and group size.

6. The Wet Tropics World Heritage Area clearly has substantial ‘untapped’ potential to become a ‘destination of choice’ for long-distance walkers similar to Tasmania and New Zealand. As a consequence, additional research needs to be undertaken to investigate the feasibility of offering a greater diversity of hiking experiences within the region. This is likely to be assisted by the adoption of an ‘experiential opportunity spectrum’ approach to planning and management of walking tracks.

7. Scope exists to substantially increase use of the Misty Mountains Trails network of long-distance walking tracks within the Wet Tropics World Heritage Area. However, this would appear to require a feasibility study to examine the ecological, economic, and social consequences of substantially improving access arrangements and upgrading visitor facilities. It would be particularly constructive to explore the feasibility of establishing a network of huts for overnight use to reduce biophysical impacts, enhance visitor amenity, and enrich the diversity of long-distance walking experiences available within the region.

"Nature can be inspiring, awesome, tranquil, or calming. People in all walks of life, in sickness and in health, in good times and bad times, find in nature something that comforts and restores?"

(Kaplan and Kaplan, 1989. p. 175)