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Remote Camping along the Ningaloo Coast, Western Australia: Relationship between Management and the Variables of Visitor Preferences, Resource Use and Environmental Impacts

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: ____________________________

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Abstract

The World Heritage listed Ningaloo coast in Western Australia is a remote camping destination and gradual environmental degradation is observable at numerous campsites. The Ningaloo coast is managed by multiple lessees and campsites within this semi-arid region are all vehicle accessible to varying degrees. Research on vehicle-accessible camping sites and their visitors in coastal protected areas is limited while empirical evaluation of management influence is scarce. The lack of baseline and current conditions data has limited management effectiveness, such as setting management priorities and selecting impact management strategies. The thesis addresses this significant research gap by focusing on the influence of management regimes and oversight on visitor preferences, resource use and environmental impacts using an integrated biophysical-social science methodology.

The study area comprises one national park, five pastoral stations, one air weapons range and one local government operated camp area. In total, 734 questionniares and 225 inital impact assessments were undertaken. Data collection procedures were adapted to semi-arid, coastal environments comprising both undesignated and designated remote campsites.

For analysis, camp areas were grouped into four statistically similar clusters, categorised by management oversight, facilities, price and access against which the data are compared. Quantitative on-site questionnaires established visitor demographics, campsite preferences, campsite activities, water and energy consumption levels and waste disposal practices. A quantitative combined survey approach utilising multiple indicator ratings and measures assessed the various environmental impacts at each site. Indices were developed to determine the relationship between regulation and both vegetation loss and overall impact of campsites. Factors which affected the magnitude of environmental these impacts were examined through correlation coefficients. Factors analysed included independent variables (vegetation, substrate, topography) and management variables (campsite distribution and location; site hardening; management presence, access, facilities).

Two levels of camper preferences were identified: those preferred by all campers, for which no significant differences were found and those which varied between clusters. Common preferences, including a desire to be close to the water and a dislike of litter, aligned with previous research. Water and energy consumption differed significantly between clusters although rubbish disposal per person did not.

An analysis of impact indices found that environmental impacts including vegetation loss significantly decreased with increasing regulation, though no clusters were flawless. Factors found to reduce magnitude of impact included management presence, campsite containment, campsite boundaries and vegetation type, whilst the provision and extent of rubbish bins were found to not necessarily reduce the presence of litter. Reducing campsite area spread and the presence of livestock should be areas of management focus in the less regulated locations.

The study provides valuable baseline data and management recommendations on this topic for the vulnerable and World Heritage listed Ningaloo coast. The relationships identified between management variables and impact and use variables contribute significantly to conceptual understanding in recreation ecology and recreation sciences. This study also addresses three major research questions for vehicle-accessed remote campsites within a coastal, semi-arid environment. What factors contribute to the problem? How effective are visitor and site management actions? And; how can research and impact assessment methods be improved?

The integrated methodology, informed by past research in recreation ecology and social science and adapted for the coastal environments, may be evaluated and/or applied by other researchers and managers interested in this field of study.

Publications during Candidature

Lewis. A & Hughes, M. (2011). Ningaloo Coast Remote Campers: a Comparison of Preferred Campsite Attributes and Activities. In Jones, T., *et al* (Eds.) *Ningaloo Collaboration Cluster: Socioeconomics of Tourism*. Hobart, Australia: CSIRO Wealth from Oceans Flagship: pp. 143-63

Hughes, M & Lewis, A. (2011). Assessing the Preferences of Campers along the Ningaloo Coast, Western Australia. In Gross, M. (Ed.) *CAUTHE 2011 National Conference*. Adelaide, South Australia: University of South Australia. School of Management: 1121-1126

Jones, T., Hughes, M., Wood, D., Lewis, A. & Chandler, P. (2009). *Ningaloo Coast region visitor statistics collected for the Ningaloo destination modeling project*, Sustainable Tourism CRC, Gold Coast Queensland

Lewis, A.R. (2008). Sustainable Camping at Ningaloo Reef, Western Australia: Overcoming Methodological Challenges, *MMV4 (Monitoring and Management Visitor Flows in Recreational and Protected Areas)*, Refereed Working Paper, Monticatini Terme, Italy

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List of Abbreviations and Acronyms

CALM[1]	Department of Conservation and Land Management
CRNP	Cape Range National Park
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEC	Department of Environment and Conservation
DoF	Department of Fisheries
DEH	Department of Environment and Heritage
km	Kilometres
L	Litres
m	Meters
NCWHA	Ningaloo Coast World Heritage Area
NROCA	Ningaloo Reef Outback Coastal Association
NMP	Ningaloo Marine Park
NS	Not Significantly different
Regional Strategy	Ningaloo Coast Regional Strategy (WAPC, 2004)
S	Significantly different

[1] The name CALM was changed to DEC when it was combined with the Department of Environment in 2006.

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Figure 1.1. Beach Camping at Fourteen Mile, Warroora[2].

1.1 BACKGROUND

At over 300 km in length, the Ningaloo Reef is the longest fringing reef in Australia (Department of Conservation and Land Management 2005) and the only major coral reef on the Gascoyne coast (Department of Fisheries 2002). It is also the largest continuous reef area in Western Australia (Department of Fisheries 2002) and has recently been World Heritage Listed. Housing a diverse range of marine species, the Ningaloo Marine Park (NMP) extends 260 km along the northwest coast of Western Australia to 40m inland past the high tide mark. It has gained an international reputation for nature-based tourism activities including wildlife

[2] All photographs were taken by the author between 2008 and 2011 unless otherwise indicated

viewing, hiking, boating, fishing, diving and snorkelling (Department of Conservation and Land Management 2005). Ningaloo Reef is 1000 km north of Perth, Western Australia. It's isolation from major population centres has meant that the Ningaloo coast has remained undeveloped with little infrastructure, having been primarily utilised for pastoral purposes over the past century. Multiple management regimes operate along the NMP comprising pastoral stations, local shires, State and Federal Departments. The camping areas along the Ningaloo coast thus differ in relation to access road quality, amenities, price, regulation and management presence.

The majority of the approximately 200,000 tourists to the Gascoyne region annually are international or interstate tourists who use official accommodation and campgrounds in the Regional Centres (Department of Conservation and Land Management 2005; Jones, Ingram et al. 2007). However, undesignated coastal camping developments have been increasing in recent years within the remote NMP. Remote campers, predominantly from Western Australia, select undesignated coastal campsites along 200 km of coastline within the Marine Park. Most remote coastal campers are considered 'repeat' (visited two to five times) or 'continuous' (visited more than six times) campers (Shafer 1969). Remote campers stay an average of between nine and 24 days (Remote Research 2002), though some may stay four months or more (Jones, Ingram et al. 2007). Remote campers are required to bring their own accommodation (caravans, camper trailers and tents), power sources and chemical toilets. Campers also supply their own water, fuel and food but generally replenish their supplies at the nearest town every fortnight or so. Campsites are not always defined, and often consist of nothing more than bare ground and a track to the beach. Depending on the locations, sites by the beach are often sandy and most require a four-wheel drive for access.

Nine different management regimes exist along the Ningaloo coastline, each with different levels of regulation, facilities, management presence, site hardening and access. Different management regimes comprise local, state and federal government agencies in addition to differences between pastoral stations. World Heritage listing does not alter tenure or take away ownership rights or control. Over much of Shark Bay in Northwest Australia, also a World Heritage Site, World

Heritage values can be effectively protected and managed with existing tenure and land use activities. Shark Bay also contains pastoral land, Shire reserves and National Parks. Changes in tenure through lease expiration may facilitate improved protection and management of World Heritage values. However, when tenure changes are considered, economic and social values also need to be taken into account (Department of Conservation and Land Management, 2008).

The least regulated camp areas along the Ningaloo coast are free to camp at for extended periods, have no management presence and are hard to access. The more regulated sites are accessible by a paved road, are highly controlled and have a high management presence. The past few years has seen conflict between stakeholders over the best way to manage this coastline, as further discussed in section 2.5.1. Despite being relatively pristine, the fragile sandy coastline is highly vulnerable to visitor pressures. Impacts from tourism include unrestricted coastal activities such as vehicle access and camping and firewood collection (Department of Conservation and Land Management 2005). These environmental areas are particularly sensitive due to their proximity to and relationship with the marine environment. Many campers along the coast pitch their tents or park their caravans within the boundary of Ningaloo Marine Park. The establishment of indiscriminate tracks to the coast leading to squatter shacks, accommodation at pastoral stations and fishing, diving and camping spots is causing loss of vegetation and subsequent dune destabilisation (Western Australian Planning Commission 2003). This problem is compounded by inappropriate rubbish disposal, unlined, open tips, disposal of waste in the dunes, increased fire risk from fire pits and degradation of native vegetation from firewood collection (Western Australian Planning Commission 2003).

Negative impacts of unregulated camping tourism in the Ningaloo Marine Park can be attributed to incremental growth, the absence of appropriate plans and management (Wood 2003) and increasing visitor numbers. The future of tourism in the Ningaloo Marine Park depends on its sustainability, largely through the maintenance of the natural environment (Wood 2003). Careful planning of future tourist developments and the management of existing activities in the area is extremely important (Wood and Glasson 2005). However, few studies have been undertaken to gain baseline quantitative information concerning the impacts and preferences of campers, and thereby to aid the planning and management of unregulated campers in the Ningaloo Marine Park (Wood 2003). Davies (2009) argues that this lack of detailed baseline data presents a major challenge to management agencies in terms of designing effective and appropriate management arrangements. Additionally, a qualitative impact study of surfers along the Ningaloo coast concluded that there was a lack of quantitative evaluation of the environmental impacts of tourism in the region, which could adversely affect its sustainable management (Hugues-Dit-Ciles, Findlay et al. 2004).

The environmental impacts of camping have been well researched within the recreation ecology literature. Reviews synthesising the research literature and management applications of recreation ecology have been published (Cole 1987; Wood and Hughes 2006). It is asserted that most campsite research has focused on soil and vegetation impacts within the United States, in designated wilderness and forested or alpine environments. As Ningaloo is a coastal, semi-arid environment, many of the impacts and methodologies documented in the literature do not apply in this environmental context. A literature review undertaken by Ingle, Leung *et al.* (2003) confirmed the existence of only a small number of references concerning visitor impacts in coastal areas. Only two studies worldwide (Hockings and Twyford 1997; Monz 1998) have examined coastal camping impacts. In addition to possessing an arid, coastal environment, Ningaloo Marine Park differs in other aspects from the majority of research locations within the recreation ecology literature. These include: a mixture of management and ownership exhibiting different regulation levels, facilities, costs and vehicle access standards; campsites accessible by four-wheel drive vehicles and in some areas two-wheel drive vehicles which are parked within the campsite; long average length of stay, meaning that resources are removed from regional centres and disposed of in coastal areas; and varied substrates and vegetation types across the management regimes. Additionally, campsites along the Ningaloo coast area:

> A very popular destination for many long term visitors. Changing use patterns and establishment of any restrictions will require further study and consultation with government agencies, user groups and other interested individuals and a phased approach should be considered (Western Australian Planning Commission 2004, p. 95).

The project was consequently planned as an exploratory field study, which evolved to become a hypothesis-testing enquiry examining the relationships between environmental impacts, camper preferences and resource use and their relationship to different management regimes. This tripartite approach which seeks to understand ecological change through examining ecological, social and managerial dimensions, was the subject of considerable research in the 1960's and 70's (Manning 1999), and has been regarded as more valuable in less developed settings (Cole 2004). However, studies examining these three aspects are also gaining momentum in front country studies (Monz, Cole et al. 2010). Whilst the Ningaloo coast is very remote and undeveloped, it is accessed by vehicle (not by foot or horse) and so straddles the concepts of front and back-country characteristically found within the recreation ecology literature, further examined in section 2.3.

The intent of this study was to contribute baseline data to support the sustainable planning and management of the Ningaloo coast while contributing academically to the field of recreation ecology. This was done through developing techniques and drawing conclusions about both camping in coastal and semi-arid environments and of the effect of management regimes on the magnitude of environmental impact. This has been achieved, in a holistic manner, both through data collection and in the design of new research methods. While the study recognises the importance of camper preferences, its main focus is on the environment and on understanding environmental impacts. Hence a larger amount of data analysis has been conducted on this topic. One outcome of this study has therefore been to develop three summary impact indices to better understand the nature of the environmental impacts of camping along the Ningaloo coast. A second has been the development of theories on the following issues, for coastal and semi-arid recreation areas accessed by vehicles: The effectiveness of visitor and site management actions to minimise the environmental impact of coastal camping;

factors contributing to this problem and; how research and impact assessment methods can be improved in this context.

In the context of this study, holistic means that the effects of management and regulation are not viewed in isolation, but in relation to a variety of variables which are linked to the different disciplines of social science and recreation ecology.

1.2 AIM AND SCOPE

This study was guided by the following aim:

> *To identify the relationship between management and the variables of visitor preferences, resource use and environmental impacts at remote coastal campsites on the Ningaloo coast.*

To achieve this aim, the following five research questions are proposed:

1. Do similarities exist between the nine management areas within the study area with regard to regulation, access, cost and facilities?
2. Do differences exist between the different management areas with regard to camper demographics, their activities and campsite preferences along the Ningaloo coast?
3. Do differences exist between the different management areas with regard to resource use?
4. Do differences exist between the different management areas with regard to the environmental Impacts of camping?
5. Do management regime levels alone influence the environmental impacts which result from coastal camping?

The purpose of this study is to make a demonstrated contribution to recreation ecology, which is both methodological and theoretical in its demonstration about the importance of management to environmental impact. This thesis expands knowledge in four ways. First, it disaggregates the myth of the 'average camper' (Shafer 1969). Second, it contributes to three common research themes for coastal and semi-arid environments from within the recreation ecology literature, as identified by Leung and Marion (2000): what factors contribute to the problem, how effective are visitor and site management actions, and how can research and impact assessment methods be improved? Third, it applies analytical techniques from elsewhere in a completely different ecological and camping context ('arid coastal' and 'drive in'). Fourth, it generates valuable baseline data and management recommendations for the Ningaloo region.

The scope of this study is limited to nine different management areas along the Ningaloo coast, between and including Blowholes camp and Cape Range National Park. All locations along this coastline are included in the study area with the exception of Ningaloo pastoral station. All campsites within the noted management areas were considered for sampling. The fieldwork component took place between September 2008 and March 2010.

The main limitations on this study were those of budget and time. Limited funding was available and transport to the remote location was costly. The whole project was limited to three years and, due to the heat in summer, impact assessments were limited to the shoulder seasons of March/April and September/October when there were fewer campers. To optimise the collection of camper surveys, the questionnaire task was limited to the peak visitation period from May to July. Due to limitations in both time and budget, the research is therefore cross-sectional. It examines a single point in time and takes a snapshot approach. Another limiting factor was that the Ningaloo environment was not a wilderness in pristine condition. The entire study area had been utilised for pastoral purposes since the late nineteenth century and much of the study area still being used for this purpose. Therefore the impacts of both productive land use and tourism had to be teased out. Since this research is a case study it can exhibit limitations (Evans and Gruba 2002). For example, some of its findings may be limited due to historic and, in places, continued existence of pastoralism. However the methods used are applicable to similar or longitudinal studies and the findings are potentially comparable with further studies in other coastal areas with a variety of management regimes.

The focus of this research, as previously mentioned, is on the differences in camper preferences, resource use and environmental impact. These variables were analysed across geographically different camp areas rather than demographically in relation to the campers themselves.

While most attention within this study is paid to environmental impacts, the thesis is primarily concerned with:

1. The fragility of the natural environment
2. The resources drawn from and the waste disposed onto the environment
3. What is important to the campers as exhibited by their preferences

Therefore this study acknowledges what people enjoy and appreciate about the resources of the Ningaloo coast. It seeks to facilitate their enjoyment of these resources but does so through the lens of environmental concern. As such, more detailed analysis was conducted with regard to adverse environmental impacts and on ways to ameliorate these impacts.

This research focuses on the four clusters of camp sites, which are compared to assess differences between the environmental impacts of the campsites, the environmental load (water, waste and energy) generated by the campers and camper preferences with regard to a range of campsite attributes. This research aids in understanding the relationships between regulation, facilities, and campsite environmental impacts, as well as what campers regard as important to their campsite choice and overall experience.

1.3 THESIS STRUCTURE

The thesis is divided into ten chapters. The structure has been shaped by the need to thoroughly address both the case study approach and the use of two different research methods. A conceptual diagram of the thesis structure is presented in *Figure 1.2*.

The first chapter provides an introduction to the study and the study objectives while the second chapter provides information about the study area and the rationale for the site selections. As this is research is a case study rather than classic study, the historical, geographical and political description of the study area is discussed prior to the reviews of theory. The third chapter comprises three sections which review the literature employed in other studies in the multidisciplinary fields of visitor preference, resource use, environmental impacts and management practices. Chapter

4, on methods, is divided into two sections which focus on the questionnaires and the environmental impact assessments. Both sections include a literature review relating to methods employed in other studies. While both sections also include a data analysis component, the impact assessment is more detailed, outlining the derivation of impact indices and the correlations to independent variables to provide a better understanding of the factors which affect the levels of environmental impact. This level of detail is necessary due to the importance of environmental impacts to this study.

Chapters 5 through 9 are results chapters which aim to address research questions one through five. Chapter 5 outlines the methods, analysis and outcomes undertaken to derive and identify the four campsite clusters, against which the analyses are measured throughout the study. Chapter 6 presents results from the visitor questionnaire on: camper demographics preferences, incorporating their preferred activities; campsite attributes; and style of management, followed by a discussion. Chapter 7 also presents results from the visitor questionnaire on campers' resource use, including: rubbish content and disposal; water use and where it was sourced from; power source; energy used and; sewerage disposal, followed by a discussion. Results from the impact assessments and associated summary impact indices are described in Chapter 8. Campsite inventory variables for each management area are first outlined, followed by impact variables incorporating: campsite area; litter and human waste; social trails and human waste. Impact indices are then presented followed by a discussion. Factors which may affect the magnitude of these impacts, and how impacts may be ameliorated are presented in Chapter 9. Independent variables and management variables are correlated against impact variables (outlined in Chapter 8) and are also followed by a discussion of results. Finally, Chapter 10 provides a conclusion to the thesis through surmising findings of objectives presented previously within this section. Two sections on management considerations and research contributions conclude the thesis

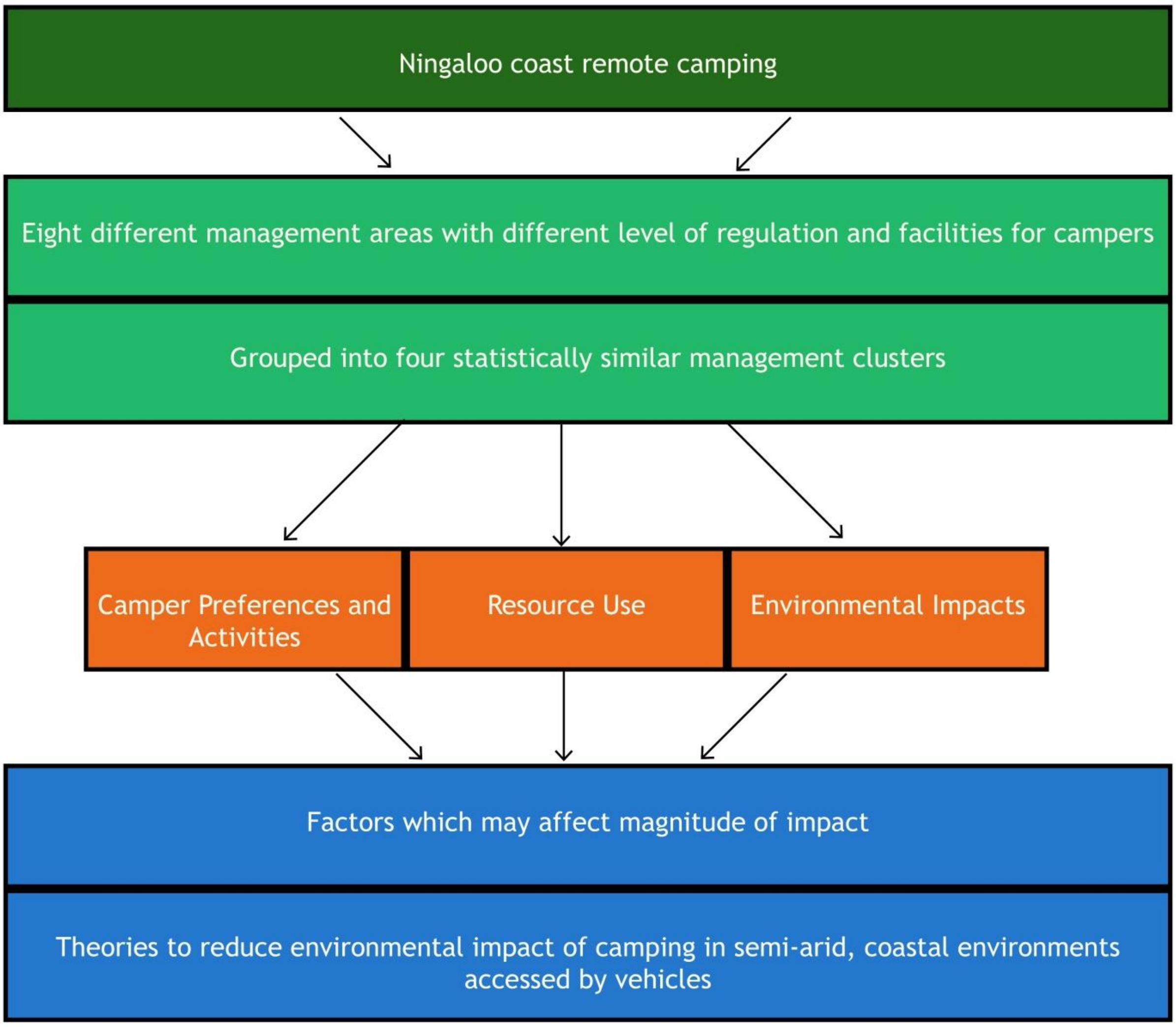

Figure 1.2. Conceptual Diagram of the Thesis Structure.

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Chapter 2: Study Area

Figure 2.1. Coastal Road, Warroora Station.

2.1 INTRODUCTION

If this study is to explore the relationship between management and the variables of environmental impacts, resource use and visitor preferences at remote coastal campsites on the Ningaloo coast, it is of paramount importance to develop an understanding of the biophysical, social and political variability between the nine different management areas. For this reason the aim of this chapter is to develop an understanding of both the unique characteristics of each management area within the study area, but also of the environmental and political context of the entire Ningaloo coast.

Section 2.2 outlines the protected area status of the Ningaloo coast, so that the level of protection and the environmental significance of each management area can be understood spatially. In section 2.3, the study area is examined through descriptions of the nine different management areas with regard to location, size number of campsite areas, facilities, tenure, relevant legislation and environmental features. As the study area comprising the nine management areas is located in the same semi-arid location with a similar natural environment, background information on the Ningaloo coast will be presented in the context of the study area as a whole in section 2.4. Topics discussed there include biophysical information, history, popularity of coastal camping, regional services for coastal campers, and the political, legislative and managerial contexts of the Ningaloo Region. Research that has been undertaken in the region on coastal campers, resource use and environmental impacts is explored in section 2.6 and not with the remainder of the literature review in Chapter 3 in order to keep the information on Ningaloo in one location.

2.2 PROTECTED AREAS

Due to the exceptionally high environmental values of many areas of the Ningaloo coast and the Gascoyne Region, a number of locations within the study area have been set aside for conservation purposes (*Figure 2.2*). These include Cape Range National Park (CRNP), the Ningaloo Marine Park (NMP) (State and Commonwealth Waters) and most recently the Ningaloo Coast World Heritage Area (NCWHA).

Protection status for the current Cape Range National Park was initiated in 1964, when a 'C' class reserve was gazetted by the Shire of Exmouth as a precursor of the National Park (Department of Conservation and Land Management 1987). The size of CRNP was limited by the boundaries of the adjacent pastoral stations but, in 1969, CRNP's size was increased to 50581ha when the pastoral lease south of Yardie Creek was added to CRNP (Department of Conservation and Land Management 1987).

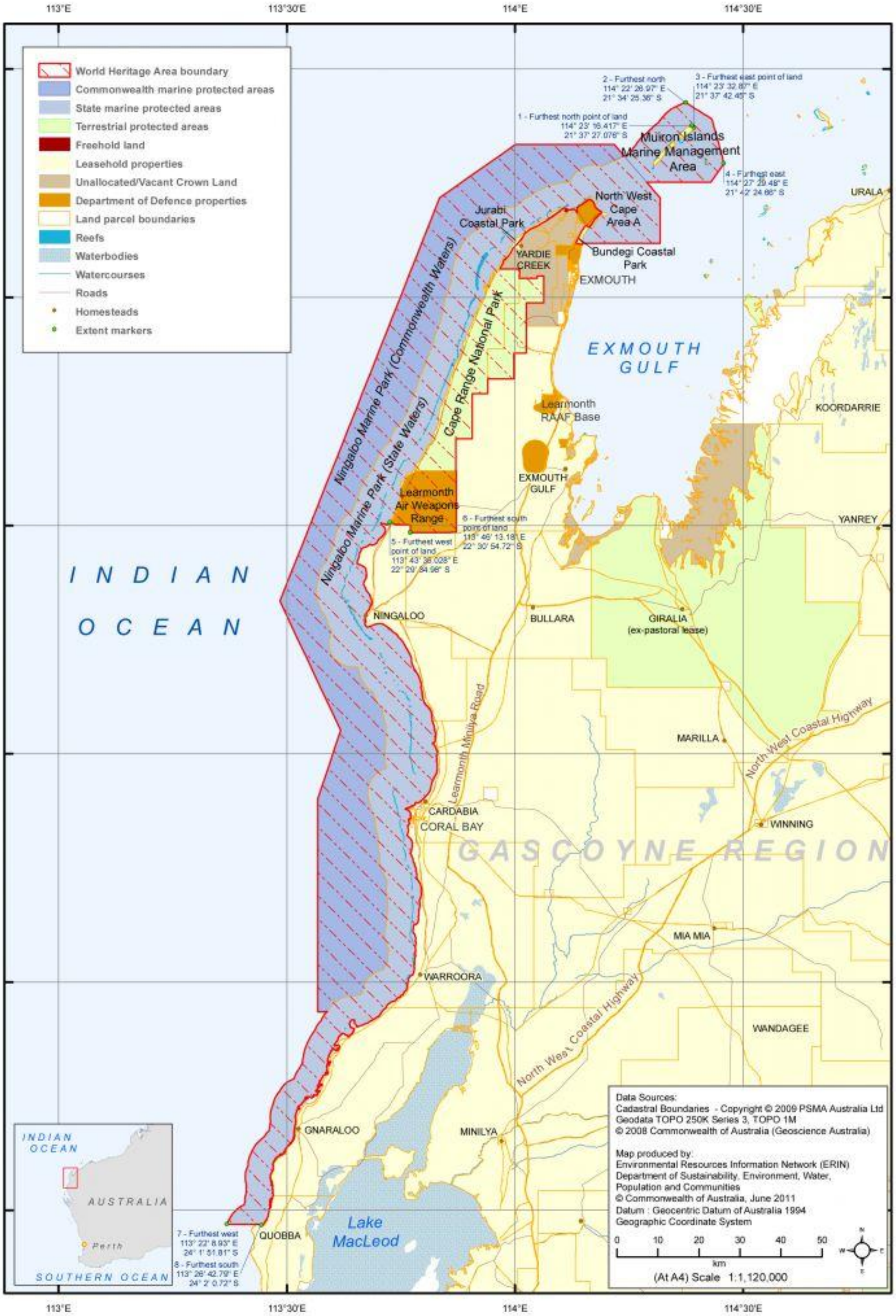


Figure 2.2. Protected Areas along the Ningaloo Coast.

Derived from Environment Australia (2010, p. 1)

Cape Range National Park was named in 1972 when its status was amended to that of a Class 'A' reserve. While the Department of Conservation and Land Management (CALM) became responsible for management of CRNP, the vesting body was the National Parks and Nature Conservation Authority (NPNCA). Following the release of the *Cape Range National Park Management Plan 1987-1997*, CRNP was recognised as an important tourist destination and development of access roads, information signs, parking, toilets, walk trails, camping and picnic areas followed.

Ningaloo Marine Park (NMP) is part of the National Representative System of Marine Protected Areas, which aims to 'contribute to the long-term ecological viability of marine systems, to maintain ecological processes and to protect Australia's biological diversity at all levels' (Commonwealth of Australia 2002). The Ningaloo Marine Park extends from Bundegi near Exmouth in the north, to, Red Bluff in the south. The Marine Park includes a terrestrial component to 40 metres inland from high tide on the pastoral stations (Department of Conservation and Land Management 2005) (*Figure 2.2*). Although full support was provided by the EPA and State Cabinet in 1976, a lack of legislation meant that only an aquatic reserve, enabled through the *Fisheries Act* (Department of Conservation and Land Management 1987), could be formed in state territorial waters. A Marine Park Working Group was established in 1978 by the National Parks Authority. Key recommendations included were that Commonwealth Waters be integrated into NMP under one management unit with State Territorial Waters (Department of Conservation and Land Management 1987). The Ningaloo Marine Park was first officially gazetted in 1987 and, in 2004 the boundaries of the no-take sanctuary zones in the Marine Park were extended to 34 %, creating tension between the Marine Park administrators, DEC and local residents (Ingram 2008). The Commonwealth Waters adjacent to the Ningaloo Marine Park (State Waters) were declared a marine park on 7 May 1987 and cover an area of 258,500 ha.

As in most marine parks and reserves in Western Australia, the NMP and Murion Islands Marine Management Area are multiple use reserves that cater for a wide range of activities. Multiple-use reserves reflect a balanced approach to conserving the environment by providing a management framework to ensure that human usage does not cause significant or long term damage. Zoning is an important part of the management framework in multiple use marine reserves (*Table 2.1* and *Figure 2.3*)

Table 2.1

Sanctuary Zone Categories within the Ningaloo Marine Park.

Zone type	Description	Location
Sanctuary zones	Sanctuary zones provide total protection for marine life.	Cape Range National Park; Air Weapons Range; Cardabia Station; Warroora Station (excluding Fourteen Mile) Gnaraloo Three Mile camp
Special Purpose (benthic protection) zones	These zones also allow visitors to observe marine life in its natural state; however recreational 'troll' fishing is allowed.	Cape Range National Park
Special purpose (shore-based activities) zones	These zones are established alongside some sanctuary zones to allow shore-based recreational fishing for finfish only.	Cape Range National Park
Recreation zones	Recreation zones are managed for nature conservation and recreation, including recreational fishing.	Cardabia Warroora (excluding Fourteen Mile) Warroora (Fourteen Mile)
General Use Zones	These zones are managed for nature conservation while allowing for sustainable commercial and recreational activities.	

Source: WAPC (2004)

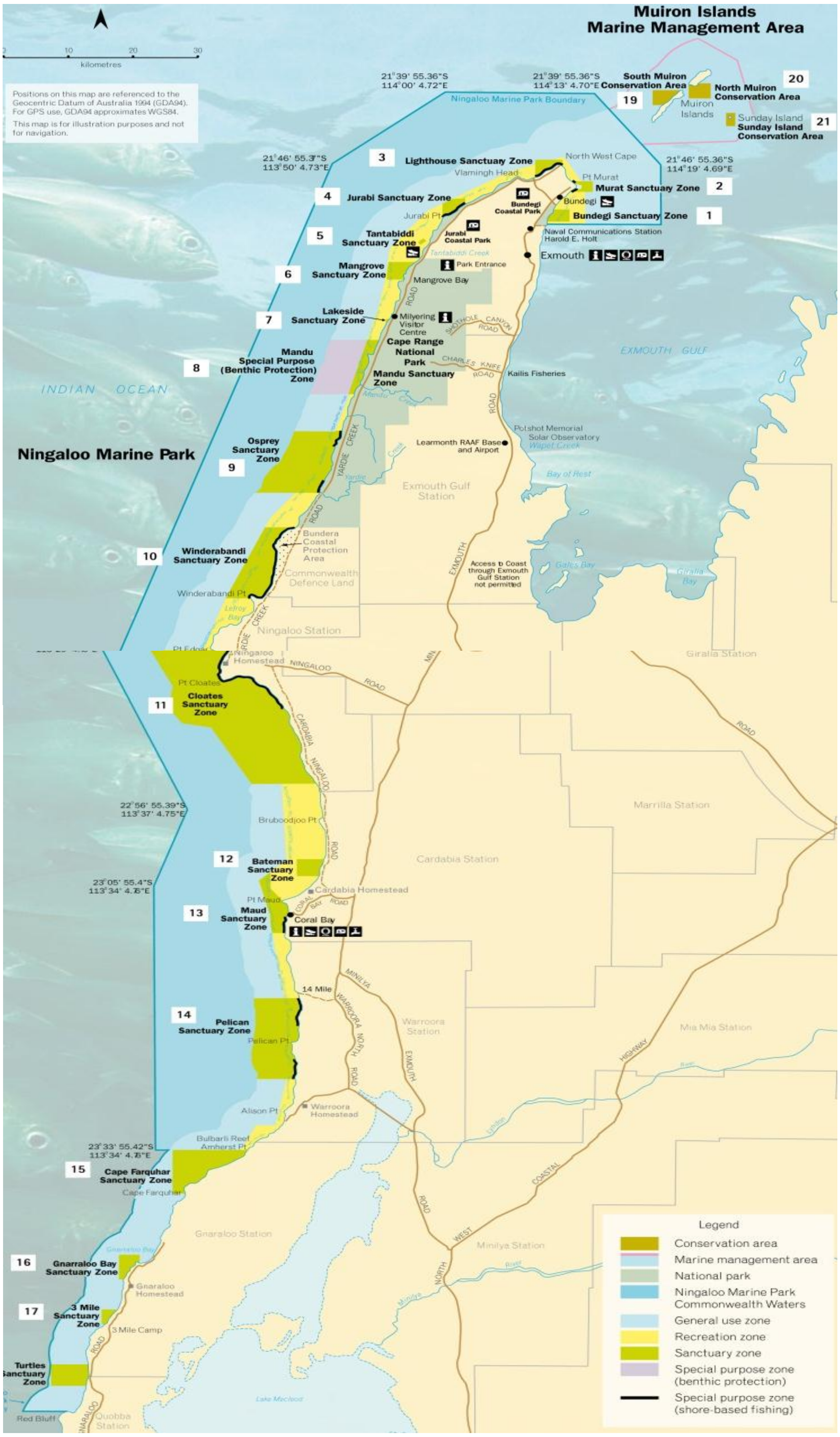


Figure 2.3. Sanctuary Zone Locations within the Ningaloo Marine Park.

Derived from DEC (2009, p. 3-4)

In some areas, fishing activities are partially or totally restricted. These zones, known as sanctuary zones in marine parks and conservation areas, provide reference areas that help us to measure the impact of human activity on the environment as well as to protect habitats and their wildlife (Department of Environment and Conservation and Department of Fisheries 2009).

Ningaloo Reef has most recently been included in the International Union for the Conservation of Nature (IUCN) list of coral reefs of international significance (United Nations Environment Program and International Union for the Conservation of Nature 1988). The nomination was assessed by the UNESCO World Heritage Committee, who decided to include the Ningaloo coast on the World Heritage List on 24 June 2011 (Department of Environment and Conservation 2011). The boundaries are shown in *Figure 2.2.*

Key values of the Ningaloo coast include

- striking natural landscapes of Cape Range and Ningaloo Reef
- high biological diversity of the reef
- opportunity for visitors to encounter one of the world's largest annual aggregations of whale sharks, as well as other marine mammals, turtles and manta rays
- rare and diverse plants and animals of Cape Range

Development and commercial activities can and do occur in World Heritage places around the world and so the current activities along the Ningaloo coast will not be affected. Many development proposals are not environmentally significant and will continue to be permitted through existing local and state government statutory processes (Department of Environment and Conservation 2011).

2.3 STUDY SITES

The study area comprises nine different management areas adjacent to the Ningaloo Marine Park located between Blowholes to the south, and Cape Range National Park to the north (*Figure 2.4*). Pastoral leases, including, Cardabia, Warroora, Gnaraloo and Quobba stations are the major land tenure holdings adjacent to NMP. In the northern area the adjacent tenure includes Cape Range National Park (vested in the Conservation Commission of Western Australia). The Department of Defence controls the Learmonth Air Weapons Range located directly south of Cape Range National Park. The Shire of Carnarvon manages the Blowholes camping area south of Quobba station, which can be accessed by sealed road from Carnarvon (Department of Conservation and Land Management 2005). As the Ningaloo Marine Park boundary sits 40 metres inland past the mean high tide mark, many coastal camping areas are officially under the jurisdiction of the Department of Environment and Conservation in spite of their location on land owned or leased by other bodies. Sixteen questionnaires were collected at Quobba homestead, one of the management area. As the camp areas are also utilised for cattle grazing on a frequent basis, impact assessments were not conducted at this location but were analysed within the Questionnaire results on camper preferences and resource use.

To be incorporated into the study area, only those management areas deemed remote were considered. Criteria included their location being within or adjacent to the NMP within 200 metres of the beach, with no running fresh water or electricity provided and more than one hour drive from a regional centre. Campers in remote campsites are therefore considered self-sufficient and as 'Remote', 'Semi-remote' or 'Roaded Natural' by the Department of Planning and Infrastructure (2003) (*Table 2.2*). Remote areas are classified as Red Bluff camp, the campsites at Warroora (south of the homestead) and the Learmonth Air Weapons Range. All other sites are considered semi-remote with the exception of Cape Range National Park which is classed as 'Roaded Natural'.

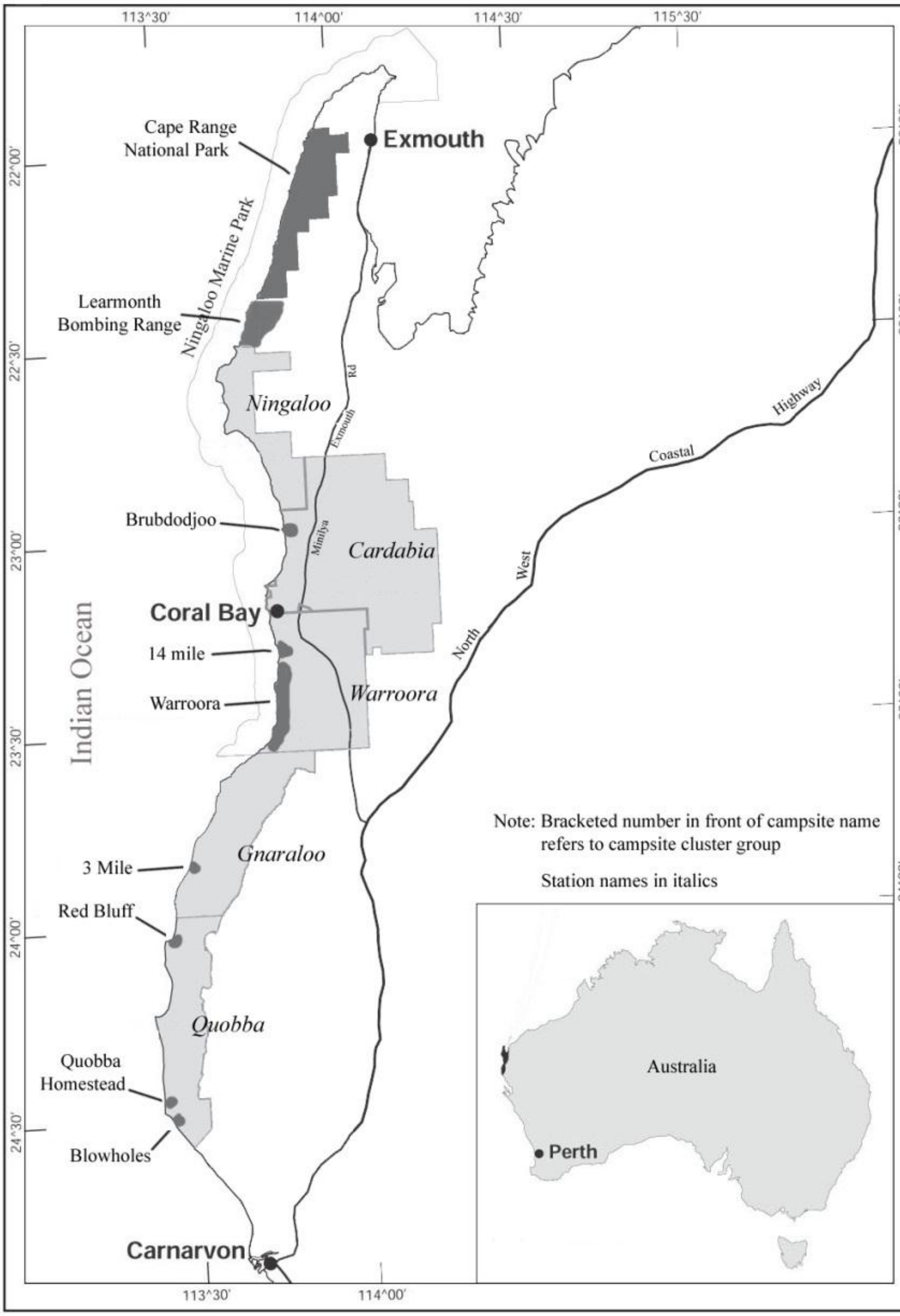


Figure 2.4. Study area, showing the Nine Management Areas.

Map adapted from Wood (2006).

Table 2.2

Remote Setting Classes.

Class 1 Remote: Natural, unmodified, undeveloped	Landscapes within this class are predominantly unmodified and display a high degree of naturalness and exhibit 'wild' qualities with negligible evidence of human activity, formed access, un-natural visual impacts or noise. Change is not in evidence
Class 2 Semi-Remote: Natural dominance, some modification/ development	Landscapes within this class are predominantly unmodified but may contain some minor evidence of human activity, noise and development including roads and walking tracks. Change is evident, but subordinate to the naturally established landscape.
Class 3 Roaded Natural: Balanced natural and modified/development	Landscapes within this class are predominantly natural, but also provide for motorised and pedestrian access (sometimes seasonal) and basic visitor facilities. Human initiated activity, noise visual alterations and support facilities are apparent but not dominant.

Source: Department of Planning and Infrastructure (2003)

In addition to the remote coastal camp sites, full-facility caravan parks and regulated camping grounds cater to visitors in the Regional Centres of Carnarvon and Exmouth, and the Sub-Centre of Coral Bay. Caravan parks usually offer powered and unpowered sites and both cater to short term holiday makers, and long-term, semi-permanent or permanent residents. Caravan Parks are regulated by industry and government and provide campers with water supplies, toilets and rubbish disposal facilities. Full-amenity caravan parks were not considered within this study. All management areas differ with regard to the provision of facilities such as toilets, sewerage dump points, and small shops.

2.3.1 Cape Range National Park

Cape Range National Park, near Exmouth, comprises 50,581 hectares and was established in 1969 when part of the Yardie Creek pastoral station was surrendered to the Crown (section 2.5.1). Cape Range National Park was gazetted as an A class reserve in 1971 (Department of Conservation and Land Management 2005).

Cape Range National Park (CRNP) contains thirteen camping areas, accommodating approximately 110 sites (Department of Conservation and Land Management 2005). Of these, seven sites (maps in Appendix A) were included within this study for impact assessments. One camp area, Boat Harbour (located south of Yardie Creek), was utilised as a study site for the Questionnaire survey only due to its remote location. Other sites were not sampled because they were closed off by management for repairs. A wide range of tours, activities and facilities are available for visitors. These include: glass-bottom boat tours, self-guided walk trails, dive trips, snorkel tours, safari tours, and interpretive activities during school holidays. A high level of interaction and socialisation occurs amongst campers. A luxury safari-tent eco-lodge, Sal Salis, is located at South Mandu. CRNP has the largest number of separate visitors of any of the management areas with records collected by the Department indicating that Cape Range National Park received approximately 250,000 visits during 2009/2010 (Department of Environment and Conservation and Conservation Commission Western Australia 2010). Visitation to CRNP is increasing, with visitor numbers more than doubling since 1987 (Department of Environment and Conservation and Conservation Commission Western Australia 2010). Boat launching facilities are available, though only at three key sites within the property (Environment Australia 2010). Visitors pay an entry fee to the Department of Environment and Conservation (DEC), $10 per person per day to access Cape Range National Park.

CRNP has the highest level of regulation, including no dogs, no fires and a maximum stay of fourteen days in peak periods. A camp host is present at many of the sites to provide information and keep the site clean. Basic facilities are found in all camp areas including toilets, roads, paths, control devices and signing (Western Australian Planning Commission 2004). Each site contains a drop toilet and rubbish bins (*Figure 2.5*). DEC (109-160 sites in 13 areas) provides garbage bins at all of its camp spots but at not day-use sites for which rubbish collection is consolidated at the Milyering Visitor Centre for collection by Exmouth Shire Council (Department of Planning and Infrastructure 2003). The campsites are located close together, with Mesa, Lakeside and Pilgramunna sharing one barren area separated by wooden logs (Plate 2.5). The management footprint at most sites is quite high due to site hardening such as at Mesa which has a manmade limestone substrate and designated paths (*Figure 2.6*).

Cape Range National Park is generally accessed from the north via Yardie Creek Road, which is sealed from Exmouth through to Yardie Creek. Park camp areas south of Yardie creek, such as Boat Harbour, are accessed by crossing Yardie Creek itself then driving south on a dirt road. Alternative access is gained by driving north from the Learmonth Air Weapons Range. Access is considered to be predominantly semi-remote for sites north of Yardie Creek, Roaded Natural for Yardie Creek and Remote south of Yardie Creek (Department of Planning and Infrastructure 2003).

The campsites are currently managed under the Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005-2015 (Department of Conservation and Land Management 2005) by DEC. Strategies to present and promote the Ningaloo coast are implemented by DEC through a variety of policies and programs (Environment Australia 2010), including the CRNP Management Plan (Department of Environment and Conservation and Conservation Commission Western Australia 2010).

Plate 2.1 Toilet, CRNP

Plate 2.2 Entrance to CRNP

Figure 2.5. Toilet and Campsite availability Chart, CRNP.

The Cape Range at 314m high is the only elevated limestone range on the north-western coast of Western Australia (Western Australian Planning Commission 2004). CRNP comprises a dissected limestone range and coastal plain (Western Australian Planning Commission 2004) and is bisected by Yardie Creek which offers hiking and native wildlife viewing. Camping areas incorporated within the study (maps in Appendix A) are: Neds Camp, Mesa, T-bone, Lakeside, Tulki, Pilgramunna, Osprey Bay and Yardie Creek. All but Osprey Bay and Pilgramunna are set behind the primary dune. Osprey Bay is set on a ridge overlooking the ocean while Pilgramunna is on a coastal floodplain looking out onto the ocean. Further descriptions of each individual site can be found in the Carnarvon - Ningaloo coast Inventory and Assessment of Coastal Usage Patterns and Site Conditions (Department of Planning and Infrastructure 2003).

Plate 2.3 Kurrajong Camp Area

Plate 2.4 Osprey Bay Camp Area

Plate 2.5 Mesa Camp Area

Plate 2.6 Lakeside Camp Area

Figure 2.6. Cape Range National Park Campsites.

2.3.2 Learmonth Air Weapons Range

The Learmonth Air Weapons Range is unofficially used for camping, and no facilities are provided. It is the only management area within this study which charges no fees and management presence is negligible other than occasional patrols by DEC staff. Sites are unregulated with no site definition. People use Doddys campsite for camping, fishing, beach access, remoteness, water activities, sense of remoteness and lack of management presence (Department of Planning and Infrastructure 2003; Western Australian Planning Commission 2004). There is a low level of social interaction as most visitors here prefer seclusion and isolation. Public access is closed when the inland weapons range is active (Department of Planning and Infrastructure 2003). Access is gained via four-wheel drive only through coastal, unsealed tracks from either Ningaloo station to the south or from Cape Range National Park to the north after crossing Yardie Creek.

Most campsites on the bombing range are small, suitable for one to five tents (Department of Planning and Infrastructure 2003) with the exception of grouped camping areas such as Doddys (*Figure 2.7*) which has approximately 37 sites (Western Australian Planning Commission 2004). As such, environmental modification is currently limited to localised disturbances at favoured campsites (Department of Planning and Infrastructure 2003) where heavy use is experienced during peak seasonal periods (Western Australian Planning Commission 2004). Anthropogenic impacts include proliferation of sandy tracks which provide access to beaches and dunes. As such, site disturbance at some locations include evident loss of vegetation, erosion and dune modification (Department of Planning and Infrastructure 2003).

Doddys Camp is located on a dune and cuspate spit coast (Western Australian Planning Commission 2004). The landscape provides attractive protected campsites and beach access. The foreshore and dune system are highly sensitive environments characterised by low rolling dunes, coastal scrub, wide beaches, variable sand spits and low salt flats (Department of Planning and Infrastructure 2003). Foreshore habitats include sand, macro algae (limestone reef), subtidal and intertidal coral reefs and shoreline reefs along most of the beach (Department of Planning and Infrastructure 2003). This area is part of the Ningaloo Marine Park and may offer views of whale migration (Department of Planning and Infrastructure 2003).

While State legislation covers all other areas along the Ningaloo coast (Environment Australia 2010), Commonwealth legislation applies to Ningaloo Marine Park (Commonwealth Waters) and the Learmonth Air Weapons Range. The Australian Government Department of Defence has been given power to manage and protect the Range, under the provision of the *Defence Act 1903*. Under provisions of this Act, the Department of Defence is preparing to gazette the Range as a ‘public area’ (Environment Australia 2010). This would give Defence the authority to curtail access and to appoint rangers to oversee management. As a Commonwealth Heritage listed property, the Range is also subject to the provisions of the *EPBC Act* (Environment Australia 2010).

Figure 2.7. Doddys camp, Learmonth Air Weapons Range.

2.3.3 Cardabia Station

The only campsite on Cardabia is at Bruboodjoo Point, also known as Nine Mile camp, which is located on the coast. Cardabia station homestead is located inland of Bruboodjoo. No facilities are present at Bruboodjoo other than an open rubbish pit one kilometre away from the camp area. Access is via a corrugated dirt track, although a network of unplanned tracks also criss-cross the site through the camp area to the beach (Department of Planning and Infrastructure 2003).

DEC rangers occasionally patrol from Coral Bay and fees ($5 per night) are collected sporadically by station staff. Activities include fishing, beach access, informal boat launching, enjoyment of the coastal scenery and remoteness, and lack of management presence and water activities (Department of Planning and Infrastructure 2003). The level of social interaction is very high during peak periods due to the crowded conditions (Department of Planning and Infrastructure 2003), whereas the summer periods see few visitors.

The Baiyungu Aboriginal Corporation gained ownership of Cardabia station in 1998, when the State purchased Cardabia Station, north of Coral Bay, on behalf of the Baiyungu people. The Baiyungu people now also hold freehold land near the tourist resort town of Coral Bay north of Carnarvon and are now involved in developing workers' accommodation in Coral Bay (Jones, Hughes et al. 2009). Undefined camping sites have encroached on to the dunes and loss of vegetation and damage to fragile vegetation is significant (Department of Planning and Infrastructure 2003; Western Australian Planning Commission 2004). The vegetation of the area is described as saltbush or blue bush with woodland or scattered trees (Western Australian Planning Commission 2004). The landscape is dominated by a spectacular north facing bay with a curved beach, and low saline plain between the dunes and a headland ridge (Department of Planning and Infrastructure 2003). The marine environment, part of the existing marine park, is also is highly sensitive and shoreline reefs exist within the foreshore (Department of Planning and Infrastructure 2003).

Plate 2.7 Bruboodjoo overview

Plate 2.8 Bruboodjoo camp set up with generator

Plate 2.9 Bruboodjoo camps set up with boat

Plate 2.10 Bruboodjoo overview to ocean

Figure 2.8. Bruboodjoo, Cardabia Station.

2.3.4 Warroora Station

Warroora Station (maps in Appendix A) contains twelve camp areas, all of which were sampled for the questionnaire and eight for the impact assessments due to inaccessibility of some of the sites. Sites sampled for the impact assessments were: Fourteen Mile (about 40 sites), Sandy Point (8 sites), Pelican Point (2 sites), Elle's Beach (5 sites), Stevens (10 sites), Bulbarli (15-20 camps), The Lagoon (8 sites) and Southern Boundary (10 sites). Both one and two bay dispersed sites and more concentrated camping areas were sampled. The latter are often preferred by return visitors and long-term users of the area (Western Australian Planning Commission 2004). Dispersed camping activities generally occur south of Fourteen Mile to Southern Boundary. Due to their isolation, campsites to the south of the homestead are less regulated than the camp sites further north, such as Fourteen Mile (Western Australian Planning Commission 2004). With regard to accessibility, campsites south of the Lagoon camp area are considered remote and campsites north of the Lagoon as semi-remote (Department of Planning and Infrastructure 2003).

This study has separated Fourteen Mile from the other sites on Warroora for analytical purposes due to the presence of a seasonal camp host at Fourteen Mile, because it is accessible by two-wheel drive vehicle, the close proximity of one of two closed rubbish tips and the presence of sewerage dump points. Camping is confined rather than dispersed at Fourteen Mile and has very high levels of social interaction due to repeat visitation.

The camp areas are managed by Warroora station staff and most camp areas have marked campsites. At all Warroora sites, firewood collection is strictly forbidden but fires are allowed. However, no physical borders are present around the campsites. A camping fee of $5 per night per person or $25 per week is in effect, collected by station staff. All camp areas get very full in winter and Fourteen Mile overflow areas provided near Sandy Point are regularly utilised (Western Australian Planning Commission 2004). Access to camp areas along the coast and to the homestead is via a sandy track running north-south. Numerous sand tracks to favourite sites and beaches exist. There are currently no public facilities in this area although the homestead node has electricity, fresh water and a communal kitchen for those staying in shearers' accommodation and cabins (Western Australian Planning Commission 2004). There is a variety of vegetation communities along the Warroora coast, including open and sparse scrub and saltbush/bluebush (Western Australian Planning Commission 2004).

Pertaining to Ningaloo's pastoral leases, the State *Land Administration Act 1997* administers Crown land and land acquisitions on behalf of the Western Australian Government with regard to leases, licences, reserve establishment and lands for roads and public access. Pastoral leases are established and managed under this Act, as are land conservation reserves when they are created as 'Class A' reserves, such as Cape Range National Park. Amendments to either the purpose or the boundary of these reserves require approval from both houses of the Western Australian Parliament. The length of tenure to be allowed on leasehold land vested in the Conservation Commission of Western Australia is currently under investigation (Western Australian Planning Commission 2004). The pastoral stations are currently managed by pastoral leaseholders who are issued with a lease by the Pastoral Lands Board. The role of the Pastoral Lands Board includes ensuring pastoral leases are managed on an ecologically sustainable basis (Environment Australia 2010).

The greatest concentration of camping on the beach and immediate foredune at Warroora is at Fourteen Mile Camp (Western Australian Planning Commission 2004) (2.3.4). Fourteen Mile is also Warroora's northernmost campsite and the closest camp area on Warroora to Coral Bay, the closest Regional sub-centre, at one hour's drive. Preferred activities include beach use, scuba diving, exploring, and surfing, boating and in particular fishing (Department of Planning and Infrastructure 2003). Fourteen Mile is favoured by many long-term visitors for whom beach camping is an activity to which many are culturally and emotionally attached (Western Australian Planning Commission 2004). Any regulatory change would be contentious and unwelcomed by current users (Western Australian Planning Commission 2004). Social interaction at Fourteen Mile is higher than at the other sites, and is favoured by groups of friends and regulars (Department of Planning and Infrastructure 2003). The camp area is accessible to two-wheel drive vehicles and caravans are managed and are maintained by a permanent, year-round caretaker.

Fourteen Mile is also in close proximity to one of two garbage tips and sewerage dump points on Warroora station (*Figure 2.10*). The other is located near the Lagoon camp area to the south (*Figure 2.11*). Both rubbish tips are enclosed by a water tank or wire gates and are equipped with a wire mesh top, which reduces wind-blown rubbish, prohibits burning and excludes feral animals. Waste can be disposed of via a metal lid, and is removed when the pit is full after which it is covered with earth. The Department of Environment and Conservation will soon be responsible for waste management on Warroora station, and is currently seeking contractual arrangements with the pastoral lessees. Environmental modifications at Fourteen Mile include an excessive number of tracks and some damage to land systems. This includes camping on the beach strand which has removed and damaged dunal vegetation (Department of Planning and Infrastructure 2003).

The remote area south of the homestead (*Figure 2.11*) has a variety of attractions including the inlet, birds, beach, camping, boating, fishing, exploring, walking, and informal boat launching facilities (Department of Planning and Infrastructure 2003). Formalised camp areas are seasonally popular, though undesignated campsites are also evident. Occasional patrols by station, Fisheries WA and DEC staff are made during peak visitation periods. A sandy, graded track from Warroora station provides nearly all weather access to dispersed sites south of the station, along the coast. Localised loss of vegetation in foredune areas is common where camping areas are located although modifications are generally low at small, single bay campsites (Department of Planning and Infrastructure 2003). Social interaction at the sites south of Fourteen Mile is variable.

Plate 2.11 Beachfront Campsites

Plate 2.12 Fourteen Mile Ridge

Plate 2.13 Fish Cleaning Station

Plate 2.14 Sign at Caretakers Caravan for new Arrivals

Plate 2.15 Campsite Access to Beach

Figure 2.9. Fourteen Mile Camp, Warroora Station.

Plate 2.16 Chemical toilet dump at Fourteen Mile

Plate 2.17 Recycling, Fourteen Mile

Plate 2.18 Rubbish Dump, Fourteen Mile

Figure 2.10. Fourteen Mile Camp Rubbish and Sewerage Disposal, Warroora Station.

Plate 2.19 Steve's Camp overview

Plate 2.20 The Lagoon

Plate 2.21 Sandy Point

Plate 2.22 Southern Boundary

Plate 2.23 Rubbish tip at Lagoon

Figure 2.11. Warroora Station excluding Fourteen Mile.

2.3.5 Gnaraloo Station

The established campsites at Three Mile Camp offer a large capacity campground for up to 250 people. Season variability sees the Camp popular with surfers in winter and with windsurfers and kite boarders in summer, as well as for general use in winter and holiday periods (Department of Planning and Infrastructure 2003). Other popular activities include fishing, coastal walks, and boat launching. The site (maps in Appendix A) is well located, featuring close proximity to coastal features and views, gently rolling topography and stable soils with typical coastal vegetation cover (Western Australian Planning Commission 2004) comprising pindan with low trees and sparse shrubs.

The area is also popular with families in winter due to the ablution facilities, rubbish removal services, sheltered beach, small shop, two phones and Internet access (Department of Planning and Infrastructure 2003) (Western Australian Planning Commission 2004). There is a relatively high opportunity for interaction within the campground. Cost is the highest for all the management areas, starting at $16 per person per night. A new well has created better water quality inside the ablution buildings, which provide the only flush toilet in all the management areas of this study. Well-behaved dogs and quiet generators are tolerated. Three Mile Camp is managed by both the station managers and a year-round caretaker located at the Three Mile Camp shop.

The Three Mile Camp environment is highly sensitive along the coast (foreshore and dunes), and moderately sensitive inland (Western Australian Planning Commission 2004). The marine environment is highly sensitive and marine habitats include shoreline reefs, intertidal and sub-tidal coral reefs, and sub-tidal reefs.

Three Mile Camp is in a semi-remote setting (Department of Planning and Infrastructure 2003). The road from Carnarvon is paved 80 km to Blowholes, and unpaved from Blowholes northwards, where it bypasses Quobba Station, Red Bluff and Gnaraloo Station. The coastal track from Gnaraloo Station to Warroora Station is closed for rehabilitation purposes (Western Australian Planning Commission 2004). Access to Three Mile Camp is via a spur track off the main coastal road from the south with rough tracks to points north.

Three Mile Camp is located near to Gnaraloo homestead, which has established visitor facilities including cabins and bunkhouse accommodation. Gnaraloo station also offers free board to backpackers in exchange for labour and operates a turtle monitoring program on its beaches over summer, employing a full-time environmental scientist. The station farms sheep and goats, which also frequent Three Mile Camp in drought months in search of water.

Like Red Bluff, Three Mile Camp at Gnaraloo is zoned as a minor tourism node and, as such, offers accommodation on approximately 60 sites, plus an overflow area. The existing camp is zoned special use under the Shire of Carnarvon Town Planning Scheme 11 (Western Australian Planning Commission 2004).

Plate 2.24 Entrance and Office to Three Mile Camp

Plate 2.25 Three Mile Campsite

Plate 2.26 Surf Break Car Park

Plate 2.27 Ablutions (bore water in use)

Plate 2.28 Farmed Goats in Campsite

Figure 2.12. Three Mile Camp, Gnaraloo Station.

2.3.6 Quobba Station

Quobba station, approximately 100 km north of Carnarvon, currently offers station stay tourist accommodation at the homestead with camping, chalets and bunkhouse-style accommodation for rent. Special attractions nearby include the HMAS Sydney memorial and extensive stretches of rugged coastline north and south of the station. Pastoral infrastructure such as roads, tracks, an airstrip and tanks are present (Western Australian Planning Commission 2004).

Red Bluff Camp (*Figure 2.13*) is situated on the coast to the north of Quobba Station homestead. Red Bluff has been accommodating visitors for over 50 years to surf, fish and relax (Western Australian Planning Commission 2004). Other attractions include boat access, scuba diving, a protected bay, dogs are allowed, high-quality surf break, spectacular views and majestic scenery, such as the Bluff itself,(Department of Planning and Infrastructure 2003) which is used for climbing, walking and exploring. A number of tracks are evident, including many small ones created by the goats which roam the Bluff hillside and occasionally coastal areas (Western Australian Planning Commission 2004). There is a narrow strip of sloping coastal plain between the Bluff, inland cliffs and the bay. Vegetation comprises predominantly coastal grasses and heath (Western Australian Planning Commission 2004) and has high environmental sensitivity. Maps of Camp Areas are in Appendix A.

As with most of the study area, heaviest visitation is April to September which is also the best surf season and during school holiday periods (Department of Planning and Infrastructure 2003). During these times, some conflicts result from the concentration of day activities, water based use and camping at the main beach (Department of Planning and Infrastructure 2003). Return visitors are common with a high growth rate over the past few years with increasing numbers of international visitors (Western Australian Planning Commission 2004). Visitors to the site prefer social interaction as part of the desired ‘experience’.

The Red Bluff camp area is highly modified locally with huts/cabins, roads and camping sites but with a high degree of retained naturalness (Department of Planning and Infrastructure 2003). A Manager’s house and small café are open in the winter months at Red Bluff. Visitors can stay in campsites ($10per night per person), one of 7 stone shacks ($20 per night per person) or one of 8 luxury safari tents. There are 17 drop toilets are available for campers, dogs are allowed and rubbish is collected from campsite bins daily (Western Australian Planning Commission 2004; Ferart Design 2007). No running water is available. Site management is leased to a resident caretaker. Campsites and walkways are in most cases defined with wooden or wire fences.

Red Bluff is managed from the Quobba Homestead, though a separate dwelling houses a caretaker and their family at Red Bluff. The Leaseholder holds two 21-year Special Use (Tourism and Camping) leases, one at Quobba Homestead and another for Red Bluff, north of the Homestead. It is identified by the *Ningaloo Coast Regional Strategy* ('Regional Strategy') as a minor tourism node (Western Australian Planning Commission 2004), and houses up to 200 overnight visitors. Site capacity is limited by topography, fragile marine features and the inability of the main beach access point to cope with greater numbers (Western Australian Planning Commission 2004). The existing Red Bluff Camp is zoned as special use in the *Shire of Carnarvon Town Planning Scheme 11* (Western Australian Planning Commission 2004).

The access track and parking nodes are well defined. The road from Carnarvon is paved 80 km to Blowholes, and unpaved from Blowholes northwards, bypassing Quobba Station, Red Bluff and Gnaraloo Station (Department of Planning and Infrastructure 2003). Within Red Bluff Camp, a sand track runs parallel to the coastline with spur tracks into campsites and cabins (Department of Planning and Infrastructure 2003).

Plate 2.29 Red Buff view, facing north

Plate 2.30 Red Bluff Office

Plate 2.31 Car Camping

Plate 2.32 Surfing

Plate 2.33 Formal Fire Pit and Campsite Area Barriers

Plate 2.34 Drop Toilet

Figure 2.13. Red Bluff Camp, Quobba Station.

2.3.7 Blowholes

The Blowholes settlement (maps in Appendix A) (*Figure 2.14*) appeals to both Carnarvon residents and visitors for its fishing and snorkelling opportunities. It is in a semi-remote setting accessed by a paved road from Carnarvon (80 km away). Attractions include shack accommodation, the proximity of Carnarvon, ease of access, protected bay, coastal scenery, fishing, swimming, picnicking, cultural heritage, and small over-the-beach boat launch facility (Department of Planning and Infrastructure 2003).

During the winter periods, a camp fee of $5 is payable to an on-site caretaker. Social interaction is high. Limited services include a large removable rubbish bin at the entrance to the camp area and a handful of bush waterless toilets, though these are rarely maintained. The nearest dump point facility for sewerage is in Carnarvon. The Blowholes camp area is managed by the Shire of Carnarvon but has an on-site caretaker during winter periods, in addition to some self-regulation by residents (Department of Planning and Infrastructure 2003).

The Blowholes camp is used year-round but is most popular during winter and school holidays (Department of Planning and Infrastructure 2003). There is room for approximately 80 campsites, though overflow sites in dunal areas have been created by campers. Windy conditions encourage campers to set up tents next to vehicles, resulting in numerous sites off the main dirt roads (Sharley 2008). Other anthropogenic impacts including the introduction of weeds, boat launching, utilities, pedestrian and vehicular activities, result in significantly altered coastal vegetation (Department of Planning and Infrastructure 2003). Camp area modification is high in association with tracks, utilities, lack of effective sewerage disposal, unregulated activity sites, roads and parking. Additionally, there is some evident damage to marine systems and the reef (Department of Planning and Infrastructure 2003). While there are no significant marine habitats in the waters adjacent to the coast, the marine environment houses a variety of corals which are highly sensitive (Western Australian Planning Commission 2004) and it is the closest snorkelling site to the town of Carnarvon.

Other than undesignated camping, the Blowholes campsite is currently used for longer-term stays in 43 makeshift squatters' shacks (Western Australian Planning Commission 2004). These shacks have developed over the years, and are subject to much debate. While these were due to be removed by 2008 under the *Land Administration Act (2007)* (Sharley 2008), many are still standing.

Blowholes is accessed via a sealed road from Carnarvon to the coast, though the 2 km long road which runs parallel to the coast connecting campsite areas is unpaved. There is little defined parking. However, user patterns have been established.

The node and surrounds are reserved as parks and recreation under *Shire of Carnarvon Town Planning Scheme 11* (Western Australian Planning Commission, 2004 #26}. The marine area adjacent to the Blowholes settlement is under consideration for protected status, while Point Quobba close by is protected as part of a Marine Sanctuary Zone. The area is subject to redevelopment and planning initiatives (Western Australian Planning Commission 2004). A Blowholes Coastal Park Concept Plan (Sharley 2008) was prepared by the Blowholes Protection Association (BPA), but does not reflect coastal setback or surge designations (Western Australian Planning Commission 2004), and it was ultimately rejected by the Shire of Carnarvon as unsuitable.

Plate 2.35 Campsite on large Barren Core Area (created by management)

Plate 2.36 Honorary Ranger’s Campsite

Plate 2.37 Prevention of Social Trail Expansion and Beach Access by Four-wheel drive Vehicles.

Plate 2.38 Two-wheel drive accessible Campsite leading to Dune Blowout

Figure 2.14. Blowholes Campsite.

2.4 REGIONAL BACKGROUND INFORMATION

2.4.1 Climate, Geomorphology and Ecology

Climate exerts a strong influence on coastal camping on the Ningaloo coast. Two seasons are experienced, a hot summer (October to April) and a mild winter (May to September), with the coolest month being July and the hottest January (Western Australian Planning Commission 2004) (*Figure 2.15*). The climate of the Ningaloo coast varies between the northern and southern locales. Cape Range National Park to the north experiences hot and arid conditions, while Carnarvon to the south experiences warm, semi-arid conditions (Western Australian Planning Commission 2004). The mean annual minimum temperature on the Ningaloo coast is 17° C and the mean annual maximum temperature is 27° C. The Ningaloo coast receives 320 days of sunshine per year (Western Australian Planning Commission 2004).

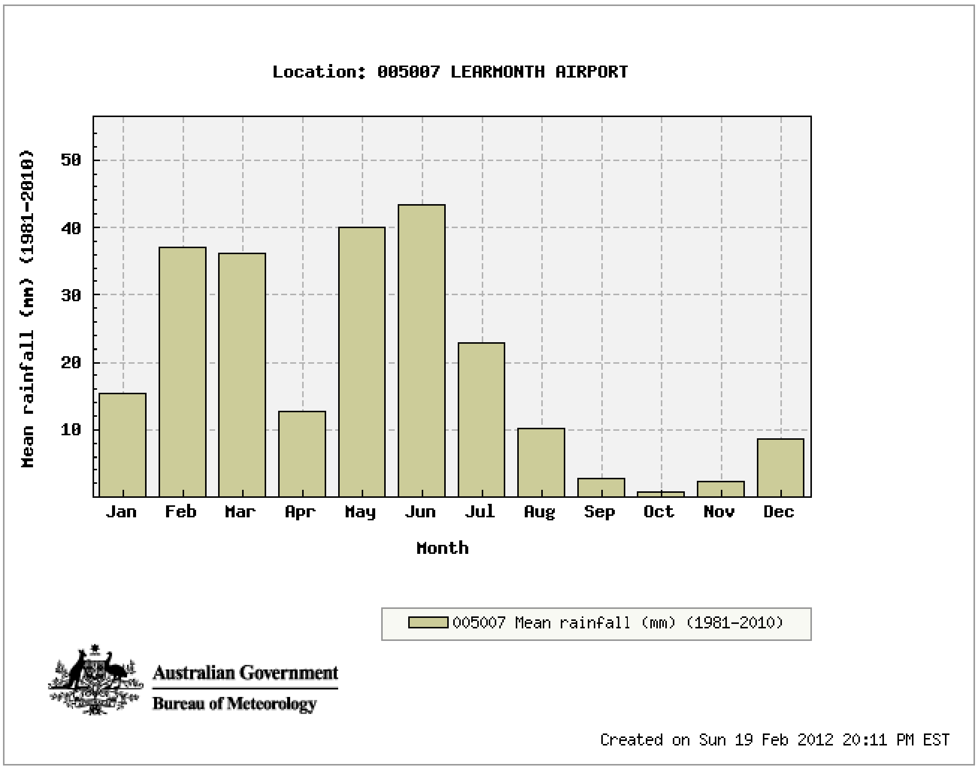


Figure 2.15.Mean Rainfall for Learmonth, located 30 km south of Exmouth. (Bureau of Meteorology Australia 2012)

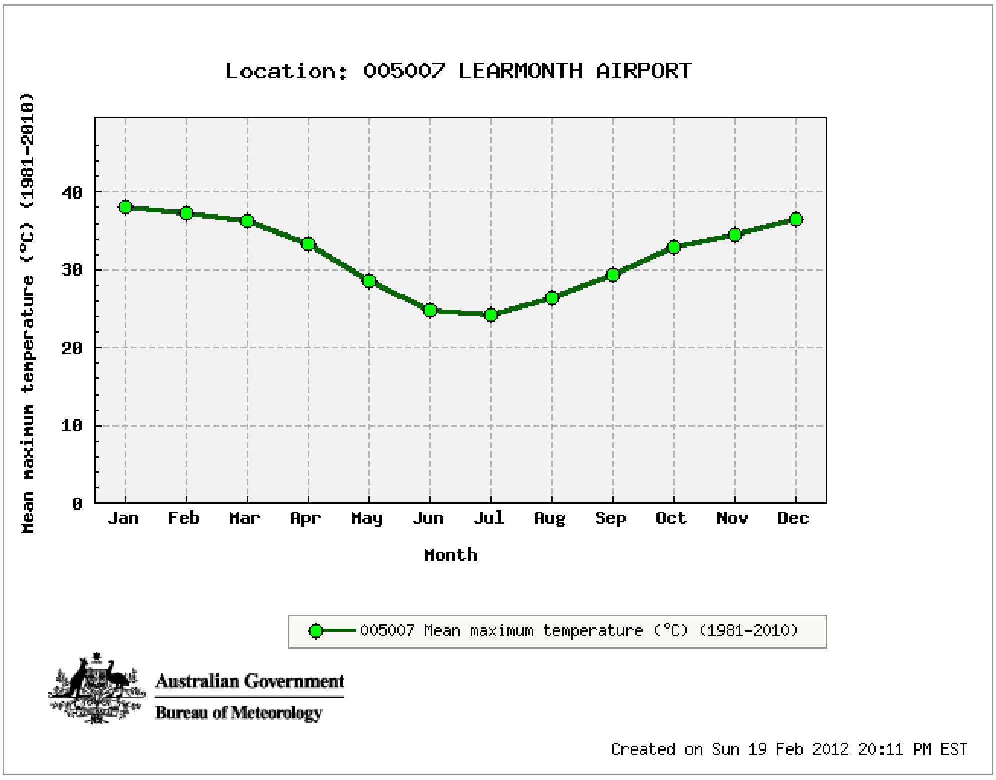


Figure 2.16. Mean Temperature for Learmonth, located 30 km south of Exmouth. (Bureau of Meteorology Australia 2012).

The semi-arid environment results from an annual rainfall of 200-300 mm which is far exceeded by an annual evaporation rate of approximately 2700 mm (Department of Conservation and Land Management 2005). In winter (June-August), rainfall is less intense than in summer but rain incidents are more frequent (Department of Conservation and Land Management 2005) (*Figure 2.16*). The driest months are September, October and November, with rainfall averaging less than 5 mm in each month (Bureau of Meteorology Australia 2012). Due to this low annual rainfall, low levels of run-off occur, allowing the reef system to grow close to shore (Department of Conservation and Land Management 2005). Summer (Dec-Feb) rainfall, a product or regional cyclonic activity, is irregular but can be heavy. Both wind and rainfall are significantly influenced by tropical cyclones which occur most frequently in February and March, with the region generally experiencing a cyclone around every two years. Severe cyclones are likely to cross the coast every 25 years. The Marine Park is slightly less influenced by cyclonic activity in the southern locations than in the north and most campers visit during the winter months when cyclones do not occur.

Coastal Geomorphology is considered to be the most significant physical factor influencing coastal land use planning (Hahesy 2004). Suitable levels of use and location for developments that can occur without causing environmental degradation are required. The landforms of the study area comprise two geomorphic districts (Payne, Curry et al. 1987), Cape Range and the coastal dunes. The Cape Range district, within Cape Range National Park, is the most elevated area of the Ningaloo coast, rising to 300m above sea level (*Figure 2.2*). The Range is an anticline structure characterised by deeply dissected limestone ridges and outwash plains. This in turn creates narrow valleys, deep gorges and limestone cave formations. The coastal biological communities adjacent to the Marine Park are typified by fragile Holocene dunal environments and hard coastal limestone platforms (Department of Conservation and Land Management 2005). Adjacent to the rangeland system, this coastal dunes district comprises gentle, stony upper slopes, sandy plains and outwash alluvial plains which receive run-off from the plateau (Commonwealth of Australia 2002).

The shoreline is characterised by sandy beaches, rocky benches or low limestone cliffs, sometimes with a sloping beach rock platform or a narrow fringing reef (adapted directly from (Department of Conservation and Land Management 2005). Camping grounds and day use sites located in the Holocene dune sequences and alluvial systems in the vicinity of the coastline are commonly characterised by poorly vegetated, unconsolidated mobile dunes (Hahesy 2004), classified as very high to extreme risk zones depending upon the magnitude of potential land use. Coastal beach ridges with a high percentage of vegetation coverage are at less risk to land use related degradation assuming that vegetation removal does not occur and these are classified as high-risk zones. Landward of the coastal dune sequences, land units consisting of a consolidated limestone foundation with high vegetation cover typically have a medium to high substrate capacity, though campsites are not found this far inland.

Primary coastal and inshore ecosystems along the Ningaloo coast include Coral Reefs and Sand banks. Extensive sand areas within the Ningaloo Lagoon provide substrate for microphytobenthos (microalgae), which support high primary productivity (Department of Conservation and Land Management 2005). Other ecosystems include algal communities, rocky shore communities, hard-bottom benthic communities and pelagic mid-water communities (Department of Conservation and Land Management 1994). Habitats include those of intertidal reef environments, lagoonal and fringing coral reef communities, and offshore oceanic environments of the continental shelf (Department of Conservation and Land Management 2005).

Reserves within the Ningaloo Marine Park contain a diversity of habitats which support over 200 species of coral, 600 species of mollusc and 500 species of fish (Department of Conservation and Land Management 2005). Habitats include those of intertidal reef environments, lagoonal and fringing coral reef communities, and offshore oceanic environments of the continental shelf (Department of Conservation and Land Management 2005). Marine mega fauna such as whale sharks, turtles, dugongs, sharks and manta rays also rely on marine reserves within the NMP, although it should be noted that many marine species are not permanently resident in the reserves and move through or in and out of the reserves during different stages of their lifecycles (Department of Conservation and Land Management 2005). Whale sharks are a key species of the nature-based tourism industry operating out of Coral Bay and Exmouth. The whale sharks can grow to 12m in length and are viewed from March to June each year. Turtle populations, including the loggerhead (*Caretta caretta*), green (*Chelonia mydas*), flatback (*Natator depressus*) and hawksbill (*Eretmochelys imbricata*) turtles, all of which nest along the foreshores and nearshore reef of the Ningaloo coast (Department of Conservation and Land Management 2005). Other marine fauna of significance, for both tourism and science, include a large number of cetacean species which are found in the Gascoyne, the most common being the bottlenose dolphin (Department of Fisheries 2002). Humpback whales travel through Gascoyne waters on their northern and southern migrations. The whales, which travel along the Ningaloo coast to breed and calve in the Kimberley during May to July, then migrate to Antarctica to feed from August through to October (Department of Fisheries 2002).

The diversity of terrestrial fauna within the study area, particularly in Cape Range, is significant with over 38 species of native ground mammal, 125 species of reptile, five amphibians and 200 species of birds within the study area (Commonwealth of Australia 2002). Terrestrial fauna overviews of the study area have been published for Cape Range (Kendrick 1993). Four fauna species, the Black-footed Rock wallaby (*Petrogale lateralis*) and the Pebble-mound Mouse (*Pseudomys chapman*) Lesser Sticknest rat (*Leporillus apicalis*) and the Peregrine Falcon (*Falco peregrinus*) are listed as Specifically Protected Fauna (Environmental Protection Authority 1997). An endemic skink lizard (*Lerista allochira*) of the Cape Range Peninsula also exists within the study area (Environmental Protection Authority 1997). Three reptile species, the green, hawksbill and loggerhead turtles are listed as threatened. Domestic species include sheep, goats, horses and cattle (Western Australian Planning Commission 2004), while introduced species including feral species such as cats, dogs, and foxes, rabbits and mice and goats place additional pressure on coastal vegetation.

Vegetation communities alongside the coast are of regional significance from a management perspective due to both their dune stabilising properties and the difficulty of restoring them (Western Australian Planning Commission 2004). The coastal biological communities are important because they protect dunes from erosion, and are an integral part of the seascape value of NMP (Department of Conservation and Land Management 2005). However, the coastal biological communities within NMP adjacent to the pastoral leases are generally in poor condition with extensive areas of degradation caused by recreational use of the coast and by grazing (Department of Conservation and Land Management 2005). The native *Triodia* has been replaced with buffel grass (*Cenchrus ciliaris*) throughout many pastoral areas. A proliferation of weed species around the towns of Exmouth and Carnarvon are also observed (Western Australian Planning Commission 2004). Arid perennial shrubs dominate the vegetation of the coastal communities. On dune fields, sandy plains and limestone within the study area, hummock grasslands with sparse overstoreys of trees and shrubs predominate (Western Australian Planning

Commission 2004). The dominant species represent a small number of families, namely *Acacia, Eremophila, Cassia, Atriplex, Triodia* and *Eucalyptus* (Snowy Mountains Engineering Corporation Australia 2000). Shrublands and low woodlands dominated by Acacia species gradually replace the hummock grasses on the sand sheets and dune fields in the eastern part of the study area (Commonwealth of Australia 2002). Due to the geomorphological diversity and aridity of the area, the diversity and richness of the floral species of the Cape Range Peninsula are highly important to the region (Environmental Protection Authority 1997).

2.4.2 Indigenous and Pastoral History

There is a great deal of Aboriginal history in the Ningaloo region as a result of extended occupation, which has been acknowledged under the *Aboriginal Heritage Act 1972* (Department of Conservation and Land Management 2005). Aboriginal people are known to have been in the region from at least 32 000 years ago (Morse 1993; Zell and Bedford 2005). Under section 359A of the *Environment Protection and Biodiversity Conservation Act* 1999 (the Australian Government's key environmental legislation), Indigenous people are not prevented from traditional use within a Commonwealth Reserve Area. This includes hunting and food gathering (for personal use), or ceremonial and religious purposes (Commonwealth of Australia 2002). The whole of the Ningaloo Marine Park is currently subject to an application for a determination of native title under the *Native Title Act 1993*, lodged in 1997 on behalf of the Gnulli Native Title Application Group (Environment Australia 2010). In 1998, the State purchased Cardabia Station, north of Coral Bay, on behalf of the Baiyungu people, who now also hold freehold land near the tourist resort town of Coral Bay north of Carnarvon and will manage new workers' accommodation being built in Coral Bay. An Aboriginal culture and heritage centre that facilitates tourists began operating in Carnarvon in 2009.

Pastoralism is one of the Gascoyne's oldest industries, commencing with sheep grazing in 1876 (Gascoyne Development Commission 2006) at Minilya Station (Commonwealth of Australia 2002). While the Station originally occupied the whole Cape Range Peninsula, it was later subdivided to comprise the stations that exist today (Commonwealth of Australia 2002). Sheep numbers in the Carnarvon Basin peaked in the 1920s but then fell sharply during the Great Depression (Gascoyne Development Commission 1997). Today about 85 % of the region is utilised for pastoral purposes (Zell and Bedford 2005), operated on a leasing system from Crown Land. When the original lease was subdivided in 1888, Thomas Carter acquired a 54,600 ha lease known as Yardie Creek (Gascoyne Development Commission 1997) and settled at Point Coates. The southern part of the station near Point Coates became Ningaloo Station which still operates today (Western Australian Planning Commission 2004). Over time, leases were subdivided to form the Stations currently present along the Ningaloo coast, including Yardie Creek, Ningaloo, Cardabia, Warroora, Gnaraloo and Quobba. Parts of Yardie Creek Station now form part of Cape Range National Park, after being acquired by the State Government (Commonwealth of Australia 2002). Pastoral stations produce cattle, sheep and more recently goats, all of which rely on natural pasture (Gascoyne Development Commission 2006). Currently low production levels and stocking rates prevail, with the low-yield situation not forecast to change in the near future (Western Australian Planning Commission 2004).

While the pastoral industry covers most of the greater Gascoyne Region, its exact monetary value is reportedly difficult to estimate (Department of Fisheries 2002) because the value of the pastoral industry fluctuates widely in response to both changing livestock numbers and market price. Currently, fifteen pastoral leases are represented within the study area of the Regional Strategy (Western Australian Planning Commission 2004), and the Gascoyne Region contains 66 pastoral leases (Gascoyne Development Commission 2006). As little surface water is available, livestock receive water from free-flowing artesian bores, windmills and dams (Gascoyne Development Commission 2006).

Over the past 100 years, settlement and pastoral development have resulted in significant landscape changes. The coastal strip is unfortunately highly prone to wind erosion resulting in loss of dunal integrity (Western Australian Planning Commission 2004). Invasive grasses are present within the terrestrial component of the Ningaloo Marine Park, which as previously mentioned includes the land up to 40 metres inland of the high tide mark. Overgrazing by livestock and native wildlife, such as the many kangaroos in the region, is common around artificial watering points provided by the stations. These areas where large numbers of hoofed animals congregate are often overexposed and are vulnerable to wind erosion, vegetation trampling and soil compaction (Western Australian Planning Commission 2004) The regional strategy therefore recommends restricting stock to areas capable of supporting pastoral activity with minimal landscape degradation. Diversification of pastoral activities has been deemed a necessity into the future. Other land use opportunities in the coastal zone, such as tourism, for which access and activities are in high demand, may be more sustainable (Western Australian Planning Commission 2004).

2.4.3 Popularity of Coastal Camping

Holiday-making in the form of caravanning and camping is a much valued part of Australian life (Western Australia Legislative Assembly 2009). By the mid-1950s, increasing car ownership gave rise to the popularity of caravanning (White 2009). Caravan parks and camping grounds have a number of social and economic benefits (Western Australia Legislative Assembly 2009, p. 6). Western Australian travellers have long sought out remote sections of the coast and established short (less than one week) to moderate term (up to four weeks) camps. These travellers primarily include residents of the local region, other Western Australians and interstate visitors, who often have strong social and cultural attachments to particular campsites (Jones, Hughes et al. 2009). In 1999, the Western Australian Government undertook an enquiry into the provision and status of caravan and camping across the State. Submissions to the enquiry highlighted the importance of camping and caravanning to the Australian Culture.

Submission No. 60 from Tourism Western Australia, 8 May 2009, p. 5:

> The Government must acknowledge the value that many Western Australians place on family holidays at a traditional caravan park by the beach. Through several generations, caravan parks were where the yearly holiday forged lifelong friendships while the kids played in a relatively safe environment and a campsite on a piece of grass overlooking a beautiful beach was within reach of most people (Western Australia Legislative Assembly 2009,p. 6)

Campers are often largely self-sufficient, carrying their own water, power, and toilet systems. While the surfers and fishermen venturing into the region in the 1960’s and 1970’s were met by padlocked gates and suspicious landholders, today tourism has the potential to substantially supplement pastoralists’ incomes (Baker, 2011). Campers value the isolation and the scenic beauty of remote camp sites, with popular activities including recreational fishing, bushwalking, wildlife observation and four-wheel driving (Jones, Hughes et al. 2009). Popular stations include Quobba, Gnaraloo, Warroora and Ningaloo, which all offer ‘wilderness’ camping and station stays along the Ningaloo coastline (Baker 2011) (section 2.3). Many regular visitors work with pastoralists on local environmental restoration projects (Jones, Hughes et al. 2009). Additionally, many long term campers who frequently visit the area undertake a number of valuable environmental protection and rehabilitation efforts. This initiative has been driven by individuals (including surfers, recreational fishers and four-wheel drive enthusiasts), engendering an ethic of environmental stewardship and a sense of community and belonging (Remote Research 2002; Davies, Tonts et al. 2009; Kobryn, Wouters et al. 2011).

Coastal camping was viewed as being a ‘low impact, culturally important’ local activity up until the 1980s. This perception shifted in the late 1990s and early 2000s to that of a ‘potentially destructive’ activity following political and public pressure to improve environmental protection measures for the Ningaloo Reef area (Davies, Tonts et al. 2009). This was in addition to rapidly increasing numbers of remote campers and a shift in planning from an economic to a sustainability rationale stemming from the ‘Save Ningaloo’ campaign (Jones, Ingram et al. 2007). It has since been recognised within the Regional Strategy (Western Australian Planning

Commission 2004) and other documents (Western Australian Planning Commission 2003; Western Australia Legislative Assembly 2009) that coastal sections of pastoral leases are under significant pressure from the rapid growth of recreational activities. Research surrounding tourism's impacts along the Ningaloo coast are further discussed in section 2.6.2.

2.5 REGIONAL SERVICES

Resources are extremely scarce along the Ningaloo coastline due to the limited facilities and services available (Department of Environment and Conservation 2004). Many resources such as the food, water and fuel consumed by the coastal campers are sourced from the regional centres, while waste and sewerage is disposed of within the coastal areas. Additionally, roads are frequently used by coastal campers which require more frequent grading and paving by local shires. While the focus of this study is on remote locations, the services provided by the regional centres sustain the coastal campers while they are in these remote areas. These towns are important in relation to coastal camping as the supply basin. Within the Ningaloo Region, three town sites are currently important hubs for residences, infrastructure and services (Jones, Hughes et al. 2009). Carnarvon (pop 6,500) and Exmouth (pop 2,300) are considered regional centres (Western Australian Planning Commission 2003) while Coral Bay is considered a sub-regional service and supply centre with a population of around 190 year-round residents (Small Township) (Figure 5.2) .

By road, Carnarvon, both the gateway to the Ningaloo coast and the service hub for Gascoyne communities, is 902 km north of Perth (Gascoyne Development Commission 2006). While infrastructure and services are central to the expansion of the tourism industry (Gascoyne Development Commission 2010), development in the region has taken place on an ad hoc basis. Infrastructure in the tourism centres of Exmouth, Carnarvon and Coral Bay is over-burdened, with the Gascoyne Region at full tourist capacity during the April to August peak tourism period (Gascoyne Development Commission 2010).

Previous research has found that the primary methods of transport by coastal campers is by vehicle (Remote Research 2002; Wood 2003; Jones, Hughes et al. 2009). The road system provides an essential transport link around the Region, especially for those camping along the Ningaloo coast. The coastal access network provides direct access to all pastoral stations within the study area. However, major reports such as the Regional Strategy (Western Australian Planning Commission 2004) have highlighted the need for improved coastal access as a result of issues surrounding the number of visitors to the Ningaloo coast.

Water availability constitutes a significant environmental constraint to future development (Western Australian Planning Commission 2003) along the coastline. Both Exmouth and Carnarvon have their own sources of fresh water, while Coral Bay operates on a dual water supply system, with fresh water sourced through desalination (Gascoyne Development Commission 2006). In remote coastal areas, the challenge of potable water availability needs to be addressed before any development proposal is accepted (Western Australian Planning Commission 2003). In remote areas, water must be carried by campers from regional centres since no potable water is available in the camping areas. Electricity is available within the town sites of Carnarvon, Coral Bay and Exmouth (Gascoyne Development Commission 2010). In the Gascoyne Region in general, there is a growing trend for wind and natural gas to be used instead of diesel fuel for power generation (Gascoyne Development Commission 2006). However, many homesteads on pastoral stations derive their power from solar and by generator, while remote campers also supply their own power sources.

Sewerage treatment presents a considerable environmental constraint to development in remote areas, especially those near fragile coastal locations (Western Australian Planning Commission 2003). Therefore, the lack of such basic facilities on the coastal stations presents some important problems for the environment (Wood and Glasson 2005). Only Quobba, Gnaraloo and Cape Range National Park provide toilets while Warroora Station is the only station which provides sewerage dump points for campers. Red Bluff and CRNP provide drop toilets. Management within Cape Range National Park removes 40,000 L of waste per year (Baker 2011). sections of Carnarvon and Exmouth have been serviced by deep sewerage, while in Coral Bay a deep sewerage system, with treatment ponds located away from the town and the ocean to minimise hazards has been installed recently (Gascoyne Development Commission 2010). Within a recent report on waste (Gascoyne

Development Commission and A Prince Consulting 2008), it was claimed that many visitors travelling through, perhaps to coastal areas, used the Caravan Parks as a ‘dump point’.

A Waste Data Report (Gascoyne Development Commission and A Prince Consulting 2008) and Strategic Waste Management Plan (Gascoyne Development Commission 2009) have been written for the Gascoyne Development Commission to address rubbish disposal in the region. Regional facilities service the main townships, whereas small landfills are owned and operated by the private sector to service the immediate needs of homesteads, roadhouses and coastal camping grounds. The Strategic Waste Management Plan (Gascoyne Development Commission and A Prince Consulting 2008) also reported that 238,000 visitors to the region stay in total 2,157,000 visitor nights per annum, which is equivalent to 5,555 residents, and generates 3,890 tonnes of rubbish per annum. This is equivalent to 1.93 kg per visitor per day. The Waste Data Report (Gascoyne Development Commission and A Prince Consulting 2008) found from an audit of a full-facility caravan park in the Regional Centre of Carnarvon that 39.6 % of rubbish by weight contained recyclable material. The follow-up feasibility study determined whether these resources can be reused locally, across Australia of internationally. This Strategic Waste Management Plan discusses the landfill challenges of the Station homesteads, the Blowholes and Cape Range National Park. The location of landfill sites adjacent to tourism developments has the potential to affect remote values and tourism amenity. It was reported that most landfill sites at Quobba and Gnaraloo homesteads have open pits and suffer problems with feral cats, foxes and wild dogs and seagulls. This may result in odour, pollutants leaching into groundwater and rubbish dispersal from strong onshore winds. Warroora has designed its own waste disposal facility incorporating a buried enclosure. There are currently no transfer stations, materials recovery facilities or alternative waste treatment facilities within the Ningaloo Region including its regional centres (Gascoyne Development Commission 1999).

2.5.1 Recent Political Context

A diverse group of regional stakeholders exist along the Ningaloo coast and in the larger Gascoyne region. Identified stakeholders within the Gascoyne region include tourism and recreation interests, the mining and petroleum industry, ports and shipping, agriculture, conservation groups, researchers, commercial fishers, recreational fishers, traditional fishers and aquaculturalists (Gascoyne Development Commission 1997; Department of Fisheries 2002). Therefore it is not surprising that change, including both greater tourism development and greater conservation in the region have been surrounded by controversy (Jones, Ingram et al. 2007). A proposal to build a marina development at Maud's Landing near Coral Bay resulted in a prolonged series of large protests in Perth, while the decision to extend the sanctuary zones at Ningaloo Marine Park in 2004 was vocally criticised by local residents (Ingram 2008). World Heritage nomination initially caused a public outcry, particularly from the President of the Exmouth Chamber of Commerce and Industry. Surfers have been also vocal in their efforts to preserve the status quo, campaigning against Rip Curl's now-aborted plans for a surfing World Tour event at Gnaraloo station, citing environmental impacts (Jones, Ingram et al. 2007; Baker 2011). Many Gascoyne locals are concerned that many decisions are made in Perth, with little regard for local opinions (Jones, Hughes et al. 2009).

The Ningaloo coast is also attracting significant attention from government agencies that are keen to preserve the natural environment while growing the region's tourism industry. For example, CSIRO has spent $36 million on research in recent years (Baker 2011). Due to its isolation, relatively little scientific or social research had previously been conducted, especially when compared with that devoted to the Great Barrier Reef. The recent World Heritage listing of Ningaloo Reef has shone a spotlight on coastal management practices in the area. Searching questions are being asked about waste management strategies at some makeshift campsites, and about the wisdom of allowing camping and four-wheel driving in fragile dunal systems (Western Australian Planning Commission 2003; Hugues-Dit-Ciles, Findlay et al. 2004).

While tenure and management responsibilities vary across the Ningaloo coast, pastoral tenures are the most contentious, with leasehold rights to a two kilometre coastal strip set to expire in 2015 at the end of the current 99-year leases. Negotiations are ongoing to determine how much coastal land the stations will have to surrender when the new leases are instated. As discussed by Baker (Baker 2011) in a recent article for Australia's Coastwatch, many of the pastoral leases were agreed upon 100 years ago or more, in 'a very different world, when the still new colony of Australia was keen to lease potential farming land to anyone keen enough to run livestock on it' (Baker 2011). Under the current lease agreements the pastoral camping areas, other than those that have been granted a tourism lease such as Red Bluff and Gnaraloo, can only charge 'access' fees (Baker 2011). However, some campers say there is no transparency in how the fees are spent and many want better facilities, such as enclosed tips and sewerage dumps, as Warroora has put in place, to reduce environmental impacts.

Pastoral lessees were notified in November 2002 of areas to be excluded from leases when they are renewed in 2015 (Western Australian Planning Commission 2003). While the Western Australian Government initially wanted to resume the two kilometre strip of land adjacent to the whole coast, the viability of pastoralists then making an income was questioned and an order over this tract of coastline was quashed. What that means for the existing unregulated coastal campgrounds is uncertain, though a joint management regime between pastoralists and Government is likely. Government agencies are unlikely to commit the resources to manage the 300 km of Ningaloo coastline by themselves. The WA Department of Regional Development and Lands released a discussion paper, Rangelands Tenure Options in April 2011 to determine the future of Pastoral Leases (Department of Regional Development and Lands 2011). Among its proposals is the granting of 'perpetual pastoral leases', to provide lease-holders with security of tenure to invest in infrastructure (Baker 2011). This is likely to attract interest from new investors and developers. This proposal is making locals and visitors uneasy due to the current affordability of the Ningaloo coastline for wilderness coastal holidays (Department of Regional Development and Lands 2011; Department of Regional Development and Lands 2011). Many believe that the pastoral leases, owned by crown land, should continue unchanged (Jones, Wood et al. 2011). Indeed, it is likely that the Liberal State Government will continue the pastoral leases. The previous State minister for Lands and Regional Development, who is pro-pastoral lease renewal, has the most control over the direction of the pastoral leases. These dynamics have changed with the change of Government at the 2008 election due to the role of the

National party at the last state election which gained the balance of power. With the election of the new government the WAPC (Western Australian Planning Commission 2004) order over the coastline came to an end. The *Regional Strategy* is still in place, but under review in 2013.

2.5.2 Legislation and Management

Australia provides a high level of legal protection to its World Heritage properties across three levels of government: national, state and local (Environment Australia 2010). The overarching responsibility for the legislative framework and governance arrangements for the Ningaloo coast falls on both the Australian Government and the Western Australian Government (a table of Management and Governance documents are provided in Appendix B). Two Acts of high importance to the Ningaloo coast are the State *Planning and Development Act 2005* and the National *Environmental Protection Act 1986.* Approval for development applications, including those for tourism development in current camping areas, is granted under the State *Planning and Development Act 2005*. The Ningaloo coast is unusual for a remote location in that the *Regional Strategy* is part of the State Planning Strategy.

Additionally, with National and World Heritage listing, the Environmental Protection Act 1986 applies to new developments that are likely to significantly affect National and World Heritage values. Currently, environmentally significant development proposals in Western Australia are assessed by the Environmental Protection Authority (EPA) under the Environmental Protection Act 1986. However, many proposals are not environmentally significant and will continue to be considered through existing local and state government statutory processes (Environment Australia 2010).

This Legislation is guided by several management plans and their complementary policies and programs pertaining to the Ningaloo coast (Environment Australia 2010). Planning frameworks aimed at protecting the environment on which the tourism industry thrives are recognised by governments as increasingly important (Lawrie 2010, p. 92). Relevant planning documents are outlined in detail within a recently published PhD thesis (Lawrie 2010), but those most pertinent to this study include: the *Regional Strategy*(Western Australian Planning Commission 2004) which was released in 2004 after extensive community consultation, establishes a framework for both land use and sustainable tourism on the Ningaloo coast and identifies tourism development nodes (Department of Environment Water Heritage and the Arts 2010).

Two documents informed the *Coastal Strategy* and underpinned subsequent management initiatives (Davies, Tonts et al. 2009): *Carnarvon - Ningaloo Coast Inventory and Assessment of Coastal Usage Patterns and Site Conditions* (Department of Planning and Infrastructure 2003) and *Future Directions: Sustainable Tourism and Land Use Scenarios for the Carnarvon-Ningaloo Coast* (Western Australian Planning Commission 2003). The first, *Carnarvon - Ningaloo Coast Inventory and Assessment of Coastal Usage Patterns and Site Conditions* (Department of Planning and Infrastructure 2003), included descriptions of the conditions of coastal camping locations and was prepared by the Department of Planning and Infrastructure. Within the latter, comments were provided on existing camping management arrangements and their limitations. While many remote, unmanaged campsite locations experienced little disturbance, the potential for unsustainable usage patterns was considered great (Davies, Tonts et al. 2009). The second, *Future Directions: Sustainable Tourism and Land Use Scenarios for the Carnarvon-Ningaloo Coast* (Western Australian Planning Commission 2003), invited feedback from the public on four scenarios previously prepared by the steering committee, the technical advisory group for the WAPC and a community stakeholder advisory group.

Most recently, the *Ningaloo Coast Strategic Management Framework* (Department of Environment Water Heritage and the Arts 2010) has defined the overall planning regime for the Ningaloo coast since the World Heritage nomination. It seeks to ensure that management of all parts of the property included in the listing is ‘consistent, coordinated and complementary’ p.10. It also provides a commitment by all parties to manage and protect the World Heritage values to meet Australia's obligations under the *World Heritage Convention* (Department of Environment Water Heritage and the Arts 2010). Additionally, there is also the previously mentioned WA Department of Regional Development and Lands discussion paper, *Rangelands Tenure Options* (Department of Regional Development and Lands 2011). The *Summary of Responses* (Department of Regional Development and Lands 2011) notes that tourism interest groups are supportive of the continuation of pastoral lease arrangements but are seeking wider powers for third parties to be involved, with or without the pastoralists, in the development of high-end tourist facilities.

With regard to management responsibilities, the Ningaloo coast is protected and managed under a thorough management system to ensure the highest level of environmental protection (management documents are provided in Appendix B). The responsible Australian Government agency is the Department of the Environment, Water, Heritage and the Arts while the Marine Parks and Reserves Authority is responsible for the Ningaloo Marine Park (State Waters). However, Ningaloo Marine Park (State and Commonwealth waters), including its terrestrial component, is managed as a single marine protected area with an ecosystem-based approach under a cooperative management arrangement between DEC (State), the Department of Fisheries (State) and the Department of Environment and Heritage (Federal). However, the day-to-day management of the various parts of the study area continues to be the responsibility of the existing owners/managers comprising pastoralists, DEC, Department of Defence (Federal) and traditional custodians. The local community and visitors also play an important role in stewardship for the Ningaloo coast (Environment Australia 2010). Management responsibilities for each study site were outlined in section 2.3.

2.6 RESEARCH ON THE NINGALOO COAST

This section outlines research that has been undertaken on the Ningaloo coast with regard to campers, and in particular to their preferences and activities, resource use and waste production, environmental impacts and management. While a number of studies have researched campers, very few studies focus on their environmental impacts along the Ningaloo coast.

Summarising the research concerning campers at Ningaloo is very challenging due to different sample numbers, different questions and differing study sites. Much of the data is presented as a general overview of the study site and the data from separate management areas, with the exception of that of Jones et al. (Jones, Hughes et al. 2009) which is not separated. For this reason, a summary table listing research undertaken along the Ningaloo coast applicable to this study has been prepared (*Table 2.3*). Detailed research findings surrounding demographics and preferred activities of campers along the Ningaloo coast are presented in Appendices C and D respectively.

Table 2.3

Research undertaken along the Ningaloo coast applicable to this Study.

Topic	Author
Camper Preferences and Activities,	(Remote Research 2002; Jones, Ingram et al. 2007; Moore and Polley 2007; Tonge and Moore 2007; Galloway and Northcote 2008; Ingram 2008; Northcote and Macbeth 2008; Lawrie 2010; Jones, Wood et al. 2011; Smallwood 2011)
Resource use	(Gascoyne Development Commission and A Prince Consulting 2008; Gascoyne Development Commission 2009)
Environmental Impacts	(Blackwell 2002; Environmental Protection Authority 2002; Leeden 2003; Hahesy 2004; Hugues-Dit-Ciles, Findlay et al. 2004; D'Andrea 2007; Bunning 2008; Kobryn, Pinnel et al. 2008; Davies, Tonts et al. 2009; Huat 2009; Kobryn, Wouters et al. 2011)
Management	(Schianetz 2007; Ingram 2008; Lawrie 2010)

2.6.1 Camper Characteristics and Preferences

Several studies have focused on remote campers along the Ningaloo coast. Geographically, their study areas varied in size from one camping area to the whole coastline adjacent to the Ningaloo Marine Park, incorporating all the remote camping areas. Questionnaires were commonly distributed, and to a lesser extent, interviews with campers were undertaken. Of most relevance to this study is research relating to camper perceptions and standards, attitudes to the environment, and trip elements rated as important (Galloway & Northcote, 2008; Jones et al., 2009; Moore & Polley, 2007; Polley et al., 2008). These studies indicated that the natural environment, solitude and the potential for self-reliant camping rated highly for all surveyed campers, while the need for facilities rated low. Another important study (Remote Research, 2002) qualitatively explored the reasons for campsite selection at Cardabia, Ningaloo and the Learmonth Air Weapons Range. Responses included:

good fishing, scenic views, sheltered and secluded campsites, good boat moorings, meeting friends, self-reliant camping and solitude. This research indicated that clear subgroups existed within the remote campers along the Ningaloo coast, differentiated through their demographics, repeat visitation patterns and preferred activities (Davies et al., 2009).

On the Ningaloo coast, factor analyses of tourist questionnaires (Jones, Hughes et al. 2009) revealed three distinct groups of visitors (including campers) who sought different experiences. These were 'the comfortable visit', the 'nature lover experience' and the 'fishing escape experience'. The most relevant to this study are the 'fishing escape experience' group, who camp for longer periods, in addition to 'the comfortable visit' seekers, who tow their accommodation with them. Davies, et al. (2009) identifies campers through the four most visible user groups: grey nomads, recreational fishers, surfers and windsurfers, and four-wheel drive tourists. These clear subgroups exist among the remote campers along the Ningaloo coast, differentiated through their demographics, repeat visitation patterns and preferred activities (Davies, Tonts et al. 2009). Grey nomads and four-wheel drive tourists are again divided into three groups each. It is acknowledged that there is a fair bit of overlap between four-wheel drive tourists and the other four categories. The goal of this paper is to compare user preferences segmented by management type, rather than to create typologies of Ningaloo campers.

The activities of those surveyed are spread through stations or the CRNP or both. The interviewees wee predominantly campers but Polley (Moore and Polley 2007) has also included half day visitors. Most surveys categorised what the campers thought was very important/extremely important or simply the activities undertaken by campers (Remote Research 2002; Galloway and Northcote 2008; Polley, Northcote et al. 2008; Jones, Hughes et al. 2009). Recreational uses of the Marine Park (Beckley, Smallwood et al. 2010; Smallwood 2011) were also explored. These latter projects found that relaxing on the beach, walking, snorkelling, fishing and swimming were the dominant activities along the shores of the Ningaloo Marine Park. Wildlife interaction, fishing and diving were the activities mainly associated with boats while snorkelling and diving were associated with coral reef habitats and sanctuary zones. Fishing was mainly conducted in general use and recreation zones.

Coastal camping was distributed over many sites adjacent to the marine park. In peak months, the highest use densities were recorded at Three Mile (Gnaraloo Station), Fourteen Mile (Warroora Station) and Red Bluff (Quobba Station).

2.6.2 Resource Use, Environmental Impacts and Management

Data surrounding the resource use patterns of these campers is limited to two waste management reports by the Gascoyne Development Commission (Gascoyne Development Commission and A Prince Consulting 2008) Strategic Waste Management Plan (Gascoyne Development Commission 2009), and a Masters research thesis on potential renewable energy sources by Chris Barker (Barker nd), Additionally, there is one unpublished study on the resource use of different accommodation sectors along the Ningaloo coast, though this focused on regional centres and not on remote campers (Jones and Lewis 2009).

While the lack of detailed baseline data presents a major challenge to management agencies in terms of designing effective and appropriate management arrangements (Davies, Tonts et al. 2009), there has been some discussion of recreational impacts along the Ningaloo coast. This includes a qualitative study on the impacts of surfers (Hugues-Dit-Ciles, Findlay et al. 2004), an Environmental Impact Assessment for a large-scale resort (Environmental Protection Authority 2002) and three Honours' dissertations on geomorphological mapping of the coastal zone. These studies analysed natural and anthropogenic coastal impacts, in addition to developing a land classification scheme based on substrate capability (Blackwell 2002; Leeden 2003; Hahesy 2004). Research into four-wheel drive vehicle tracks and vegetation densities utilising hyper spectral imaging was also undertaken to detect areas vulnerable to erosion and sedimentation (D'Andrea 2007; Bunning 2008; Kobryn, Pinnel et al. 2008; Huat 2009; Kobryn, Wouters et al. 2011). Additionally, a number of Government reports and online articles have highlighted the presence of the environmental impacts of camping along the Ningaloo coast (Western Australian Planning Commission 2003; Department of Conservation and Land Management 2005; Davies, Tonts et al. 2009).

The study by (Hugues-Dit-Ciles, Findlay et al. 2004) at Gnaraloo Station concluded that there was a lack of quantitative evaluation of the environmental impacts of tourism in the region, which could directly restrict the development of sustainable management strategies. Local campers and surfers are starting to accept that some of their own activities - camping and four-wheel driving in fragile dunes, collecting firewood, walking over reefs and digging bush toilets are likely to have adverse impacts (Baker 2011). The environmental impacts were related to access, consumption, surfing activity and ancillary activities. It is argued that careful planning and monitoring of the coastal roads and the access points to beaches is required in order to minimise natural resource degradation (Hugues-Dit-Ciles, Findlay et al. 2004).

Bunning's (2008) study observed that there was little control over the development and spread of coastline tracks south of Yardie Creek. These tracks then tend to diverge in a fan shape toward foredunes and beaches which create multiple access routes for visitors. It was therefore concluded that access track development has the greatest impact since it is frequently uncontrolled, and that this causes the proliferation of networks of tracks (Bunning 2008). Significant degradation of this fragile environment, predominantly the erosion and remobilisation of sediment, occurs despite the land and tourism management strategies already put in place on the respective Stations. Degradation is associated with nodes of activity that are typically established campsites, heavily used tracks or camping facilities. However, within the Cape Range National Park, effective management of roads, tracks and paths was observed. These had been aligned and constructed to minimise habitat degradation and disruptions to faunal movement. The type of land tenure was important since it defines the management arrangements along the coast, also the type and amount of vegetation potentially impacted by four-wheel drive tracks varied along the coast according to vegetation association distribution and land tenure. Tourist accommodation also has an impact on surrounding vegetation. Finally, the number of access tracks was greater in coastal areas not vested in the Department of Environment and Conservation tenure area.

Research by the three Honours dissertations concluded that Steve's Camp (Warroora Station) had substantial track development causing the initiation of dune degradation, while at Bruboodjoo Point high use areas bordering the coast have very low substrate capability. The dunes behind are low capability while the flat areas on the high ground have medium to high capability (Blackwell 2002). This suggests that the current campsites are not optimally located from an environmental perspective. Clare Hahesy (2004) concluded that, within Cape Range National Park, activity nodes are located in Holocene coastal dune areas where substrate capacity is low and they are therefore at high risk of degradation. This is because the substrate in these regions is highly susceptible to change. For the study areas of Gnaraloo and Red Bluff, Cherie Leeden (2003) argued that poor access track development and lack of environmental maintenance have the greatest anthropogenic impacts on the coast adjacent to the Ningaloo Reef. These are followed by the environmental impacts associated with nodes of activity such as camping sites. The degradation predominantly occurs as erosion and remobilisation of sediment, triggered by the loss of vegetation. Such degradation is more pronounced in those areas which receive significantly higher tourist and vehicle numbers. Despite the various land and tourist management strategies put in place by the pastoral station managers, Leeden (2003) states that significant degradation of this fragile environment is occurring. No studies have provided detailed impact assessments along the Ningaloo coast of the environmental impacts brought about by camping activity.

2.7 CONCLUSION

An examination of the management areas comprising the study area has demonstrated the importance of remote coastal camping to visitors and the complexity of the political arena along the Ningaloo coast with regard to tenure and management. What have also been demonstrated are the differences between all nine management regimes despite their only occupying a 300 kilometre stretch of coastline within one World Heritage area. The management areas are unique with reference to the sites' locations, size, and number of camp areas, facilities, tenure, relevant legislation and environmental features. Additionally, it has been demonstrated that a host of anthropogenic environmental challenges currently face all these areas. Concerns include the impacts of four-wheel drive vehicles for access to campsites and activities, trampling of dunes, removal of firewood, lack of effective waste and sewerage disposal, and unmanaged boating, fishing and snorkelling activities. Despite the World Heritage listing, few grounded studies have been undertaken on the precise environmental impacts of camping along the coast, or of the resource use patterns and preferences of the campers. No studies have compared the management regimes to better understand the relationships between management and these three factors. Therefore, this chapter has established that further examination of coastal camping along the Ningaloo coast is warranted to contribute important regional baseline data and to contribute to the field of recreation ecology in arid and coastal environments.

Chapter 3: Literature Review

Figure 3.1. Fourteen Mile Boats, Warroora.

3.1 INTRODUCTION

While the Study site of this research is located in a coastal, semi-arid environment and is highly sensitive to human impacts, it has become a popular remote camping destination. The future of tourism in the Ningaloo Marine Park depends on its sustainability, largely through the maintenance of the integrity and diversity of its natural environment (Wood 2003). Careful guidelines for decision makers (Moscardo, Pearce et al. 2001) on what is deemed sustainable development are also essential (Wood and Glasson 2005). It is therefore argued that careful planning of future tourist developments and the management of existing activities in the area are extremely important (Wood and Glasson 2005).

Managing recreation resources requires both descriptive and evaluative (judgmental) considerations (Vaske 2008). The aim of this chapter is therefore to provide an understanding of previous research surrounding camping preferences, resource use, and environmental impacts and their management to put the current Ningaloo situation into the context of both the international literature, and the mixed methodological approach of this study. Those studies which have compared preferences, resource use or environmental impacts across management regimes will also be examined. However, regulation and management in the context of camper preferences and resource use has generated a limited research literature to date.

Research pertaining to camper preferences for various campsite attributes is presented in section 3.2. The major research findings on the resource use of camping and other forms of tourist accommodation in remote areas are located in section 3.3. Insights into the impacts of vehicle-accessed coastal camping activities at Ningaloo can be gained by reviewing the literature on three analogous locations: forested environments, coastal environments, and semi-arid environments. Across these environments, the impacts of hiking, camping and four-wheel driving are examined in section 3.4. The management of camper impacts is reviewed in section 3.5. This chapter focuses on national and international literature to complement the review of local research that has been undertaken on camper preferences, resource use, environmental impacts and management at Ningaloo Reef which was outlined in section 2.6. A conclusion outlining how the literature leaves unanswered questions that this thesis seeks to address in the context of Ningaloo is presented in section 3.6.

3.2 CAMPER PREFERENCES

3.2.1 Importance of Camper Preferences

Knowledge of visitor preferences is vital for both planning and management purposes, and for promoting a positive visitor experience (Roggenbuck and Lucas 1987). Having a good understanding of camper preferences is a necessary first step to the planning and design of campsites (Foster and Jackson 1979). The preferences held by campers have been shown to affect both camper use patterns and campsite popularity (Choi and Dawson 2002). Thus, it is commonly accepted that some campsites in given locations are heavily frequented, while others are hardly used

(Hendee, Stankey et al. 1978; Gascoyne Development Commission and A Prince Consulting 2008). From an environmental perspective, uneven campsite distributions can result in a mismatch of use, with high densities of campers residing on unsuitable fragile sites (Cole 1987). In terms of the camper experience, campsite location choices can affect the sense of solitude of remote campers (Stankey 1973), strongly influencing their perceptions of the quality of their experiences (McCool, Stankey et al. 1985). Through careful planning, knowledge of key desirable attributes may aid in reducing conflict between the conservation goals held by managers and the experiential goals of the campers (McCool, Stankey et al. 1985). Campsite attributes considered desirable from within the international literature are noted below.

3.2.2 Campsite Attributes considered Important to Campers

The literature on those campsite attributes considered important by campers was reviewed by Choi and Dawson (2002). Key attributes influencing site selection include: distance between campsites for privacy, amount of vegetation for shade and screening; vegetative barriers; visibility of ponds, lakes and rivers from the site, accessibility to water from the site, campsite level ground; use levels and crowding; and level of campground and campsite developments (Clark, Hendee et al. 1971; Foster and Jackson 1979; Heberlein and Dunwiddie 1979; Bumgardner, Waring et al. 1988; Brunson and Shelby 1990). Stankey (1973) argued that seclusion at campsites was the most important aspect for most visitors, while Lucas (1990) claims that waterfront sites were the most universally desirable factor for campsite selection. Lime and Lucas (Lucas 1970; Lime 1971) also concluded that highly used campsites are either immediately adjacent to, or within view of, water bodies.

The literature notes that preference research focusing on the experiences and meanings of camping has steadily declined since the camping boom in the 1960s and 1970s within the United States Garst (2005). This earlier research mainly described both camper characteristics and the public's participation in camping (Bury and Margolis 1964; King 1965; Beardsley 1967; LaPage 1967; King 1968; LaPage 1968; Shafer 1969). The research focus then shifted over time to reflect management needs in different geographical regions (Brunson and Shelby 1990). As a result, camper preferences relating to campsite attributes have been studied in a wide variety of settings (Lime 1971; Pfister 1977; Harris 1982; Clark, Koch et al. 1984).

Within Australia, Winter (2005) examined the attitudes of vehicle-based campers toward site management for unregulated camping areas on the Murray River and this is the most directly comparable study to that of campers along the Ningaloo coast. However, she grouped campers by their demographic characteristics rather than by campsite attributes, as is done in this study. Campers were divided into two groups, 'recreationalists' and 'nature-lovers', who differed significantly in their attitudes to toilet and shower facilities in particular. Overall, the least popular options for facilities were barbeques and car parking, yet firewood being provided was generally popular. Respondents agreed that they preferred to have no rules, and that they should be free to camp where they liked. They disagreed that there should be a limit to the number of campers allowed to camp, and with being told what they could and could not do.

While some authors have argued that common themes can be found between different camper studies (LaPage 1966; Zuckert 1980), others have strongly argued that campsite preferences are inconsistent across different recreational settings. Bumgardner, et al. (1988) stated that inconsistencies in the camping preference literature were due to variations in the natural resource, region, and desired activities that formed part of the studies. Because of this variability in research settings and results, it is argued that camper preference findings within the literature cannot be generalised and thus cannot function as a reliable guide for managers in specific locations. According to Shafer (1969, p. 1) in his article 'The average camper who doesn't exist', "there is no more use comparing preferences across regions than of comparing widgets to wombats". He considered that grouping camper research findings would result in the fabrication of a non-existent 'average' camper, which can be misleading for management. This phenomenon has been exacerbated by a growth in the mass-market appeal of camping for an increased range of demographic types (LaPage and Cormier 1977; Matheusek and Allan 1983). Consequently, common practice has focused on the identification of camper subgroups, or 'market segments'. Knowledge of these segments is considered vital both for campsite planning and to market management decisions to relevant camper audiences

(Crompton 1983). Most of this research originated from forested Alpine camp areas in the United States, and few studies have been conducted on campsite preferences in an Australian setting (Morin, Moore et al. 1997; Smith and Newsome 2002; Winter 2005; Moore and Polley 2007). Even rarer are studies surrounding camper preferences in remote camping locations accessed by motor vehicle (Winter 2005), or in coastal settings. This is despite the growth in these recreational markets (Winter 2005).

3.2.3 Campsite Attribute Preferences under Different Management Regimes

Since the study area for this research comprises nine different management areas (section 2.3), previous research which compares preferences across geographical locations is relevant. Various studies have compared preferences between different types of camp areas, such as the patrons of public and private, or primitive and developed campgrounds McEwen and More (1986). Hammitt (2006) investigated camper choice behaviours between three camp settings with different facilities, located within a three mile radius. Six of the eight user characteristics measured were found to be significantly different, indicating that the three site settings were serving distinct groups of campers. Bumgardner, et al.(1988) found that campers in developed campgrounds considered utilities to be most important attribute, while campers in undeveloped campgrounds favoured water body visibility, a good breeze and site privacy. McEwen and More (1986) found those in private developed and public developed campgrounds prioritised both utilities and social context, while campers at primitive sites had an aversion to commercialization within the campground. By contrast, Choi and Dawson's (2002) study, which compared three 'less-developed' to three 'more-developed' campgrounds, found that all of the campers had similar preferences. It should be noted that the 'less-developed' sites in this study were relatively developed when compared with 'primitive' sites such as those researched by McEwen and More (1986) researched in other studies. These 'less-developed' sites were also more developed than all the Ningaloo management areas assessed within this study since they contained sewerage dump points, fresh-water showers and playgrounds.

The alleged reasons behind these preference differences were varied. In addition to amenities and management, it was found that preferences were also based on the characteristics of the camping groups such as their size, activities, convenience, travel patterns, recommendations from friends and prior knowledge (Shafer 1969; Heberlein and Dunwiddie 1979; Zuckert 1980; Roggenbuck and Lucas 1987; Hendee, Stankey et al. 1990; Choi and Dawson 2002; Hammitt 2006). Prior knowledge of a region may influence individual campers who are either familiarity seekers or novelty seekers, and this in turn can affect their campsite preferences (Lucas 1970). Improvements in camping equipment thus creating greater comfort, have created a wider demographic of campers. This has resulted in some individual campers displaying stronger social and weaker environmental orientations at developed campsites (Etzkorn 1964; Burch and Wenger 1967). Whether or not campers would substitute one site for another in a different management area has also been examined, with findings supporting the notion that different users want particular experiences and therefore will rarely substitute one site for another (McEwen 1986; Hammitt 2006). McCool (1985) noted that, while campers will often ‘make do’ with what is available at any given location, this may not necessarily be considered satisfactory. However, other studies found that, despite different preferences, campers substituted sites quite often (Bumgardner, Waring et al. 1988). For the Ningaloo coast, it may be possible to increase the infrastructure for the region in a way that can satisfy the majority of current visitors if the environmental impacts of visitation are deemed to be unacceptable particularly if numbers increase further. Evidence from the interviews suggests that visitors would respond more positively to management by the pastoral station owners than by government agencies. For instance, the owners of Warroora Station advocate a two fish per day policy, which may reduce catch without causing resentment (Jones, Hughes et al. 2009). Perceptions of campground management are therefore a very important component of site selection for many campers (McEwen 1986).

3.3 RESOURCE USE IN REMOTE AREAS

3.3.1 Importance of Resources in Remote Coastal Environments

By definition, remote locations are difficult to access (Carson and Harwood 2007) and many lack basic infrastructure (Zurick 1992). Remote area tourism landholders in Australia therefore face a number of difficulties, including the provision of basic infrastructure such as water supply, energy generation and waste removal (Western Australian Tourism Commission 2000). While all tourism destinations are susceptible or sensitive to disturbances, remote tourism's emphasis on pristine nature and isolation render the surrounding environments highly vulnerable to damage (Haider and Hunt 1997). However, the appeal of these pristine natural landscapes is the basis for their promotion to visitors (Erdogan and Tosun 2009). The Ningaloo coast is no exception, with the Ningaloo Strategy (Western Australian Planning Commission 2004) describing the study areas within this research as either Remote or semi-remote (section 2.3).

Resorts, eco-lodges, full-facility caravan parks and campgrounds currently exist, or have been proposed along the Ningaloo coast over the past decade (Western Australian Planning Commission 2004). In 1999, the Coral Coast Resort which comprised a tourist, residential and incidental commercial facilities at the Maud's Landing site between Coral Bay and Cardabia was proposed but later rejected (section 2.5.1). This proposal also included a 62 hectare Services Area to develop infrastructure and public utilities services, including solid waste management, a power station, storage of natural gas, general stores and wastewater treatment infrastructure.

Tourism nodes catering for up to 500 people are currently proposed along the Ningaloo coast. Eco-lodge nodes have been proposed within the Ningaloo Strategy (Western Australian Planning Commission 2004) as being located at Gnaraloo Bay, Elle's Camp (Warroora), and Cape Range National Park where an eco-lodge, Sal Salis, currently exists. Along the Ningaloo coast, resource use with regard to development is an important issue due to its semi-arid location and sensitive environment, and these have been considered widely within planning documents (Wood 2003; Western Australian Planning Commission 2004; Gascoyne

Development Commission 2009). As outlined in the Ningaloo Strategy (Western Australian Planning Commission 2004), proposed tourism developments will require water and energy and will produce waste which then needs to be disposed. Accommodation providers will no doubt need to consider available resources and waste management within this remote, semi-arid environment. This section examines the resource use requirements for the different accommodation types found in remote areas including hotels, resorts, eco-lodges and caravan parks. These will be compared with the levels of resource use currently practiced by remote campers along the Ningaloo coast, later in the thesis (Chapter 7).

3.3.2 Impacts of Resource Use in Remote areas

The tourism literature discusses many adverse environmental impacts resulting from tourism development (Schianetz 2007). Accommodation facilities including hotels, resorts and campgrounds are most frequently criticised due to their potentially negative environmental consequences (Erdogan and Tosun 2009). The onsite impacts of most concern are resource use and waste production (Buhalis 2000; Western Australian Tourism Commission 2000; Jónsdóttir, Sparf et al. 2005). Tourism development in remote protected areas such as national parks and reserves creates environmental challenges related to water and energy production and effluent and solid waste disposal.

Intensive water extraction to supply tourism accommodation and amenities can result in depletion of water (Sasidharan, Sirakaya et al. 2002), Accommodation facilities may use local ground water (as is the case on the Ningaloo coast) instead of scheme water piped from dams, and this can result in vegetation death which has large and sustained impacts in the harsh environment (Newsome, Moore et al. 2002). Various forms of environmental pollution waste can result in a range of impacts from decreased visitor satisfaction to wildlife kills (Newsome, Moore et al. 2002). Other problems include the disposal of liquid and solid waste, which at Ningaloo is challenging due to the remoteness. Rubbish also attracts wildlife. Goats, sheep and kangaroos visiting camping areas can transmit diseases (Newsome, Moore et al. 2002). Additionally, local populations can be affected by these impacts, as occurred in the Caribbean where several islands experienced water and power shortages as a result of the tourism industry consuming too much power, using approximately twice as much as the locals (Jackson 1986).

The extent of any negative impacts depends on a variety of factors. These include the developments' locations, building designs and adaptation to existing natural conditions, waste treatment systems, recycling and pattern of resource consumption (Smith and Newsome 2006). For remote and protected areas worldwide, funding challenges can result in a failure to provide proper maintenance, development and management of facilities and surrounding environments (Moore, Smith et al. 2003; Alpizar 2006). These challenges are also felt along the Ningaloo coast, which comprises a large geographical area for local management staff to regulate and monitor.

Built amenities such as roads, picnic sites, viewing platforms, boardwalks and visitor centres are often the focus of intense visitation (Buckley and Pannell 1990). The consequence of these activities and associated impacts is that they can alter the character of the region, particularly in fragile, remote and supposedly pristine locations (Dinan 2000).

In fragile coastal areas, accommodation impacts can contribute to beach erosion, deterioration of water quality, flooding and the disappearance of natural wetlands (Mastny 2002; Worboys and DeLacy 2003). The value of tourism in these instances may be outweighed by its impacts. To address these challenges along the Ningaloo coast, a setback for coastal accommodation has been recommended by the Regional Strategy (Western Australian Planning Commission 2004).

3.3.3 Comparison of Resource use between Different Facilities

There are many different types of accommodation available to a range of visitors in remote nature-based recreational areas which include campsites, huts, and caravan parks, resort developments and hotels (Erdogan and Tosun 2009). Within Western Australia establishments in remote areas tend to be small-scale, nature-based, facilities, often managed by owner operators (Western Australian Tourism Commission 2000) while large coastal developments have been controversial. Remote locations such as Ningaloo are promoted as the 'real Australia' by the

Western Australian Tourism Commission. Due to limited resources and its fragile coastal environment, development envisaged for the Ningaloo coast tends toward the low-impact, eco-lodge style of development (Western Australian Planning Commission 2004). Larger-scale, resource intensive tourism developments are planned for regional centres such as Carnarvon and Exmouth which have suitable infrastructure and facilities such as sewerage and power (Western Australian Planning Commission 2004). Yet coastal areas outside town sites, such as the Blowholes camp area have been identified as potential sites for full-amenities style caravan parks. As a variety of accommodation styles are therefore being considered for the Ningaloo coast, the water, energy and waste requirements of these proposed accommodation types merit exploration.

Although information surrounding resource use and waste production of different accommodation types in remote areas is generally lacking (Becken 2002), it has generally been found that different accommodation types (such as hotels, backpacker hostels and caravan parks) require different water and energy usage requirements, and have varying levels of waste output (Nepal 2008; Erdogan and Tosun 2009) (*Table 3.1*).

For electricity use, the findings between studies varied substantially for each accommodation type. Vacation hotels/resorts had the highest electricity consumption in one study (340MJ per guest night) (Australian Bureau of Statistics 2000; Earthcheck 2005), but also one of the lowest (38.9MJ per guest night) in another (Jones and Lewis 2009). Full-facility caravan parks were found to use the least electricity overall, with energy consumption values ranging between 16MJ and 31MJ per guest night (Warnken, Bradley et al. 2005). Water usage also fluctuated, with resorts exhibiting the highest overall usage (605-780L per guest night). Resorts often have large green areas and consume a large amount of water through fountains, swimming pools and gardens (Trung and Kumar 2005). Other significant areas of water use in resorts are within the guestrooms themselves, the laundries and the kitchens (Trung and Kumar 2005; Ali, Mustafa et al. 2008).

Interestingly, even fully-accredited eco-resorts fail to achieve above average standards when measured against environmental performance indicators for energy and water consumption. Eco-lodges audited by (Warnken, Bradley et al. 2005) consumed on average164MJ per guest night of electricity and 653L per guest night of water which was higher than some hotel audits.

In an attempt to minimise resource use by mainstream accommodation facilities within remote areas, eco-lodge style accommodation has been developed which ideally reflects international standards for ecotourism certification (Russell, Bottrill et al. 1995), such as the Nature and Eco-tourism Accreditation Programme (Buckley 2002). However, their environmental performance with regard to resources has been little researched (Osland and Mackoy 2004). One such study by Warnken (2005) compared five eco-resorts against eleven hotels, thirteen condominium complexes and six caravan parks in Queensland. The complexities of comparing these accommodation types arose from the buildings' individual characteristics such as age, size and layout, extent of communal facilities and climate. For example, there is a large variation in the per capita energy consumption in the eco-resorts (Warnken, Bradley et al. 2005), which varied between 7 and 257 MJ/guest night. Large variations were also found for full-facility caravan parks, which had a large variance of between 132-558 MJ per guest night for energy consumption. The businesses that incorporated eco-efficiency into their planning phases had the best results, although none of the businesses could provide data for waste generation, including wastewater (Warnken, Bradley et al. 2005; Trung and Kumar 2005).

Table 3.1

Water and Electricity use by different Accommodation Types.

Accommodation types	**Electricity (MJ/Guest Night)**	**Author**	**Water (L/Guest Night)**	**Author**
Vacation Hotel/Resort	340	(Australian Bureau of Statistics 2000; Earthcheck 2005)	780	(Australian Bureau of Statistics 2000; Earthcheck 2005)
	155	(Becken, Frampton et al. 2001)		
	191	(Warnken, Bradley et al. 2005)	621	(Warnken, Bradley et al. 2005)
	38.9	(Jones and Lewis 2009)	605	(Jones and Lewis 2009)
Motel	170	(Australian Bureau of Statistics 2000; Earthcheck 2005)	270	(Australian Bureau of Statistics 2000; Earthcheck 2005)
	32	(Becken, Frampton et al. 2001)		
Bed and Breakfast	240	(Australian Bureau of Statistics 2000; Earthcheck 2005)	340	(Australian Bureau of Statistics 2000; Earthcheck 2005)
	110	(Becken, Frampton et al. 2001)	No data	
Holiday Rental	27.694	Jones, Lewis	452	(Jones and Lewis 2009)
Hostel	170	(Australian Bureau of Statistics 2000; Earthcheck 2005)	270	(Australian Bureau of Statistics 2000; Earthcheck 2005)
	39	(Becken, Frampton et al. 2001)	No data	
Eco-lodge	164 (mean)	(Warnken, Bradley et al. 2005)	653	(Warnken, Bradley et al. 2005)
			20	(Salis nd)
Full-facility Caravan Park	25	(Becken, Frampton et al. 2001)	No data	
	31	(Warnken, Bradley et al. 2005)	558	(Warnken, Bradley et al. 2005)
	16	(Jones and Lewis 2009)	132	(Jones and Lewis 2009)

Many guidelines for best-practice lodges have now been published (Beyer, Elber et al. 2005) and, along the Ningaloo coast, two eco-lodges or 'safari bungalows' operate as best-practice models to reflect the low resources available in the region. All three Eco Safari style Bungalows sleep from two to eight people and have full size fridge/freezers, rainwater showers, "Natureloo" environmental toilets and private decks. Seascape Bungalows are fully self-sufficient and run on 24 hour solar power and rainwater. Sal Salis, is a model ecotourism camp subject to licence conditions set by the Department of Environment and Conservation. Whilst catering to the luxury market and therefore very expensive, by virtue of its small size (5 luxury tents) its impact on the environment is minimal

With regard to primitive campers, no research on resource use, or from where their resources were obtained, has been undertaken. While they are unlikely to use as many resources as those in mainstream accommodation types, large numbers of campers in sensitive environments still produce waste and require resources. Their presence can put pressure on surrounding towns and on the environment. While this considered beyond the scope of this review of site-related resource use, transport impacts have been the only ones examined for primitive or remote campgrounds. While transport is the key driver of energy use for all tourists, it is most important for camping tourists, accounting for 79 % of their carbon output through energy use (Becken and Cavanagh 2003). While camping tourists consume the most energy per trip, because they travel long distances and stay for a long time, when this is expressed on a daily basis, they travel comparatively energy-efficiently (Becken and Cavanagh 2003). No recent literature has been located which describes resource use of remote campers who camp for long periods with few facilities (Remote Research 2002). The resources consumed by this group are of interest because resources are likely sourced from regional centres, yet waste is likely deposited locally near to the camp areas.

3.4 ENVIRONMENTAL IMPACTS

3.4.1 Ningaloo in the Context of Recreation Ecology Research

Recreation ecology can be defined as 'the scientific study of recreation impacts' (Leung and Marion 2000, p.80) and may be considered as the study of the ecological interrelationships between humans and the environment in recreational and tourism contexts (Wagar 1964; Leung and Marion 1996). The detrimental effects of recreation and nature-based tourism are many (Thompson and Schlacher 2008), spanning from physical habitat damage to reductions in plant and animal abundance and diversity (Hosier and Eaton 1980). Recreation impact studies originally fell into four groups; plants, soils, wildlife and aquatic. However, discipline boundaries have been crossed as new problems arose, resulting in the formation of the new discipline of recreation ecology.

The earliest research was undertaken in coastal and mountainous areas due to their high visitor numbers (Cole 2004). However, the majority of work has since been conducted in forested mountain regions, while recent coastal work has shifted to reef and intertidal impacts (Hawkins and Roberts 1993; Rouphael and Inglis 2002). Since the 1980s, the geographic distribution of studies has expanded, to incorporate ecotourism destinations beyond North America and Europe (Cole 2004).

Within Australia, many studies have been conducted since the 1980s (Liddle and Thyer 1986; Liddle and Kay 1987). Buckley et al.(2006) and Sun and Walsh (1998) provide excellent summaries of recreation ecology research undertaken within Australia. Most Australian research has been within protected areas experiencing high-impact activities. However, the environmental impact to previously quite remote regions such as central Australia has also been explored (Hillery et al 2001).

Camping studies have been conducted in tropical areas (Talbot, Turton et al. 2003; Turton 2005; Wilson, Turton et al, 2004), eucalyptus forests (Smith and Newsome 2002) and the Australian Alps (Growcock and Pickering 2011). While there are many marine-focussed studies such as those of scuba diving on corals (Plathong, Inglis et al. 2000; Rouphael and Inglis 2002) and whale watching (Higham and Lusseau 2004), coastal research appears to have been restricted to four-wheel driving impacts along beaches (Hercock 1999; Priskin 2003; Foster-Smith, Birchenough et al. 2007; Schlacher and Thompson 2007; Schlacher, Thompson et al. 2007; Schlacher and Thompson 2008; Sheppard, Pitt et al. 2009; Lucrezi 2010; Schlacher and Lucrezi 2010).

Campsite impacts have until recently received research attention almost exclusively in North America (Morin, Moore et al. 1997; Smith and Newsome 2002). Most campsite studies have been conducted in the back country areas in the United States (Cole 1987; Leung and Marion 2000; Smith 2003). In more recent years it is still the case that most research is conducted in alpine and subalpine ecosystems or in humid forests (Andrés-Abellán, López-Serrano et al. 2006). Few studies have been carried out in semi-arid (Atik, Sayan et al. 2009), or coastal conditions despite Monz et al.(2000) arguing that such surveys are needed to make comparisons of recreational impacts across different ecosystem types.

Additionally, Buckley (2006) questions whether findings from one country can be applied to comparable ecosystems elsewhere. This is because recreational impacts differ considerably between activities and between ecosystems' (Buckley, Pickering et al. 2006, p. 84). Different continents and geographical regions have different flora, fauna, terrains and climate (Weaver 2001; Buckley 2004). For this reason, while studies from similar ecosystems may be comparable, they are all unique. There are very few study sites comparable to Ningaloo, but these include coastal camping on Fraser Island Australia (Hockings 1997; Hockings 1998), and at Baja in Mexico (Monz 1998).

As the Ningaloo coast is a coastal, semi-arid environment, many of the impacts found and the methodologies used within the traditional, forested recreation ecology literature do not apply. This was also noted by other researchers in coastal or semi-arid environments (Monz 1998; Cole, Foti et al. 2008). This particular vehicle-based camping and caravanning market, which seeks a camping experience in remote locations, is "a growing but relatively unknown type of recreation. A significant management problem that relatively little is known about" (Winter 2005, p. 1). Despite the camping areas within the study area falling within the Ningaloo Marine Park (up to 40m past the high tide mark), the land adjacent to the marine park is privately owned or unprotected. Many camping areas in these locations do not have planning or management strategies in place.

Other characteristics of the Ningaloo camping areas make research at Ningaloo unique within the recreation ecology literature. Four key differences are: the semi-arid, coastal environment; the multiple management regimes existing adjacent to the Ningaloo Marine Park, (resulting in differing coastal camping impacts, and indicating the challenges raised by the regional scale of this study); low levels of vehicle accessibility to campsites; and the long average length of stay (47 days) (Remote Research 2002)with, in some cases, no site charges. This study addresses these gaps within the recreation ecology literature. To contextualise the impacts currently afflicting the Ningaloo coast, the impacts of hiking, camping and four-wheel driving in coastal environments and semi-arid environments are further examined in section 3.4.3.

Major research questions and themes of research surrounding recreation impacts and management in wilderness areas have been examined by Leung and Marion (2000), of which this study seeks to address three. These are: What factors contribute to the problem? How effective are visitor and site management actions? And; how can research and impact assessment methods be improved? Other research themes focused on site experimentation or temporal research which was beyond the scope of this study due to time limitations.

Whilst Ningaloo is a very unique study area as described in the above paragraph, findings may not be directly transferrable to other coastal locations. However, this this study hopes to contribute to the broader recreation ecology literature through contributing knowledge to the above three recreation ecology themes for a coastal, semi-arid environment.

3.4.2 Importance of Coastal systems

The coastline is a natural target for human recreation and is considered among the most desirable habitats for recreational use (Rickard, McLachlan et al. 1994). Access to, and use of beaches is considered to be the most significant issue in coastal tourism (Newsome, Moore et al. 2002). Anthropogenic disturbances include shoreline disruption, urban development, beach erosion, littering and waste dumping, and trampling by foot or vehicle (Nordstrom 2000; Schlacher, Schoeman et al. 2006; Defeo, McLachlan et al. 2009). While recreation disturbance is relatively minor when compared with development, sand mining or the natural cycle of erosion and accretion, it is continuous or at least seasonal (Bonanno, Leopold et al. 1998; Curr, Koh et al. 2000).

The beach profile is integral to dunal health and is therefore very important when considering development and campsite facility construction (McHarg 1992). Dunes provide irreplaceable ecosystem services including erosion control, critical habitat and nesting sites (Thompson and Schlacher 2008). In their natural state, sand dunes are dynamic geomorphic features which are resilient to stress. However, it is well established that dune vegetation is susceptible to trampling by animals and humans, and to crushing by vehicles (Liddle and Greig-Smith 1975; Williams, Randerson et al. 1997). Other ecological impacts on coastal areas resulting from recreation include loss of habitat, reduced biodiversity, threatened native vegetation species, reduction of seed sources, lower plant community resistance, and increased risk of dune erosion from storms (Nordstrom, Lampe et al. 2000).

Most dunes are also highly sensitive to direct human disturbance, which often causes changes to dune morphology, stability and dynamics, which can lead to some coastal dune systems becoming irreversibly altered (Williams, Randerson et al. 1997; Curr, Koh et al. 2000; Williams, Alveiriinho-Dias et al. 2001; Heslenfeld, Jungerius et al. 2004; Thompson and Schlacher 2008). Any disturbance to the natural sand cycle can potentially alter the shoreline, both in shape and position (Newsome, Moore et al. 2002). As such, numerous studies of dune sites document the features, processes and stages of dune degradation (Nordstrom, Psuty et al. 1990; Louisse and Meulen 1991; Nordstrom and Arens 1998). It is generally accepted that a threshold can be reached at which irreversible damage can occur and recovery of dune ecosystems is at best unlikely and at worst impossible (Alveirinho-Dias, Curr et al. 1994; Valles 2011).

Vegetation removal in particular can lead to localised foredune erosion areas called blowouts, and these can be observed along the Ningaloo coast. This can lead to sand being transported further inland through loss of the dunes' buffering capacity (Newsome, Moore et al. 2002), leading to the burial of once-stable coastal vegetation. More frequent and severe storm events are predicted to reduce the ability of dune systems to recover from such anthropogenic impacts (Harley, Hughes et al. 2006). Coastal sand dunes are therefore considered among the most susceptible habitats to recreational use (Nordstrom, Lampe et al. 2000) and tourist activities can contribute to their destruction and a consequent reduction of the recreational values connected to nature (Bonanno, Leopold et al. 1998).

3.4.3 Impacts of Camping and Recreation in Coastal Environments

While this thesis is set in the context of a semi-arid coastal environment, for which studies are limited, some generalisations are applicable from within the recreation ecology literature. Smith (2003) breaks down the impacts of camping into three different types: biological, physical and social (*Table 3.2*), incorporating both direct and indirect impacts. Examples of direct impacts include vegetation damage and soil erosion. Indirect impacts can include vegetation species composition (Smith 2003) while off-site indirect impacts as a result of camping also include the development of informal trails and the collection of wood (Cole 2004). Other common forms of campsite impact include campsite proliferation (increasing number of sites), expansion of campsite size, disturbance or loss of vegetation cover degradation of soils and soil fauna, improperly disposed human waste and multiple campfires (Obua and Harding 1997; Gajda, Brown et al. 2000; Leung and Marion 2000).

Table 3.2

Type of impact: Impacts from the Use of Camping Areas in Natural Environments.

Biological Impacts	**Physical Impacts**	**Social Impacts**
Soil Impacts	*Soil Impacts*	Littering
Organic Matter Reduction	Soil compaction	Human Waste
	Soil Erosion	Vandalism
Vegetation Impacts	Infiltration rate reduction	Visitor conflict
Loss of Groundcover	Exposed mineral soils	Crowding
Vegetation damage		Loss of aesthetic appeal
Human damage to trees	*Vegetation Impacts*	Noise pollution
Change in species composition	Root exposure	
Seedling removal		
Introduction of exotic species		
Loss of Coarse Woody Debris		

Sourced from: (Parsons and MacLeod 1980; Cole and Fichtler 1983; Martin, McCool et al. 1989; Buckley and Pannell 1990; Cole 1990; Kuss, Graefe et al. 1990; Sun and Liddle 1993; Trumbull, Dubois et al. 1994; Cole 1995; Cole and Landres 1995; Marion 1995; Leung and Marion 2000; Smith 2003)

Reviews of the recreation ecology research (Leung and Marion 2000; Cole 2004) present a similar argument (*Table 3.3*) namely: that impacts such as those listed above arise not only from campsite use, but also from recreation and movements associated with campsite use; that the intensity of use and the extent of use contribute to the total impact; that a number of factors can determine the amount of impact that occurs; and that effective management and planning can help ameliorate many of these impacts whilst still enabling a high level of visitor satisfaction.

Table 3.3

Five Generalisations of Findings from within the Recreation Ecology Literature. Sourced from (Cole 2004)

Generalisation	Management implications
Impact is inevitable with repetitive use	Even very low levels of repetitive use cause impact.
Impact occurs rapidly while recovery occurs more slowly	It is easier to avoid impact than to restore impacted sites Pristine areas should receive more management attention than impacted areas
In many situations impact increases more as a result of new places being disturbed than from the deterioration of places that have been disturbed for a long time	Be attentive to pristine places and spatial distribution of us Periodic inventories of all impacted sites are more important than monitoring a sample
Magnitude of impact is a function of frequency of use, the type and behaviour of use, season of use environmental conditions and the spatial distribution of use.	Primary management tools involve manipulation of these factors
The relationship between amount of use and amount of impact is usually curvilinear	Concentrate use and impact in popular places. Disperse use and impact in relatively pristine places.

3.4.3.1 Trampling and Four-wheel drive vehicles

Smith (2003) asserts that natural areas in Australia are accessed either by foot or car, and this is reflected within the literature where a comparatively high proportion of Australian studies focus on the impacts of four-wheel driving. Trampling of vegetation and four-wheel drive vehicle use by campers are important side-impacts of camping along the Ningaloo coast. A summary of studies on trampling and off-road vehicles in coastal environments is presented in Appendix E. The intensity of impacts is exacerbated by weight—the heavier the item, the greater the damage. Vehicles therefore produce the greatest damage when compared with walking or horse access, especially as most campsites in Western Australia are accessed by car (Smith 2003). Once visitors have set up camp, impacts result primarily from trampling.

Coastal ecosystems can be damaged by visitors who are attracted to remote coastlines with exclusively four-wheel drive vehicle access (Newsome, Moore et al.

2002). Visitors can gain adventure experiences from creating new tracks, particularly in dunal areas (Priskin 2003). Recreational driving of four-wheel drive vehicles (ORVs) is perhaps the most environmentally damaging form of direct human dune use (Godfrey and Godfrey 1980) because dunes have a low tolerance of vehicles. Along the Ningaloo coastline, studies have argued that vehicle tracks through coastal dunes, used to access the coastline and campsites, are the biggest ecological challenge for the region (Bunning 2008). Many of these tracks result directly from accessing remote coastal campsites, either for the first time from a main road, or through daily trips undertaken for recreational or supply activities. Dune vegetation can take two years or longer to recover from vehicle damage (Hosier and Eaton 1980; Anders and Leatherman 1987; Thompson and Schlacher 2008).

Studies relating to four-wheel drive vehicles have been conducted both in dunes and on beaches. The literature on ORV use predominantly focuses on coastal areas within the US and these sources are summarised in *Table 3.4*. Within Australia, quite a few studies have been undertaken by Schlacher and others on ORV impacts on fauna (Schlacher and Thompson 2007), its spatial quantification (Schlacher and Thompson 2008), and specifically on invertebrates (Schlacher, Thompson et al. 2007; Sheppard, Pitt et al. 2009; Lucrezi 2010; Schlacher and Lucrezi 2010). Compared with international studies, four-wheel drive vehicle impacts in coastal areas have received limited attention in Australia and Western Australia. However, most of this research has been conducted within the past ten years.

Table 3.4

Factors Influencing the degree of Impact caused by Four-wheel Drive Vehicles reflecting both Environmental and Operational Vehicular Activities.

Environmental	**Operational and Vehicular Factors**
Surface soil characteristics	Acceleration
Soil moisture content	Speed
Vegetation type	Turning radius
Slope	Wheel track pressure
Climate	Wheel track configuration
	Skill and attitude of the operator
	Season the activity takes place

Sourced from (Rickard and Brown 1974; Newsome, Moore et al. 2002)

Once at a campsite, many campers along the Ningaloo coast trample vegetation inadvertently to access other campsites, lookouts, the ocean or portable toilets. Intensive and uncontrolled visitor traffic in the coastal dunes exacerbates such trampling. Trampling is recognised as one of the most damaging impacts and can cause serious environmental alterations. Studies of the impact of trampling have principally been carried out internationally. These include studies on soil compression, overland seawater flow, loss of vegetation cover and erosion (Andersen 1995; Kutiel, Zhevelev et al. 1999; Heslenfeld, Jungerius et al. 2004). Excellent reviews of research into tourism activities in dunal ecosystems, primarily on trampling, are also available (Andersen 1995; Kerbiriou, Leviol et al. 2008) and (Bonanno, Leopold et al. 1998), summarised in Appendix E. In highly disturbed conditions such as those affected by high-use recreation and associated developments, exotic species tend to perform better than natives, which supports the idea that exotics are better adapted to disturbances novel to the recipient plant communities (Chiuffo and Hierro 2010). This is common along the Ningaloo coast which hosts many exotic species due to pastoral activities. Some coastal plant communities are more resistant to trampling than others, and therefore localised baseline data are needed to understand localised ecological processes.

3.4.3.2 Campsites

Few studies on campsites in coastal areas exist. As stated by Hockings and Twyford (1997, p. 28) "Research and monitoring into beach camping use and impacts are limited and represent a significant constraint to effective management". Coastal campsite studies have been conducted on rocky, temperate shorelines in Canada (Gajda, Brown et al. 2000), on the sandy shores of Baja (Monz 1998) and on Fraser Island, Queensland (Hockings 1997; Thompson and Schlacher 2008; Schlacher and Thompson 2009; Tully, Carter et al. 2009; Schlacher, de Jager et al. 2011). The environment in Baja is semi-arid (Monz 1998) and so is similar to that of Ningaloo. However the access is by kayak, not four-wheel drive, and so the area affected and the intensity of disturbance is bound to be less. Thompson's (2008) study on coastal camping at Fraser Island is the most similar to this study, since these campsites are within an Australian World Heritage area, and unmanaged camping occurs on dunal areas accessed by four-wheel drive vehicles. This study involved assessment of camping impacts, campsite availability and usage along the eastern and northern coasts of Fraser Island. Other Fraser Island studies (Hockings 1997; Thompson and Schlacher 2008; Schlacher and Thompson 2009; Tully, Carter et al. 2009; Schlacher, de Jager et al. 2011) focus more on the tracks that result from camping in coastal systems rather than the on-site campsite impacts themselves and, as such, are discussed in greater detail in section 3.4.3.1. The Fraser Island Defenders Organisation (FIDO) (Fraser Island Defenders Organisation nd) discussion paper also enumerates a range of impacts which are outlined in Table 3.5. Vegetation impacts, human waste, litter, campfires and dogs are common challenges.

A number of studies of coastal camping and recreation have demonstrated that beaches and foredunes are highly sensitive to human disturbance (Hockings and Twyford 1997; Monz 1998; Gajda, Brown et al. 2000). The reasons for foredune impacts (*Table 3.5*) can be summarised, following the Fraser Island Defenders Organisation (Fraser Island Defenders Organisation nd) as:

1. The impact on the site through vegetation clearance to clear and level tent sites and sometimes for drainage.
2. The impact of establishing vehicular access to the sites.
3. The establishment of ancillary functions, including establishing toilet and ablution sites and the tracks between them.
4. It is notable that many sand blows originated from vehicle tracks through the foredunes and from pedestrian tracks climbing foredunes.

Few quantitative studies have been undertaken on the impacts of human waste disposal (Leonard and Plumley 1979; Reeves 1979; Temple, Camper et al. 1982), despite their environmental, aesthetic and health concerns. Recent studies (Leung and Marion 2000; Leung and Marion 2000; Cole 2001) have noted issues surrounding inappropriate human faecal waste disposal in back country areas, including 25 % of National Park Service managers reporting that inadequate disposal of human waste was a common problem in many of their back country areas (Marion, Roggenbuck et al. 1993).

There are few studies on the impacts of recreating or camping with dogs. Human waste impacts would be compounded by the presence of dogs since their waste may not be buried and could pose a bacterial threat even where toilets were provided for visitors. Cole (2004) simply states that hikers with dogs disturb wildlife more than hikers without dogs (Macarthur, Geist et al. 1982).

Although the other coastal study areas cited here differ from Ningaloo in terms of geology (Monz 1998; Gajda, Brown et al. 2000) and access (Monz 1998; Gajda, Brown et al. 2000) , they do provide insights into the problems of using monitoring guidelines which focus on forested environments. These included the lack of organic soil layer in the sandy substrate, a commonly used impact indicator in forested environments, and the presence of large campsites with indeterminate borders in the arid areas (Monz 1998). The Ningaloo campsites share these issues and will require similar adjustments to methods.

Table 3.5

Impacts of Dunal Camping.

Impact	Country	Author
Vegetation Disturbance		
promote the invasion and spread of exotic species		(Allen, Forys et al. 2001)
Substantial vegetation losses	Baja, Mexico	(Monz 1998)
Existing shrubs and trees cut down for firewood	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
Dune Disturbance	Queensland (Fraser Island)	(Tully, Carter et al. 2009)
Vegetation clearance to clear and level site for drainage	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
Social trails	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
the potential for increased size and number of campsites due to visitors drifting because of the unclear campsite border	Baja, Mexico	(Monz 1998)
Litter and Human Waste		
Litter and lack of toilet facilities	Western Australia	(Hercock 1999)
Disposal of food scraps could modify the trophic dynamics of animal consumers	Cyprus	(Strachan, Smith et al. 1999)
Human waste and trash were also found at 41 to 59% of the sites	Baja, Mexico	(Monz 1998)
microbial pollution and increased nutrient loading to the dune sands and underlying aquifer from human waste	Queensland (Fraser Island)	(Tully, Carter et al. 2009)
human faeces and toilet paper was observed within 10m of the campsite	Baja, Mexico	(Monz 1998)
There are no rules and no conventions covering the disposal of faecal material in any of the free-range camps. There are no regulation depths and no rules for marking sites used where such pit toilets have been so that someone may subsequently establish their food preparation areas on this very site.	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
Introduced pathogens	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)

Dogs and Campfire Rings		
Old fire pits, Resulting in ground sterilisation and public safety challenges	Western Australia/ Queensland (Fraser Island)	(Hercock 1999), (Fraser Island Defenders Organisation nd)
There is the direct impact on the ground itself where the ground is sterilised as a result of the heat. All the hyphae in the soil are not only killed but appear to take decades before they can recolonise areas subjected to open fires.	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
There is a major issue of public safety. Environmental Protection Agency officers have estimated that almost one medical evacuations call per month is to deal with people who have suffered severe burns and most if not all of these occur from the campfires of beach campers.	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
The cost of supplying firewood is a major drain on the budget for managing Fraser Island and is diverting resources from other more critical aspects of recreation management on Fraser Island. It has been estimated that most of the $600,000 spent supplying firewood for campers is consumed at beach campsites.	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
Dogs - same issues as human waste contamination and wildlife disturbance	Alberta, Canada and others	(Macarthur, Geist et al. 1982; Newsome, Moore et al. 2002; Cole 2004).

3.4.4 Variables Which affect the Magnitude of Impact

While the impacts surrounding trampling, camping and four-wheel drive vehicles in coastal environments have been discussed above, factors which may influence impact patterns in coastal environments will now be examined. Studies surrounding the factors that influence the magnitude or intensity of impacts are most useful to management as they seek to explain why impacts are minor in some situations and severe in others (Cole 2004) (*Figure 3.2*). For example, area of impact is primarily a result of the spatial distribution of recreation use (Cole 1987). Knowledge of these factors for fragile areas utilised for recreation are considered critical because ‘it is through manipulation of these factors that managers can control recreation impacts’ (Hammitt and Cole 1998, p. 143).

Empirical studies have attempted to identify those factors which strongly influence amount of impact through the exploration of the relationships between dependent variables of campsite impact and independent variables, such as vegetation and use distribution. Factors which strongly influence amount of impact can then be identified (*Table 3.6*) and may be controlled to minimise impact. While general factors that influence amount of use have been acknowledged, isolating the influence of individual variables has proved challenging. This is because the impact of a single variable is most often influenced by the presence of another (Cole 1992). For example, when studying the effects of 'amount of use', a remote, infrequently used campsite is likely to have a different type of camper demographic than are frequently used sites. So the effects will not only be due to amount of use but also type of use (Cole 1992).

Table 3.6

Variables which affect Magnitude of Impact

Environmental Durability	**Visitor Use**
Vegetation density	Amount of use
Vegetation resistance and resilience	Use distribution
Soil characteristics	Type of user group
Environmental Durability	Party size
Topographic characteristics	User Behaviour (minimum impact knowledge, experience level, user motivation, social group and structure)
Ecosystem characteristics	Mode of Travel and Access
Wildlife impacts	Severity of direct impacts associated with specific activities
Water impacts	Severity of indirect impacts
Season of use	Social dimensions of timing
The conservation value of the site	Ecological dimensions of timing
Susceptibility to erosion	
Total area affected	

Sourced from: (Cole 1992; Hammitt and Cole 1998; Cole 2004; Pickering 2010)

Factors which have been identified to influence impact generally comprise two groups, a site's environmental durability and its visitor use which influences both the area and intensity of impact (*Figure 3.2*). Environmental durability is considered a highly complex subject which yields few definitive answers because different aspects, such as vegetation or soils may have different levels of durability to impact. Resistance is the site's ability to tolerate recreational use without changing or being disturbed, whereas resilience is the ability to recover from any changes that occur (Hammitt and Cole 1998). Certain plants are better able to survive trampling than others, such as those that are low-growing, with wiry leaves and stems (Cole 1987). Also, fine-textured soils are more prone to compaction than coarse soils (Cole 1987). Likewise,

> The extent to which certain features are present affects amount of impact. Sites with little or no vegetation cannot suffer much vegetation loss. A substrate without any coherent structure, such as a sand beach, cannot be compacted. Sites without trees cannot suffer tree damage. Thus, both extent and vulnerability are relevant (Cole 1987, p. 256).

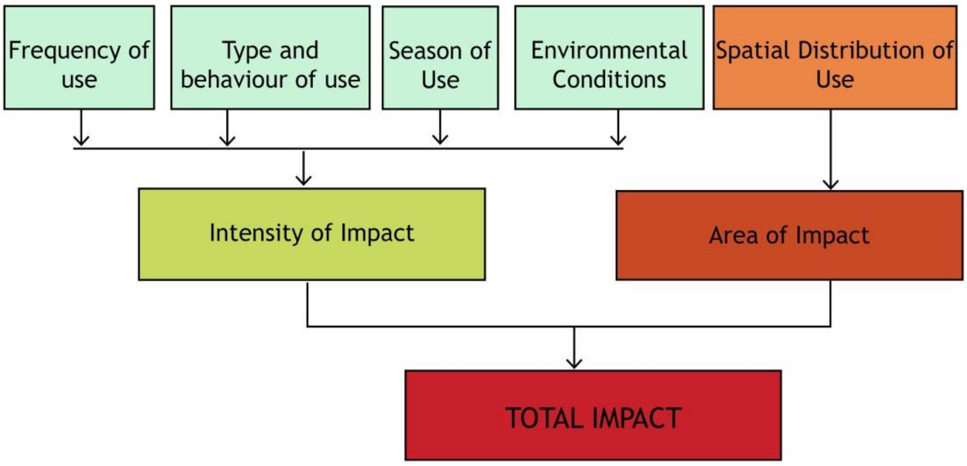


Figure 3.2. Factors that Influence the Intensity and Area of Impact and therefore the Total Amount of Impact.

(Cole 2004, p. 52).

The effects of campsite impacts associated with access are an important consideration along the Ningaloo coast because campsites are almost always vehicle-accessed. The impacts associated with motorised travel differ from those due to transport by foot or horse (Hammitt and Cole 1998). With regard to susceptibility to erosion, the physics of weight over area is the main factor (Pickering 2010).

Differences in pressure will affect the severity and area of damage to vegetation and soils (Liddle, 1997), and the introduction of weeds (Smith and Newsome 2002). This is calculated by ground pressure (gcm^2), with pressure ranging from 7 gcm^2 for a snowmobile to 4,380 gcm^2 for a horse with rider, simply because weight is dispersed over a smaller area. Therefore, four-wheel drive vehicles cause more erosion than horse riding, and horse riding causes more damage than hiking (Liddle 1997). While much research on pack stock has found that they cause more impact and disturbance than hikers (Whinam, Cannell et al. 1994; Cole and Spildie 1998; Deluca, Patterson IV et al. 1998; Smith and Newsome 2002), the main form of transport into natural areas in Western Australia is by motor vehicle or foot (Smith 2003). This is because horse use is limited to a small number of parks and recreation areas (Smith and Newsome 2002) and many natural areas are accessible by road. No research which focuses on the magnitude of impacts has been identified for coastal environments

3.4.5 Comparing Camping Impacts across Management Regimes

In Western Australia, Hercock (1999) studied recreation and tourism impacts at three locations in the Kimberly region, and questioned the sustainability of promoting an increasing number of four-wheel drive visitors. Impacts to different locations were compared. Old fire pits, litter, tracks comprising compacted soil and a lack of toilet facilities were all observed. Their impacts varied depending on their locations, due to the presence of different management regimes. It was argued that choosing sustainability indicators for such a geographically large area was therefore difficult and so a different indicator such as environmental health should be considered in relation to carrying capacity. It was suggested that the majority of four-wheel drivers in the Kimberly were difficult to confine and manage and that eco-tourists taking part in pre-sold packages were the easiest to control.

A study undertaken in the Eucalypt forests of Western Australia's south-west (Smith 2003) examined environmental and social camping impacts in designated, developed and informal camping sites. It found that designated campsites experienced significantly fewer adverse impacts than did the informal ones. There are no known studies comparing environmental impacts across differing management regimes within coastal or semi-arid environments.

3.5 MANAGEMENT

3.5.1 Importance of Management

Decisions surrounding the management of remote areas involve potential trade-offs between their social, resource, and managerial attributes (Lawson and Manning 2002). Recreationists in remote areas are thought to prefer a pristine natural environment, a high degree of freedom from management control and distance from other campers. While this is the ideal, managers often have to strike balances between these dimensions, or need to favour one dimension over another to protect the environment which attracted visitors in the first place (Lawson and Manning 2002). Numerous management actions have often therefore been taken to limit campsite impacts (Cole 1992).

Beach camping was noted as one of the greatest environmental management concerns for the Fraser Island region (Hockings and Twyford 1997). As previously discussed beach camping is a primary cause of dune disturbance (Western Australian Planning Commission 2004). Current levels of environmental change along the Ningaloo coast caused by dune camping may not be compatible with both the sustainable use of coastal resources and the conservation obligations of the area. Therefore, as decided at Fraser Island (Hockings and Twyford 1997; Thompson and Schlacher 2008), restoration and mitigation interventions and changes to the camping management strategies could be required to prevent severe degradation and to maintain World Heritage values.

Ultimately, coastal management needs to develop and implement strategies that reconcile demands for human recreation, including beach camping, with the conservation of coastal dune ecosystems. A variety of visitor and site management actions can be implemented to either reduce or contain the adverse environmental impacts caused by camping. Various studies have examined the success or otherwise of those actions which seek to both reduce impacts and be acceptable to visitors.

3.5.2 Visitor Management

Numerous management actions have been attempted to limit those variables which affect impact. Visitor management actions involve regulating visitors (such as visitor numbers, group size and length of stay) and visitor communication and may include use limitations, restrictions on activities, charging of fees, increased enforcement and visitor education (Cole 1987; Marion 1995; Marion and Cole 1996; Marion and Farrell 2002) (*Figure 3.3*). Generally, regulations should only be used when indirect options are likely to be ineffective (Lucas 1990). In remote and primitive areas, indirect visitor management through education and communication was encouraged, and was thought to be both effective and preferred by guests (Hendee, Stankey et al. 1990). More regulatory approaches such as restricting visitor numbers conflicted with the central aim of encouraging people to visit outdoor areas. However, (Cole 1990) argues that more proactive regulatory management, before irreversible impacts occur, is the more effective solution.

Length of stay - typically 47 days at Ningaloo (Remote Research 2002)- is generally not in itself a cause of overuse however (Lucas 1990). Limiting length of stay in popular areas is therefore unlikely to reduce impacts (Hammitt and Cole 1998). However, these limits may allow more people access whilst maintaining use levels and existing impact levels (Cole 1990). This practice is slowly being implemented at Fourteen Mile at Warroora where time limits at some premium beachfront sites are being limited to two weeks. However, in remote areas, Hammitt and Cole (1998) suggest that visitors should stay no longer than a night or two at each site, since eating and sleeping at different places can significantly reduce impact levels (Cole 1990). This would not be an acceptable solution to the current cohort of Ningaloo campers.

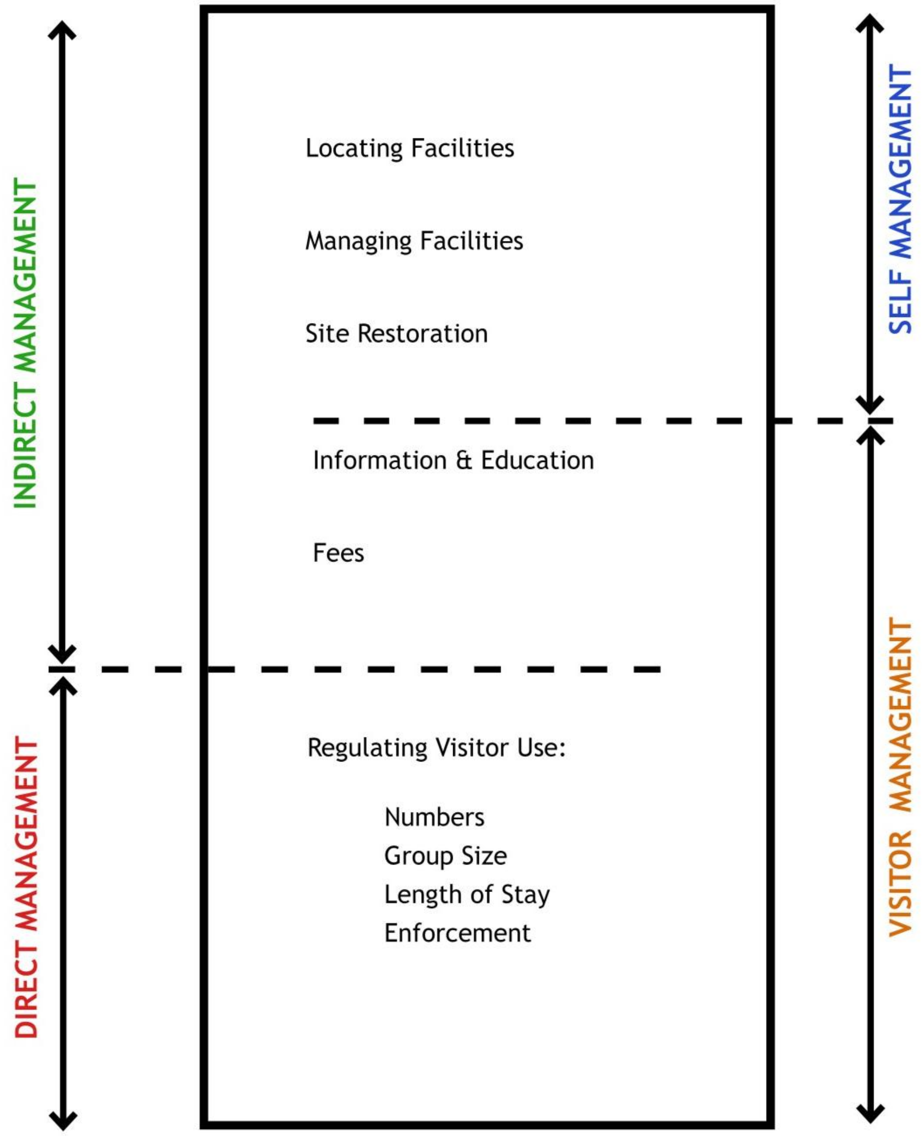


Figure 3.3. Common ways of Classifying Approaches to Managing Visitors to Natural Areas.

Adapted from Hammitt and Cole (1998) in Newsome, Moore et al.(2002, p. 199).

3.5.3 Site Management

Site actions include: selection of resistant sites, site construction and hardening, facility development, site maintenance, site closure and restoration, and dispersed or designated camping policies. Different factors can influence the choice of management actions adopted (Newsome, Moore et al. 2002). A common management consideration includes whether campsites should be designated or undesignated, consideration between campsite dispersal and containment, and the location and design of campsites (Newsome, Moore et al. 2002).

3.5.3.1 Site Hardening and Impact Creep

The most common form of site management in non-wilderness areas is site hardening to improve site durability around built accommodation, interpretive facilities and across campgrounds (*Figure 3.4*). The level of facilities provided depends on visitor numbers and the experience that visitors are seeking, For example, some wilderness visitors consider toilets as human intrusions (Lucas 1990), however (Cole, Petersen et al. 1987) notes that toilets are standard in natural areas and are becoming increasingly common in heavily used wilderness areas. Managing vegetation is also important to prevent site deterioration from trampling, erosion and muddiness, to maintain a site's visual attraction, and to provide a visual and sound buffer between activities and protection form the weather, and for educational purposes (van Riet and Cooks 1990). In two examples presented by Smith and Newsome (Smith and Newsome 2006), negative environmental impacts were reduced through site hardening and associated developments, which in turn increased their attractiveness to a wider visitor profile which can result in different levels of expectations and resource consumption.

Development associated impact creep is often a knee-jerk reaction causing increasing environmental impacts in natural, remote areas. This form of development often occurs with very little visitor consultation and once the site is hardened, more visitors may be attracted to the site which results in more development and further site modifications over time. Where impacts are reduced through more effective management, with increased visitor satisfaction impact creep can be considered a positive outcome. However, responding to increasing impact and overcrowding, perhaps resulting from more convenient access, by environmental and facility modification may result in reduced visitor satisfaction and be a negative aspect of impact creep. Impact creep may also lead to a recreation areas becoming more uniform and less varied, displacing visitor types and creating highly developed as opposed to natural product as a result of facility provision (Smith and Newsome 2006).

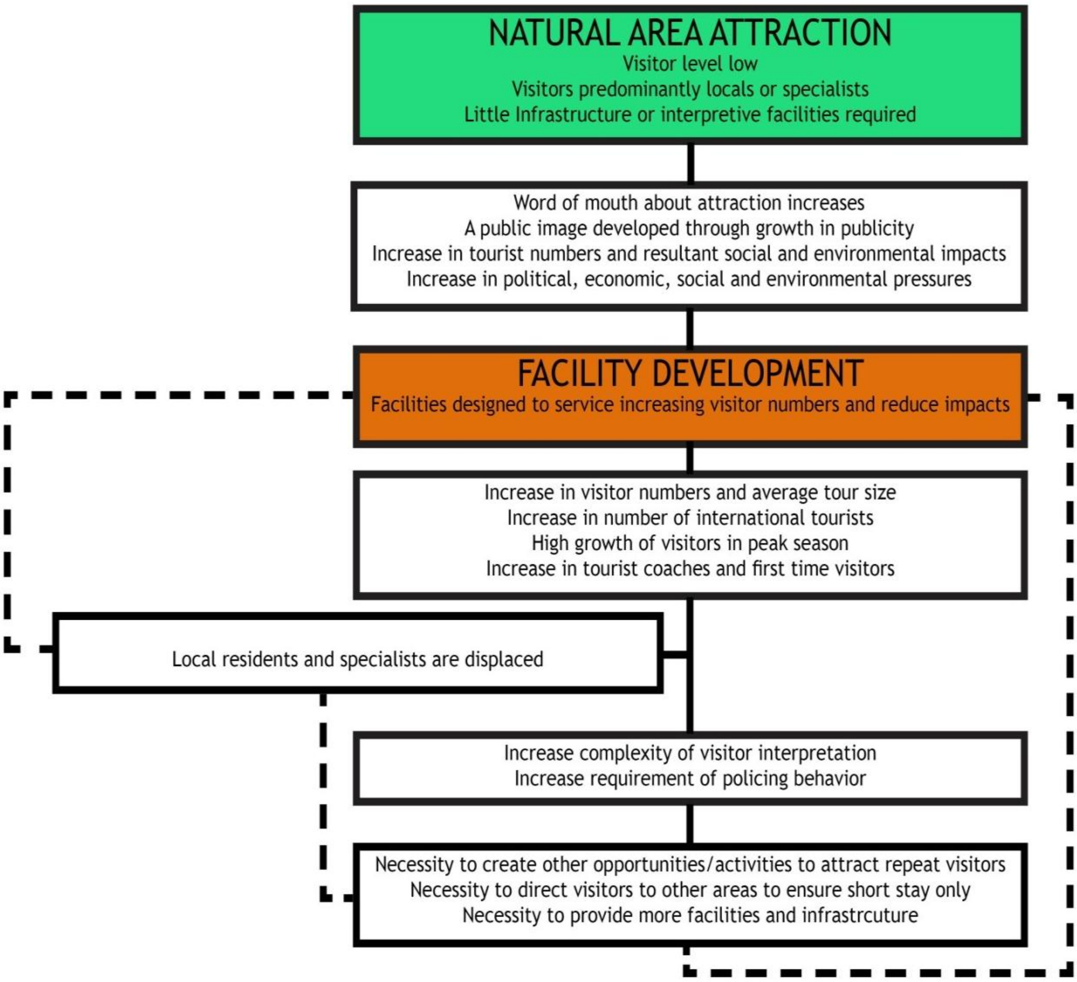


Figure 3.4. Theoretical Framework of Impact Creep and Subsequent Development. Adapted from Smith and Newsome (2006, p. 5).

3.5.3.2 Designated and Undesignated campsites

Undesignated camp areas are characterised as having have low levels of regulation and, as such, visitors can select either an existing campsite or create a new one (Leung and Marion 2000). Few studies which compare impacts between designated and undesignated sites(Marion 1995; Smith 2003; Cole, Foti et al. 2008), yet these authors suggest that having undesignated sites can result in many poorly located campsites (Cole 1993). Most research has also found that designated campsites can be significantly less impactful than undesignated ones (Marion 1995; Smith 2003; Cole, Foti et al. 2008). A 50 % reduction in aerial disturbance was noted by Marion (1995) by designating campsites and installing fire grates, together with education, regulation, and provision of structures or facilities to attract concentration of activities. However, Cole (2004) found that, while impacts at designated sites did not increase, additional undesignated campsites were created as a result of overflow. Therefore, designated sites can reduce campsite proliferation but not eliminate it. As vegetation has a slow recovery rate in arid environments, these new sites can become permanent (Cole 2004). Campsite proliferation and expansion was also a common factor in a study which surveyed only undesignated sites (Leung and Marion 2000).

Keys to avoiding the proliferation of undesignated campsites include: inventory and monitoring; education; and maintenance and restoration. Other management outcomes were that concentrating use on designated campsites in popular areas, but allowing dispersal elsewhere remained the best option (Leung and Marion 2000). It was argued that managers should therefore either accept larger sites for large groups, or lower the size limit of groups (Cole, Foti et al. 2008). Challenges for the designated sites included getting campers to use them, and dealing with concentrated use challenges such as the larger amount of human waste.

Designated sites will inevitably be used more frequently than primitive sites, and so a common form of site management is site hardening. Gravel or pavement is utilised to minimise muddy areas and prevent soil compaction. It can also improve site durability around built accommodation, interpretive facilities and across campgrounds. In two examples presented by (Smith and Newsome 2006), negative environmental impacts were reduced through site hardening and associated developments, which increased their attractiveness to a wider visitor profile. As campers in the Ningaloo region visit the area for its relative sense of wilderness and remoteness, site hardening at designated campsites may attract a different user profile and displace current users, as described above (section 3.5.3.1). Alternatives may therefore be to locate designated sites at already affected sites with resistant surfaces. However, the challenge of four-wheel drive vehicle access to campsites in dunal locations remains.

3.5.3.3 Campsite design and location

Leung (1999) noted the importance of campsite and campground design in reducing impacts within and around visitor campsites and the spatial elements of campsites are commonly integrated into planning and management frameworks (for example (Clark and Stankey 1979). Understanding the spatial strategy typologies of campsites ‘offers a useful means of organising and understanding the wide variety of management strategies and actions applied to managing visitor impacts in parks and protected areas’ (Leung and Marion 1999, p. 20). Additionally, Leung and Marion (Leung and Marion 2004, p 251) argue that ‘By arranging the campsites and access trails in an appropriate spatial layout, the problem of site proliferation, site expansion and social trail creation may be minimised since campsites’ activity patterns are matched by the site layout’.

Campsite dispersal and containment are two campsite design strategies focused on within a review of campsite management (Leung and Marion 2004) and these two strategies have dominated the recreation ecology literature. Results (Williams and Marion 1995; Marion and Leung 1997) indicate that, where use levels tend to be low and resistant soil and plant communities exist, dispersal can be an effective strategy. In areas with higher use and with substrates that are susceptible to impact, containment strategies can be a more effective method of avoiding overall increases in the amount of disturbed area. For example, in both Prince William Sound and Baja California Sur, a containment approach to overnight use, through more rigorous education of visitors or campsite designation could be part of a future management strategy (Monz 1998).

Campsite containment aims to concentrate camping use in a small number of high-use sites in an effort to reduce the total area of impact (Leung and Marion 2004). It is recommended that containment strategies be integrated with spatial configuration strategies when new campsites are designed, because campsite movement patterns are influenced by the site layout (Leung and Marion 2004) (*Figure 3.5*). Understanding campers’ needs, preferences and activity patterns is necessary for the success of this integrated system.

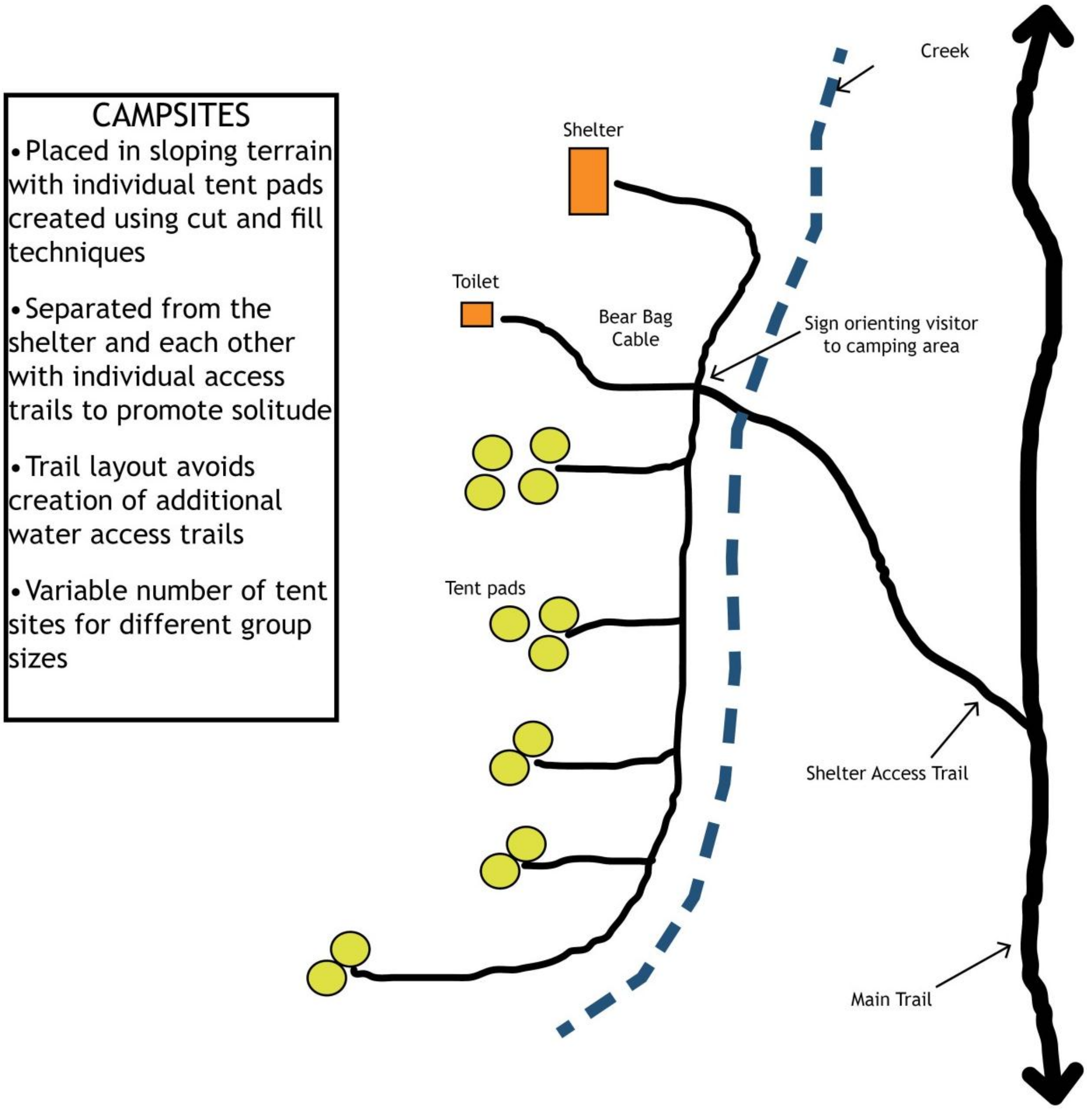


Figure 3.5. Example of a Preferred Spatial Arrangement of Campsites and Related Facilities.

Adapted from Cole (2004, p. 254).

Individual campsite design is also an important consideration (Biscombe, Hall et al. 2001). Designated campsites experiencing high use should also be created in areas both resistant and resilient to environmental damage and expansion. Site definition through visual cues, such as logs or rock boundaries (both used in different Ningaloo campsites) or natural topography may also be used to limit campsite expansion (Marion and Farrell 2002). Another method, distance regulations such as 'no camping 7 m past this sign' is less likely to be effective in the Ningaloo context due to the unlimited possibility for campsite expansion and the size of some camping rigs which may necessitate expansion past set boundaries. Within vehicle-accessed campgrounds, site design and facilities such as barriers and identifiable parking spots, anchored picnic tables and fire grates on formal fire pits enhance spatial concentration. This has been achieved at Cape Range National Park.

Campsite expansion within car-accessible campgrounds can be restricted through site design and facilities, such as barriers and gravel placed to identify a parking spot, and permanently anchored picnic tables and fire grates on formal fire pits to enhance the spatial concentration of camping activities. Natural topography may also be utilised to restrict campsite expansion. For instance, selection of hillside positions for campsite development has proved effective in limiting site expansion (Leung and Marion 2004). Campsite screening through revegetation is also needed to provide a sense of campsite boundary, noise reduction, shade, and enhanced visitor experience through connection to the natural environment (Biscombe, Hall et al. 2001). However, Bisxombe, Hall et al.(2001) suggests that the design of campsites with vehicle access has changed little since the 1930s (*Figure 3.6*). Parking on the paved spur is crowded, the camping area has no boundaries, and the site furniture is not ADA (wheelchair) accessible. The same campground design still exists in Yosemite and heavily used areas have been impacted through soil compaction, erosion, vegetation damage, and lack of vegetation regeneration. As such, four campsite prototypes were developed (Biscombe, Hall et al. 2001) to help mitigate impacts which all featured:

- A flat parking-campsite surface of crushed granite,
- A clearly defined, permanent boundary for the campsites,
- New designs for picnic tables, food storage lockers, and fire pits
- Group sizes ranging from one to six individuals, and areas from 138 to 197m^2
- ADA (wheelchair) accessibility

Through questionnaires and observations it was concluded that the new designs were an improvement and may be utilised as an adaptive management tool (*Figure 3.7*). Additionally, the overall reaction to the prototype campsites was very positive. However, campers were seen stepping over the boundary threshold for a variety of reasons up to 12.4 % of the time, though it is thought that this, can be alleviated through the campsite design being incorporated into the entire circulation system for vehicles and pedestrians throughout the campground.

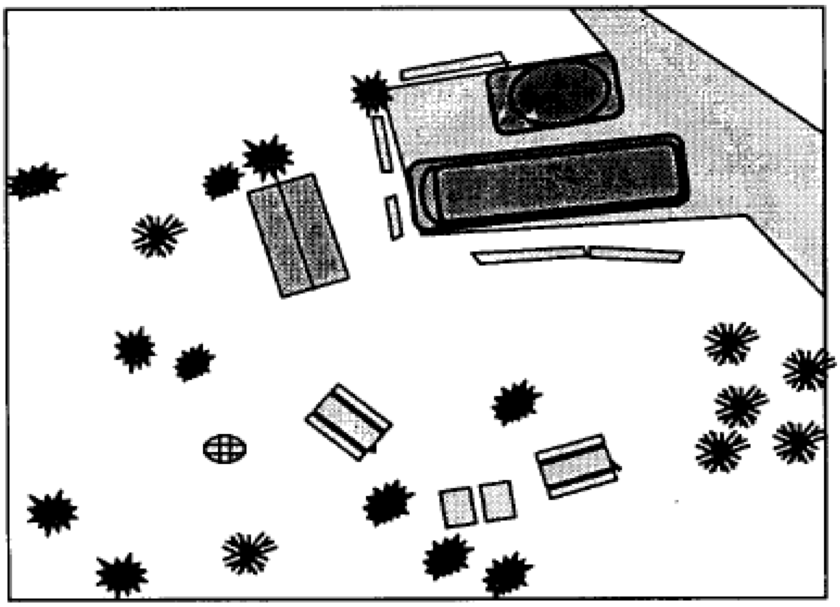


Figure 3.6. Schematic plan of the Existing Yosemite Campsite.
From Biscombe, Hall et al.(2001, p. 151)

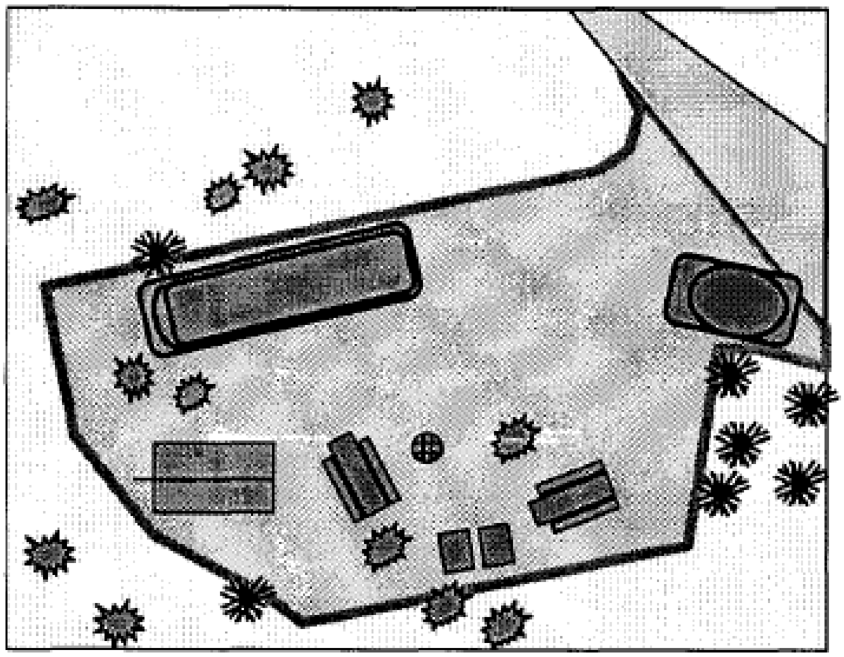


Figure 3.7. Schematic plan of the Universal Campsite Design.
From Biscombe, Hall et al.(2001, p. 152)

3.5.4 Campsite Management in Coastal Environments

For coastal campsites, the majority of the literature focuses on rehabilitation and site management of dunes as a result of recreation. Only a small number look at visitor management as a prevention strategy. One such author is Bonanno (1998, p. 49), who argues that ‘While recreation can compromise the integrity of a dune barrier, well-planned and executed management can mitigate those effects while allowing high recreation use’. The main challenge for managers is to maintain dune integrity through determining the ecological carrying capacity for camping in dunal systems (Thompson and Schlacher 2008). Once this is determined, visitor numbers may need to be limited accordingly to enable the sustainable use of coastal resources. Spatial prioritisation of rehabilitation and conservation efforts is crucial (Thompson and Schlacher 2008), while closure of campsite areas can be considered as a more complementary approach.

Other management recommendations include:

1. Restricting access to camping zones during certain times of the year to allow regeneration,
2. Closing access tracks and camping zones during severe weather events,
3. Establishing a system of alternating open and closed zones, and
4. Limiting the total number of campers allowed in the dunes.

The location of impact as well as intensity of impact is also important as Monz (1998) reaffirms that camping and traveling on durable surfaces and other minimum impact principles can be effective in coastal desert regions. Whether visitors can be excluded from nondurable surfaces or put in durable surface pads for campers and how this fits with the wilderness experience along the Ningaloo coast is further discussed in section 9.4.

For areas that are already damaged, rehabilitation efforts are of high importance (Thompson and Schlacher 2008). Understanding the nature, cause and functionality of variation in the dune ecosystem and landscape is fundamental when considering restoration techniques (White and Walker 1997). Cole (1990) also argues that restoration needs to be site-specific and to utilise native vegetation.

3.6 CONCLUSION

The aim of this chapter was to provide an understanding of previous research on campers' preferences, resource use, environmental impacts and their management, and to place the current situation at Ningaloo in the context of the international literature. It has been demonstrated how unique the Ningaloo semi-arid, coastal camping situation is to the majority of other studies within the recreation ecology literature. The review demonstrates the lack of studies in the literature concerning coastal impacts as a result of recreation, and more specifically, of camping. The resources consumed by remote campers, and from where those resources are derived, have also not received the attention of researchers. While the environmental impacts of recreation activities and preferences of camping in forested environments have been the focus of numerous studies, this review determined that limited knowledge exists on con camping impacts in coastal, semi-arid environments or on campsites accessed by vehicles. This is despite coastal areas being amongst the most sensitive, yet most highly visited, locations worldwide. Likewise, few studies have compared preferences, resource use and environmental impacts across different management areas. This is despite numerous authors concluding that understanding the characteristics and preferences of campers at different camp areas is essential for successful management. A combined method approach is outlined in the following chapter to achieve a better understanding of the relationships between management and the variables of camping impacts, preferences and resource use in coastal areas accessed by vehicles.

Chapter 4: Methods

Figure 4.1. Fourteen Mile Ridge Campsites, Warroora.

4.1 INTRODUCTION

It was noted in the previous chapter that a number of questions exist both in the international literature and along the Ningaloo coast with regard to a holistic approach to environmental management through a better understanding of camper preferences, resource use and camper impacts. A 'combined method', comprising both qualitative and quantitative approaches, was therefore developed for this study (Creswell 1994).

From a thorough review of the literature, it is clear that more research is required in coastal areas or semi-arid areas on the impacts, user preferences and resource use of campers. The effect of management on these three factors has also been underexplored. In response to these research needs and to answer the aim which guides this study, five null hypotheses were developed to test the relationships between management and the variables of campsite preferences, resource use and environmental impacts. Research questions, hypotheses and objectives were developed for this study because the development of well-defined and specific research questions, incorporating supportive hypotheses and objectives, are a necessary key step in producing valuable, relevant results (Farrugia, Petrisor et al. 2010). The five null hypotheses and their associated objectives presented below support the five research questions presented in the introduction (section 1.1). The null hypotheses are 2-sided because the outcomes are not specified as positive or negative, that is, either more impact or less impact given different management regimes.

The five null hypotheses are:

Null hypothesis 1: Similarities do not exist between the seven management areas within the study area with regard to regulation, access, cost and facilities.

The associated objectives were to:

- Develop a technique to group management areas for analytical purposes, in order to better understand the relationships between the management strategies and user preferences, resource use and visitor impacts.
- Identify and describe similar management groups to use as a basis for data analysis throughout the research

Null hypothesis 2: There are no differences between management areas with regard to camper preferences

The associated objectives were to:

- Develop a questionnaire to better understand camper demographics, their activities and their campsite preferences along the Ningaloo coast
- Describe and compare the demographics, activities and campsite attribute preferences of campers across the different management regimes

Null hypothesis 3: There are no differences between management areas with regard to camper resource use

The associated objective was to:

- Describe and compare resource use across the different management regimes

Null hypothesis 4: There are no differences between management areas with regard to camper generated environmental impacts

The associated objectives were to:

- Develop a new quantitative measurement system, involving inventory indicators, impact indicators and summary indices for assessing the biophysical impacts camping within a semi-arid coastal environment

- Characterise the extent and intensity of environmental impacts at campsites, and assess variations in the intensity of the impact indicators at campsites within different management regimes along the Ningaloo coast

Null hypothesis 5: The current magnitude of environmental impacts is influenced by management variables alone

The associated objective was to:

- Describe and compare the relationships between the environmental impact indicators and both management and independent variables

To test these null hypotheses, a 'combined method' research approach was required, combining both qualitative and quantitative assessment strategies through questionnaires and impact assessments (Creswell 1994). Complexity is therein added to the design (Creswell 1994). Various authors (Jick 1979; Mathison 1988; Swanson 1992) have suggested additional reasons for combining methods in a single study. Those most appropriate to this study are: to seek convergence of results from different point sources (triangulation); because overlapping and different facets of a phenomenon may emerge (complementarity); and because mixed methods add scope and breadth to a study (expansion).

However, few studies of outdoor recreation have utilised the combined method approach (Smith 2003). Smith (2003) and Smith and Newsome (2002) sought standards for indicators of campsite condition by asking visitors to give the maximum level of change they would accept, which were then compared to biophysical measurements. Cole et al.(1997) and Cole et al. (1997) explored the biophysical and social impacts of trailheads at high-use visitor destinations. One coastal study focusing on beach impact management and planning in the United States was by Vaske (1992), whose study integrated both social and ecological impact studies at three barrier beaches. His aim was to demonstrate the value of an inter-disciplinary approach to resource allocation and visitor management. This approach was considered important because fragile beaches have a 'high demand for human recreation but low tolerance for human impact' p.1. Within Australia, the relationship between measured environmental impact and tourists' perception of it, at ten sites in Central Australia was also investigated by Hillery et al (2001).

The aim of this section is therefore to explore potential methods in the literature using both clustering techniques and questionnaires from the social sciences and impact assessments the recreation ecology which might be suitable to answer the null hypotheses and to select and describe the most appropriate methods for this study. Section 4.2 outlines the clustering method utilised to best answer null hypothesis 1, while section 4.3 discusses the use of questionnaires to answer null hypotheses 2 and 3. Sections 4.4 and 4.5 outline impact measures assessment results to answer null hypotheses 4 and 5.

4.2 CAMPSITE CLUSTERS

4.2.1 Clustering Concept

The clustering method was developed to help answer null hypothesis 1. This clustering method will build on the concepts utilised by Shafer (1969) and later Choi and Dawson (2002) with nine management areas being grouped to reflect key regulation variables. Additionally, Winter (2005) utilised the clustering method on vehicle-based campers in South Australia, but these groups were formed based on camper, rather than campsite, attributes. The term ‘cluster’ was utilised by Winter (2005) where campers were grouped into two statistical clusters, Nature lovers and Recreationists, based upon their values. Whilst this study adapted different statistical techniques to those utilised by Winter (2005), the term ‘cluster’ has been used for consistency.

The concept of camp area ‘clustering’ was adapted from research undertaken by Choi and Dawson (2002) and Shafer (1969), who grouped similar camp areas prior to analysing camper preferences. It is argued that the survey locations should be grouped by campgrounds which contained comparable features or characteristics (*Table 4.1*). Sampling at random at several camp areas and then analysing the results as one group risks generating data output which describes a non-existent ‘average’ camper (Shafer, 1969). This information is considered undesirable for recreation planners who require locationally and attitudinally accurate information for decision-making (Shafer 1969). Shafer (1969) recommended the clustering methods after researching campsite preferences at five different campgrounds and found that analysing the data by campground significantly affected the results of all seventeen questions. One outcome of his study was to strengthen the researchers’ awareness of the variations in camper preferences across different campgrounds.

Table 4.1

Characteristics used to Group Campsites within the Literature.

Derived from Choi and Dawson (2002) and Shafer (1969).

Shafer (1969)	**Choi and Dawson (2002)**
Number of campsites	Camping fee
Average distance between campsites	Number of campsites
Average slope of campground	Facilities available
Average density of vegetative screening	Activities available
Average overstory	Geographical location
Average distance between campsite and lake	
Lake available for motorboats	
Additional lake available by canoe portage	

One objective of Choi and Dawson's (2002) exploratory study was to compare campsite attributes at two different types of camp area. Six camp areas were divided into two groups comprising three less-developed campgrounds and three campgrounds which were more developed. Significant differences were found between four of the seventeen attributes amongst the two campsite groups.

The results gained through the analysis of similar, clustered campsites along the Ningaloo coast should identify variations in camper preferences, their resource use levels and their environmental impacts. As stated by Shafer (1969) survey locations should be grouped by combining the results from campgrounds which contain comparable characteristics. For this study, ten management variables which reflect the levels of regulation along the Ningaloo coast were selected (*Table 4.2*).

Table 4.2

Characteristics used to Group Campsites within this Study.

Regulation characteristics, Ningaloo coast	**Method**	**Measurement Scale**
Management presence	Rating	(1) No management presence, (2) Seasonal caretaker on-site, (3) Year-round caretaker on-site, (4) Year-round ranger on site
Site hardening	Rating	(1) No site hardening, (2) Limited campsite definition, (3) Campsite boundaries, (4) Campsite pads and boundaries
Access	Rating	(1) Only accessible by four-wheel drive, (2) Not sealed but accessible by two-wheel drive, (3) Sealed road
Campfire provision	Rating	(1) Yes, (2) No
Toilet distance	Rating	(1) <than 5 m (2) 5-10 (3) 10-20 (4) 20-50 (5) more than 50m
Rubbish Bin Distance (Measurement)	Rating	(1) less than 10 m (2) 10-50 (3) 50-200(4) 200-1km(5) more than 1km
Sewerage Dump Point (measurement)	Rating	(1) less than1km (2) 5-10km (3)10-20 (4) 20-50 (5) more than 50km
Distance to Rubbish Tip (Measurement)	Rating	(1) less than less than 1km (2) 1km-5km (3) 5km-10km (4) 10-15km (5) more than 15 km
Number of other campsites within a 50 metre radius	Count	NA
Price	Count	NA

4.2.2 Ningaloo Management Areas

The nine management areas which comprise the study area of this research (section 2.3) were grouped into four similar 'clusters' based on the characteristics presented in Table 4.2. One management area, Warroora station, was separated into two areas, comprising Fourteen Mile Camp in one section and the rest of Warroora station into another in another due to their different features as described in section 2.3.4.

Six of the ten variables were derived directly from the campsite impact assessment inventory proforma (Appendix F). The remaining three management variables, 'management presence', 'site hardening' and 'access' were adapted from the literature to suit the camping context at Ningaloo. The variable ‘number of campsites in one camp area’ as used by Shafer (1969) was not directly suitable. As within one management area at Ningaloo, there were up to eight different camp areas. Therefore the variable ‘number of campsites within a 50m radius’ was utilised instead. ‘Distance from population centres’ (Shafer 1969) and ‘geographical location’ (Choi and Dawson 2002) were not included because managers had little choice concerning their location. Instead, ‘access’ was selected, reflecting whether road quality allows four-wheel drive access only. The variable ‘price’ was included, mirroring Choi and Dawson’s (2002) ‘camping fees’. The attributes ‘management presence, ‘and ‘site hardening’ were developed specifically for the Ningaloo coast and represent both the presence of management personnel at the site and physical campsite alteration by management, which had been designed to minimise campsite damage overall.

4.2.3 Analysis

One goal of the clustering method was to create sample sizes from data spread across the nine management areas large enough for robust statistical testing. Four clusters were chosen as a balance between the integrity of the management areas’ characteristics, which may represent camp areas in other Australian (and possibly worldwide) locations and a robust data set with which to undertake statistical analysis. The nine management areas were therefore placed, from prior knowledge of the area, into one of four management clusters based on variables presented in *Table 4.2*, with the primary factor being regulation. Each cluster was then characterised by increasing levels of increasing levels regulation, represented by their numerical order. Cluster 1 was the least regulated and Cluster 4 the most regulated (*Table 4.3*). Therefore, the Clusters were not categorised into four groups as a result of statistical analysis as much as placed into groups pragmatically based on the ten campsite characteristics (*Table 4.2*), which were then tested statistically for differences and commonalities.

A one-way ANOVA test for statistically significant differences between all four clusters, and for each of the ten management variables was conducted. Additionally, a Bonferonni post hoc test was conducted to analyse the relationships between clusters at the 0.05 significance level, for each management variable. As part of the Bonferroni post hoc test, each cluster was compared with the other three clusters at 0.05, 0.01 and 0.001 significance levels, producing twelve relationship results for each management variable. To test for a relationship between regulation and each management variable, a Pearson two-tailed Regression Analysis was also conducted. Results and analysis are presented in Chapter 5.

Table 4.3

Management Areas and their Associated Cluster.

Cluster	**Management Area**	Increasing cluster number represents increasing regulation
4	Cape Range National Park	
3	Three Mile Camp (Gnaraloo Station)	
3	Red Bluff (Quobba Station)	
2	Fourteen Mile Camp (Warroora)	
2	Blowholes	
1	Warroora (Excluding Fourteen Mile)	
1	Nine Mile (Cardabia)	
1	Learmonth Air Weapons Range	

4.3 QUESTIONNAIRE RESEARCH

4.3.1 Sampling Approach

To answer null hypotheses 2 and 3 on the differences between camper preferences and resource use levels under different management regimes, it was necessary to gather information using a survey method. Sampling approaches differ in response to the type of population being surveyed, the availability of time, budget and the study’s overall purpose (Vaske 2008). Survey research has both advantages and disadvantages. The primary advantage is to obtain a sample population representative of a much larger population, in a scientific way at a reasonable cost (Vaske 2008). Other advantages of an on-site survey are that the cost is moderate, the response rate is at least potentially high and either the interviewer or respondent can fill out the survey (Smith and Newsome 2002). One challenge of questionnaires is that in some cases only one interest group (at Ningaloo, the current visitors) is being surveyed (Stewart and Cole 2001). However, along the Ningaloo coast, current remote campers are the primary interest group and the time to collect questionnaires was limited due to the scope of the study. Therefore, applied implementation strategies for on-site surveys were important in achieving the highest possible response rate, or proportion of completed questionnaires (Veal 2006). Such adaptations in methods in outdoor recreation to suit the study site and targeted population are common (Roggenbuck, Williams et al. 1993).

The survey type of most interest to this study is the on-site survey (also known as the site, user or visitor survey). On-site user questionnaires are the most common type of questionnaire used by managers in the leisure and tourism fields (Becken 2005; Veal 2006). While the goal of quantitative data collection is to get a representative sample (Veal 2006), it should be noted that, when conducting on-site surveys (Neuman 2007), population lists are often unavailable (Vaske 2008). The nature of the sample group, remote coastal campers, was that they were isolated and transient. Other than by face to face contact, there were few means of communicating with them. On-site surveys were also selected due to their characteristically high response rate, assuring as broad a sample population as possible. This is also called convenience sampling, a non-probability sampling technique. The sample size is rarely determined in advance because there is limited knowledge about the group or population from which the sample is taken (Neuman 2007), and there are little data available for camper numbers or demographics on the Ningaloo coast. The sample is advantageous for exploratory studies because new ideas may be generated from the results.

A cross sectional sampling, technique was used to gather data from a broad range of campers within the set time frame, between May and July 2009. Cross-sectional sampling examines data collected a single point in time, and is also called a snapshot approach. This approach is considered the simplest and least costly alternative, yet due to its nature, it cannot capture social processes or change. Further discussion on survey distribution is provided in section 4.3.3.

4.3.2 Questionnaire Structure and Content

Written questionnaires were chosen over interviews to reduce the time taken, costs and interviewer bias. Question format and survey structure can have a significant effect on visitor responses (Hall and Roggenbuck 2002). Questions can be pre-coded or open-ended. In a respondent-completed questionnaire, a closed or pre-coded question offers the respondent a range of choices while, for a closed question, a line or space can be left for respondents to write their answers (Veal 2006).

To ensure that the results from this study could be compared with similar work elsewhere in the Ningaloo region, the questionnaire format and content were based on the approach taken by Moore and Polley (2007) and Smith and Newsome (2002) and then adapted to suit the objectives of this study. The tour operator survey and visitor questionnaire were produced following the guidelines for questionnaire development outlined by Denscombe (2010). Questions were also developed in consultation with Pastoralists, the managing agency - Department of Environment and Conservation (DEC) and the Ningaloo Sustainable Development Committee to ensure that the results were relevant to their planning and management needs (Moore and Polley 2007). An explanatory cover page was included, modelled on that used by (Jones, Hughes et al. 2009). A copy of the questionnaire can be found in Appendix G.

The visitor survey (*Figure 4.2*) was organised into four parts. These questions were designed to gauge the campers’ perceptions and opinions relating to the current and future management of camping in the region, and current resource use.

Part 1 – Campsite preferences and activities

Part 2 – Resource use

Part 3 – Information about you

Part 4 – Comments

The questions in Part 1 addressed preferences concerning campsite site selection, distance to ocean, management preferences and activities. Part 2 gathered information on resource use, namely waste, water and energy use per campsite and distance driven to the campsites, all for the purpose of assessing environmental load. Visitor demographics, such as age, gender and origin were recorded in Part 3 to compare these between clusters. Part 4 included a series of open ended question on the need for, and possible ways to, minimise the environmental impacts of camping at Ningaloo and to record campers' views on any desired changes concerning the future of camping at Ningaloo. Due to the time constraints of the thesis, the comments section results were not analysed in detail. The short answer results of the questionnaire outlining: why respondents select a given campsite area; what Respondents do not want to see changed in the future concerning camping at Ningaloo and; what respondents would like to see done to minimise the environmental impacts of camping at Ningaloo are provided in Appendices H, I and J respectively.

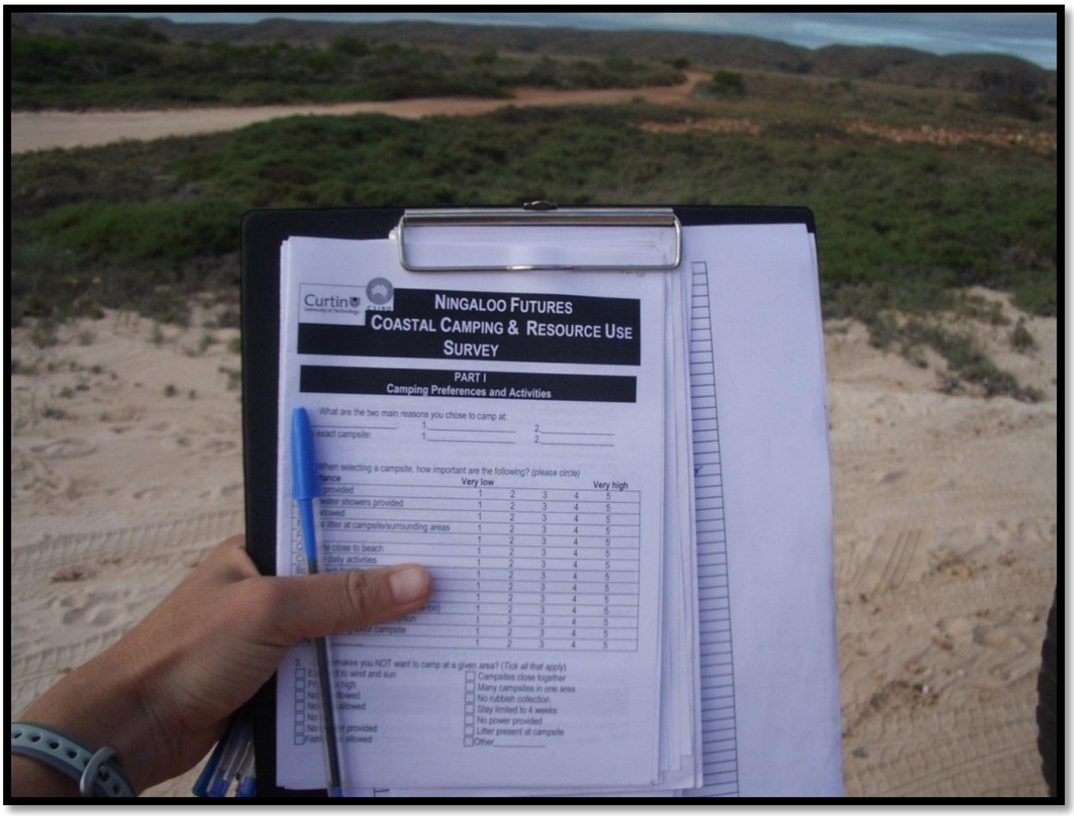


*Figure 4.2.*Ningaloo Futures Coastal Camping and Resource Use Survey.

4.3.3 Survey Distribution

On-site, self-completed visitor questionnaires were distributed and completed to collect qualitative and quantitative data on the resource use levels of campers, their activities, campsite preferences and demographics. The survey was distributed to campers aged 18 and over who camped in the designated camp areas along the Ningaloo coast for at least one night. All coastal campers within the nine study areas were considered appropriate for sampling. Accommodation type (for example, tent or caravan) did not alter their likelihood of being asked to fill out a survey. The questionnaires were distributed throughout the Ningaloo coast with permission from environmental agencies, resource managers and the Curtin University ethics committee. Formal university identification and a DEC letterhead communicating permission to distribute the surveys when at Cape Range National Park were accessible at all times and places.

The questionnaires were distributed by the researcher or by field assistants directly to the campers. Five volunteer field assistants worked closely with the author to distribute questionnaires at different times over the distribution periods. Respondents were asked to fill in a questionnaire, which was picked up 30 minutes later. The surveys took approximately ten minutes to self-complete a questionnaire. An interview schedule was conducted for subjects who preferred the survey to be read to them while the researcher recorded the answers. This took approximately 20 minutes per survey and respondents were therefore encouraged to fill in the survey themselves. For respondents not willing to fill out the survey, or conduct an interview based on the survey at the time of request, a reply-paid envelope and a questionnaire was provided. The importance of maintaining ethical standards in the conduct of this research was paramount. All study participants were requested to provide written consent, with confidentiality assured for the publication of results in accordance with Curtin University's ethical guidelines. Additionally, respondents were advised of their right to not complete a survey.

Questionnaires were distributed to campers in nine remote camping areas of Ningaloo Marine Park over a six week period between May and July, 2009. The survey was timed to capture a range of demographics including long term winter campers and families on shorter stays during school holidays. By the end of May many long-term campers are established at their camp areas for the winter, and through the July school holidays the area is popular with families staying for approximately two to three weeks. Surveys were distributed more than once in all areas with the exception of Warroora (south of Fourteen Mile) and the Defence Lands, due to their remoteness. Blowholes, Red Bluff, Gnaraloo, Warroora (Fourteen Mile), Cape Range National Park, Quobba Station and Cardabia were all sampled twice, three weeks apart. Campers at Warroora (Fourteen Mile) often stay longer than three weeks, and so approximately 50 % of the campers had already been surveyed at the time of the second survey round. In areas with less site fidelity (in particular those in Cape Range Park) there was nearly a full new turnover of campers, with the exception of caretakers and campers previously sampled in another location. Others (Cardabia, Defence lands, Quobba station) had a smaller population of campers and so sample sizes were smaller. Questionnaires from each management area were amalgamated into one of four clusters for analytical purposes as outlined in section 4.2.

4.3.4 Pilot survey and Field Assistant Training

A pilot study was conducted in March 2009 to trial 25 surveys across a range of camp areas. Prior to conducting the field surveys, the survey was appraised by DEC staff, Curtin staff members and supervisors of the project and the Curtin Ethics committee. Questionnaires for the pilot study were distributed by the primary researcher. The main surveys were slightly modified for question clarity as a result of the pilot. As such the pilot survey results were not included in the final survey tally or data analysis.

Formal training for field assistants was conducted as outlined by Marion (Marion 1991). The focus was to communicate and illustrate field procedures, develop and refine experience and judgement in the campsite settlings along Ningaloo, and build a commitment to quality. Five field assistants total were utilised for the duration of the field work who each volunteered between two and three weeks of their time at different intervals. Therefore, the researcher plus one or two assistants were conducting surveys at any given time throughout the survey period.

Training consisted of discussing the survey contents, the objectives of the data collection, data uses and management outcomes. Survey collection procedures were demonstrated during a formal survey collection period. Following a question and answer session, field staff separated into groups to hand out ten surveys. Any concerns or comments were raised during the hand-out period or afterwards. The field researcher walked around with each group at least once on the first day, to hand out 20 surveys with them to ensure communication with the campers was clear, friendly and effective. Thereafter, the field assistants handed out surveys independently in the most effective manner possible. For example, for one camp area with twenty sites, the researcher would survey campsites one thru ten and the field assistant eleven through twenty simultaneously.

4.3.5 Analysis

The questionnaire data was entered into the SPSS (Statistical Package for the Social Sciences) computer program for data analysis. The survey data was entered into Microsoft Excel and SPSS for analysis. The data was tested for significant differences between camp ground clusters in relation to camper preferences. Pearson's Chi-Square and ANOVA tests were used to identity significant differences between variables.

Levene's tests were undertaken for each question to test the homogeny of variances between the camp areas or clusters. Homogeny of variance is an assumption of the one-way ANOVA test. While the Levene's test showed that some questions did not satisfy this assumption, a robust test of equality of mean was instead undertaken which may provide more accurate outputs if the assumptions are not satisfied.

To test the significance of descriptive trends within clusters, pair-wise comparisons were also conducted using the Bonferroni posthoc test. Posthoc tests consist of pairwise com parisons designed to compare all combinations of the treatment groups. The Bonferroni Posthoc test was selected to minimise Type 1 error $< .05$. A trade-off for controlling family wise error rate is loss of statistical power. For instance, the probability of rejecting an effect that does actually exist is increased. The Bonferroni Posthoc test is also more powerful when the number of comparisons is small (in this case with three other clusters).

Chi square tests were used to test whether the variables were independent for Questions 3, 4, 5 and 6 on the Questionnaire. The Questionnaire is provided in Appendix G). To test the significance of descriptive trends within clusters, post hoc tests were conducted. Additionally, Posthoc tests consisted of pairwise comparisons designed to compare all combinations of the treatment groups (for example, Clusters 1-4 would be one treatment group). Through the Posthoc tests, clusters could be compared against each other for significant differences.

4.4 IMPACT ASSESSMENTS

4.4.1 Research Design

Impact assessments were undertaken to determine null hypothesis 4. Four different research designs have been employed to study recreational impacts on the natural environment (Cole 1987; Cole 2004): descriptive surveys of recreation sites, comparisons of used and unused sites, before-and-after natural experiments, and before-and-after simulated experiments. Trail and campsite condition assessments often adopt the first two designs with few exceptions (Cole 1995; Leung and Marion 2000), the most common being the ‘descriptive survey’, also called an ‘initial impact assessment’ (Monz 1998) or ‘visitor impact inventory’ (Marion 1991).

For the purpose of this study this will be called an ‘initial impact assessment’. Initial impact assessments can assess impacts on an entire park, campground or trail system (Cole 2004) and produce highly relevant site-specific information, though its downside is its lack of ability to identify cause-and-effect. Since one purpose of this study was to provide baseline data across different management regimes in order to aid management decisions along the Ningaloo coast, an initial impact assessment is the most applicable method.

Initial impact assessment methods, aimed at first-time assessments of a site, are derived from the environmental monitoring literature. Over time, sites may be selected for long-term monitoring which can determine changes in campsite conditions and attempt to relate these trends to changes in the amount, type, and distribution of visitor use (Monz 1998). Collecting baseline data to compare across management regimes was one objective of this study. Therefore a high accuracy is required to inform current and potentially future management decisions.

4.4.2 Assessment Approach

Different campsite impact assessment approaches can provide managers with information at either a general level (reconnaissance approach), or through more intensive measurements for individual resource indicators (multiple-indicator approach). These systems differ significantly in the type, accuracy, and precision of information collected, assessment approaches used, and assessment time required (Marion 1991). Reconnaissance approaches include photographic assessment (Magill 1989) and condition class observations (Frissell 1978) (*Table 4.4*), while multiple-indicator approaches include assessment of individual indicators through ratings on a scale, quantitative measurement or a combination of these (Leung and Marion 2000; Smith 2003). Multi-indicator approaches (Leung and Marion 2000), also called multi-parameter systems are 'based on independent assessments of several inventory and impact parameters' (Marion 1991, p. 14)and are presented in *Table 4.4*. Each indicator, or impact parameter, is represented through either pre-defined ratings or quantitative measurements depending on the nature of the information sought.

Both multiple indicator ratings and multiple indicator measurements were selected for this study, resulting in a combined survey approach (Smith 2003). This combined approach was chosen because it could offer a high level of reliability on a wide variety of indicators (Smith 2003). These more complex research designs are often required to determine interrelationships between campsite impacts, levels of use and environmental factors. Additionally, the system needed to be cost effective and to require minimum equipment, due to the monetary and distance restrictions of the study. The methods had to be applicable to a wide range of semi-arid coastal environments, because the campsites have different substrates in different geological areas along the coastline.

Continued advancements have been made through the expanding application of Geographic Information Systems (GIS) (Gajda, Brown et al. 2000) and statistical software programs (Monz and Twardock 2010). Leung and Marion (Leung and

Marion 2000) and Hockings and Twyford (Hockings and Twyford 1997) also used aerial surveys for monitoring campsites along the coast of Fraser Island, Australia. As these are not directly related to initial impact assessments, they are beyond the scope of this study. Multi-indicator approaches are most important to this study in order to quantitatively explore each of the three null hypothesis related to the impact assessment techniques.

Table 4.4

A Summary of different Campsite Impact Assessment and Monitoring Approaches and Designs.

Adapted from Leung and Marion (2000, p.29).

	Reconnaissance approach		Multiple-indicator approach	
Item	Condition class	Photo appraisal	Ratings	Quantitative measurement
Implementation	Descriptive classes is are defined and assigned to each campsite	Site photo taken and evaluated for each campsite	Assessment at ordinal scale is made on each selected indicator on a campsite	Measurement is taken for each selected indicator on a campsite
Typical data type(s)	Nominal/ordinal	Interval/ratio	Ordinal	Interval/ratio
Major utility	Prompt characterization of campsite conditions	Visualise campsite conditions; relocation	Efficient field work; minimal training required	Accurate and precise; permit quantitative analysis; allow aggregate measures; adaptable to management frameworks
Limiting factor(s)	Singular measure; conflicting criteria within a condition class	Scale and quality of aerial photos; photo interpretation skills	Composite ratings may not be mathematically appropriate	Field time; staff training; accuracy and precision
Examples	Frissell (1978); Marion (1995)	Magil (1989), Berrier (1984)- in Marion 1991	McCewan et al. (1996)	Marion (1991; Marion and Cole (1996)

Methods for campsite assessments in forested environments have been developed by the US Forest Service (Marion 1991) and the USDA Forest Service (Cole 1983). There have been refinements of the assessment and analytical procedures and adaptations of these assessment procedures to different environment types (Gettinger, Krumpe et al. 1998; Monz 1998), though few relate to campsite impacts in coastal and semi-arid environments (lit review). Marion (1991) suggests that specific management concerns and their application to desert or beach environments may require methodological modifications. One example is provided by Monz (1998) for the semi-arid environment of Baja, Mexico where low vegetation density, sandy soils and dispersed campsites make assessments by traditional methods challenging. The impact parameters utilised by Monz are listed below (Table 4.5).

Monz (1998) found that, although the modification of existing campsite monitoring protocols to non-forested ecosystems was necessary, the original methods are applicable, overall, to coastal ecosystems. These methods have been further adapted to suit the Ningaloo environment because 'Recreational impacts differ considerably between activities and between ecosystems' (Buckley, Pickering et al. 2006, p.84). For this study, a multi-indicator approach using quantitative counts and ratings, was preferred over the condition class approach utilised by Monz (Monz 1998) due to the increased accuracy obtained and the considerable variability between the sites.

Table 4.5

Campsite Inventory Parameters and Impact Assessment Parameters at Baja California Sur.

Sourced from Monz (1998, p.118.)

Inventory Indicators	Impact Indicators	
Site number (designated) and name	Size of impacted area	Number of tree stumps
Site location (GPS coordinates	Condition class	Number of trails
Substrate of landing area	Vegetative ground cover on site	Number of fire pits
Substrate of campsites	Vegetative cover off site	Litter and trash present
Number of campsites at beach	Mineral soil exposure	Observable human waste
Compass orientation of beach	Tree damage	Root exposure

4.4.3 Sample Design and Timing of Impact Assessments

A sample rather than a census of campsites was chosen due to the resource restrictions of the project and the large spatial extent of the study area. The campsites selected represent a combination of designated and undesignated sites.

Initial impact assessment data was collected twice in both 2009 and 2010, over three week periods between March and early April. Assessments were timed to avoid the hottest time of the year (Nov-Feb) but to be in periods of low visitor numbers. The first waves of campers generally appear in the Easter school holidays, commencing on April 18 in 2009. Therefore, the sites were sampled after being left undisturbed for a few months over the summer. This has certain implications including the potential for more damage due to absence of camp hosts and the peak-time demographic of repeat grey nomads, many of whom act as environmental stewards. So there may have been less impact over the summer period in terms of numbers, but perhaps impacts such as litter accumulation may have been greater because no-one was there to take care of the area. Perhaps it would have been best to assess the sites immediately after the peak camping impact in September but this was not possible due to the tight timeline of the project.

Additionally, a reconnaissance trip was made in September 2008 for five days to locate campsites and to become familiar with the camp areas and managers. Campsites that had been measured in 2009 were not remeasured, and instead new campsites were selected in 2010. The 2009 and 2010 data sets were then combined into one database for analysis. No sites were sampled at the Learmonth Air Weapons Range due to their isolation and difficulties of access with the necessary equipment. Impact assessments were also not made at Quobba homestead where the campsites were being utilised for pastoral purposes. These sites were only utilised for questionnaire distribution.

4.4.4 Control Sites

Control sites located away from camping areas and other anthropogenic pressures were surveyed at the same time as the campsites and on the same proforma as the initial impact assessments. The locations of the control sites were also recorded with photographs and by GPS. Approximately two controls per camp area were surveyed, one to the north and one to the south (*Figure 4.3*). Their size was set to $10m^2$, by measuring with the roto-wheel and defining this area with orange cones. The controls were always at least 50 m from a used campsite or other anthropogenic alterations such as roads. Identifying undisturbed controls along the Ningaloo coast was challenging after more than one hundred years of pastoral activity. The camp areas are grazed by livestock, creating trails, and many old camp areas have been closed for rehabilitation, and it is not certain whether any given area has ever been camped on. The vegetation between campsites can also be highly varied due to changes in substrates and distances from the ocean. Cole (Cole 2004) notes that even decent control sites are never perfect replicates of pre-existing conditions, so results from them can be misleading. As such, it was subsequently considered more meaningful to utilise the perimeter and boundary photographs from each individual campsite to calculate vegetation change rather than to compare the campsites with control areas.

Figure 4.3. Potential Control Area with Livestock Trails and Dune Blowouts, Cluster 3

4.4.5 Pilot study and Volunteer training

Two pilot assessments were conducted in order to refine the campsite assessment procedures, in terms of allocation of tasks between field researchers and estimation of the time taken to complete a single assessment. Trials were undertaken 2 km south of the Warroora homestead, on an area of land which had combinations of bare clay and vegetation, similar to those in a campsite. After the pilot study, the layout on the proforma was re-arranged to enable more efficient data scribing.

At least two individuals were required to be in the field at all times for both safety purposes and to make data gathering more effective. Field assistants included science graduates known to the author. Between one and two volunteers were present at any one time, for time periods of one to three weeks at a time. A total of five volunteers assisted with data collection at separate times over the three field trips which focussed on impact assessments. Volunteer training was conducted according to the method outlined by Marion (1991), discussed above (section 4.3.4).

4.4.6 Campsite Data Form

A proforma (Appendix F) enabled systematic collection of data through observations across the study site (Denscombe 2010). Maps of the Study site are provided in Appendix A. The campsite data form was designed to collect both inventory and impact measurements at campsites along the Ningaloo coast. The site proforma content and structure was adapted from previous studies (Cole 1987; Marion 1991; Monz 1998) to suit the coastal, semi-arid environment of Ningaloo. The proforma comprised a two-sided A4-sized sheet of paper, with one proforma designed to be used per campsite. Side one contained campsite inventory indicators, including facilities, and two areas for the camp site and camp area sketch. The second side contained campsite impact indicators, including litter, vegetation presence and social trails.

Key ‘indicators’ or ‘parameters’ are required to utilise multi-indicator assessment systems (Merigliano 1990; Watson and Cole 1992). An indicator is defined as ‘an important quality that indicates resource change due to recreational use’ (Leung and Marion 2000, p.29). Indicators may comprise either impact or inventory parameters, and it is common for a study using a multi-indicator approach to contain both (Smith and Newsome 2002). Using a multi-indicator approach requires selecting and modifying field assessment procedures for each indicator. Numerous specific approaches exist for evaluating any given parameter but these vary with respect to accuracy, precision, and assessment time (Marion 1991). Impact indicators for the initial impact assessments were selected based on their ecological, visitor and managerial importance within the context of Ningaloo Marine Park. Indicators were determined through both consultations with staff from DEC and an extensive literature review. The applicability of the indicators to both regulated and unregulated sites, upon different substrates, was also considered. Indicators from previous studies (Cole 1982; Monz and Twardock 2010) that were not applicable to the Ningaloo coast included: stumps/cut shrubs, campsite substrate type, human waste sites, root exposure, tree damage, and mineral soil loss.

4.4.6.1 Inventory Indicators

4.4.6.1.1 Vegetation Type, Dispersion and Distribution

Vegetation type is represented by grasses, spinifex, saltbushes, small shrubs (less than one metre high), large shrubs (over one metre high), small trees (less than two metres high) and large trees (over two metres tall). Any number of these vegetation types can be found at a campsite or at a campsite perimeter. Dominant vegetation types were assessed through ocular estimation (Cole 1989).

Vegetation dispersion related to the density pattern of vegetation within the camp area, including uniform dense, uniform medium, uniform sparse, clumped in one area, clumped in more than one area. The importance of this measurement was to see whether the impacts were uniform across the campsite. A similar indicator, vegetation distribution, was also recorded, which identifies whether the vegetation is evenly distributed, increasing from the core, increasing from the road or patchy across the whole campsite. Additionally, any soil and vegetation modifications made to campsites by campers were noted (*Table 4.6*).

Table 4.6

Vegetation Type, Distribution and Dispersion Measurement Scales.

Site Attribute	Method Used	Measurement Scale
Vegetation dispersion	Ocular Estimation	(1) Uniform dense (2) Uniform medium (3) Uniform sparse (4) Clumped in one area (5) Clumped in > one area
Vegetation distribution across whole campsite	Ocular Estimation	(1) Evenly distributed (2) Vegetation increasing from core (3) Vegetation increasing from area nearest to road (4) Vegetation patchy
Vegetation type	Ocular Estimation	(1) Grasses (2) Spinifex (3) Salt bushes (4) Small shrub (5) Large Shrub (6) Small tree (7) Large tree

4.4.6.1.2 Substrate, Beach Profile, Distance to Ocean

Substrate, beach profile and distance to ocean (*Table 4.7*) were measured qualitatively through visual (ocular) estimation, (Monz 1998) then assigned measurement ratings based on this visual assessment. No instrumentation was required for these assessments, hence only the author undertook these estimations for continuity. The measurement ratings utilised on the pro forma were selected to suit the campsites along the Ningaloo coast. Substrate was measured as sand, limestone, red clay, or gravel or 'other'. If the substrate was compacted, this attribute could also be selected. As such, beach profile was broken down into the five classic beach profile (McHarg 1992) components of start primary dune, end primary dune, secondary dune, trough and ridge. Distance to ocean was measured in seven increments, to cover distances from five metres to more than 500 metres.

Table 4.7

Substrate, Beach Profile and Distance to Ocean Measurement Scales.

Site Attribute	**Method Used**	**Measurement Scale**
Substrate	Ocular Estimation	(1) Compacted (2) Loose sand (3) Red clay (4) Gravel (5) Other______
Beach Geomorphology/landscape setting	Ocular Estimation	(1) Secondary berm (2) Primary dune (3) Secondary dune (4) Field (5) Ridge
Distance to Ocean	Ocular Estimation	1) 5-10 (2) 10-20 (3) 20-50 (4) 50-100 (5) 100-200 (6) 200-500 (7) more than 500

4.4.6.1.3 Facilities

Facilities recorded included number of fire pits, and distances to drop toilets, sewerage disposal sites, garbage bins and tips (*Table 4.8*). The number of fire pits was counted, whereas distance to facilities (distance to open or closed tip and dump point or rubbish bin and toilet) were recorded using measurement ratings. Measurement rating increments were selected based on the amount of effort required to use certain facilities. For example, a rubbish bin less than 10 m away (the closest rating) would be considered a very easy location to deposit rubbish, yet a rubbish bin more than 1 km would be unlikely to be utilised frequently by campers.

Table 4.8

Measurements for Facilities.

Site Attribute	Method Used	Measurement Scale
Fire pit	count	Blank = no, number = yes
Distance to toilet	Ocular Estimation	Blank = no, (1) <than 5 m (2) 5-10 (3) 10-20 (4) 20-50 (5) more than 50m
Distance to Sewerage disposal	Ocular Estimation	(1) less than1km (2) 5-10km (3)10-20 (4) 20-50 (5) more than 50km
Distance to Garbage Bin	Ocular Estimation	(1) less than 10 m (2) 10-50 (3) 50-200(4) 200-1km(5) more than 1km
Distance to Tip	Ocular Estimation	(1) less than less than 1km (2) 1km-5km (3) 5km-10 km (4) 10-15 km (5) more than 15 km

4.4.6.1.4 Campsite location

A Garmin hand-held GPS (model GPS 45, Garmin International, Lenexa, KS 66215 U.S.A.) was used to obtain latitude and longitude coordinates for all campsites, both designated or undesignated, observed during the survey, whether or not they were sampled. Photographs were also taken at each campsite regardless of whether they were sampled or not. The purpose was to document impacts, to help with site relocation and to act as a future reference if needed. Photographs were taken of both the overall campsite and individual impacts which aligned to those on the campsite pro forma. These included any vegetation damage, social trails or fire pits. Also, photographs were taken of perimeter vegetation (one metre from the boundary of the camp area) and boundary vegetation (vegetation surrounding the perimeter), both across the vegetation and pointed at the ground, to get an understanding of vegetation density in different areas.

4.4.6.1.5 *Distance to Closest Campsite and Number of campsites within a 50m radius*

The distance to other campsites, number of campsites in a 50 metre radius and number of campsites on one barren core area recorded to understand whether cumulative environmental impacts occur when campsites are closer together. Ratings were grouped into 7 different measures, ranging from 5-10 metres to more than 500 metres.

Table 4.9

Measurement Scales for Campsite Density.

Site Attribute	Method Used	Measurement Scale
Distance to closest campsite	Ocular Estimation	(1) 5-10 (2) 10-20 (3) 20-50 (4) 50-100 (5) 100-200 (6) 200-500 (7) more than 500
Number of campsites in a 50m radius	Ocular Estimation	(1) None (2) 1-3 (3) 3-5 (4) 5-8 (5) more than 8

4.4.6.2 Impact Indicators

A number of impact indicators were derived from the literature and modified to suit the semi-arid, coastal environment. For example, root exposure, vegetation/soil modifications, campsite vegetation distribution and dispersion did not yield results that were relevant to the study site and so were not included in the analysis. While inventory and facility indicators reflect what development and facilities are present at the site, impact indicators can measure changes in campsite condition. The impact indicators primarily focussed on changes in campsite area, vegetation, litter and social trails.

4.4.6.2.1 *Area: Campsite, Vegetation and Barren Core Area*

Calculating the campsite area required a high level of accuracy because other impacts such as vegetation loss, tree damage and litter were assessed within the camp area boundary. Therefore, reduced precision in the results for these other parameters may result from inaccuracies with regard to the campsite area (Cole 1989). There are typically four commonly used approaches to define a campsite area for an initial field assessment, the fixed radial transect method, the variable radial transect method, the geometric figure method and estimation of campsite area. In selecting a method, the effectiveness, time, ease of re-measurement for future managers gaining a quantitative measurement, and applicability to the campsites at Ningaloo were all considered. Ningaloo campsites comprise a sliding scale from simple (geometric) to complex shape patterns. Due to the high level of accuracy required to answer the null hypothesis, quantitative methods were selected for this study. Three measurement methods were considered, fixed radial transect and variable radial transect (*Figure 4.4*) and geometric figure methods. The advantages and disadvantages of these methods are summarised in *Figure 4.5* and *Table 4.10*. The fixed radial method was not suitable because it is considered inaccurate on campsites with complex shapes (Marion 1991). The variable radial method, although highly accurate, is the most time consuming method and requires arithmetic procedures to calculate the area which would have been overly time consuming for the large number of sample sites at Ningaloo.

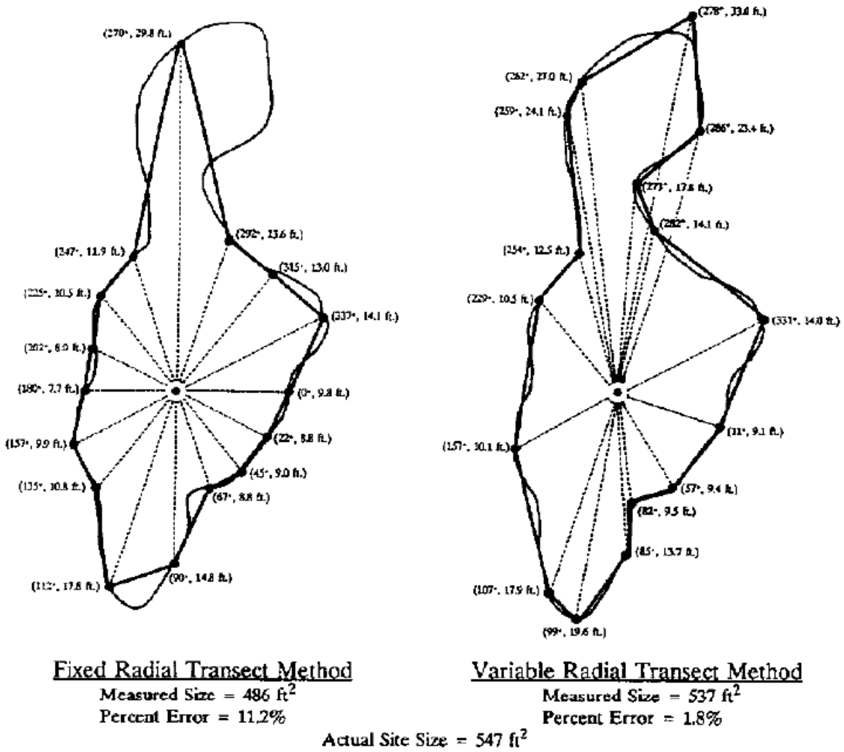


Figure 4.4. Example of Fixed and Variable Radial Transect Methods Sourced from Marion (1991, p. 21).

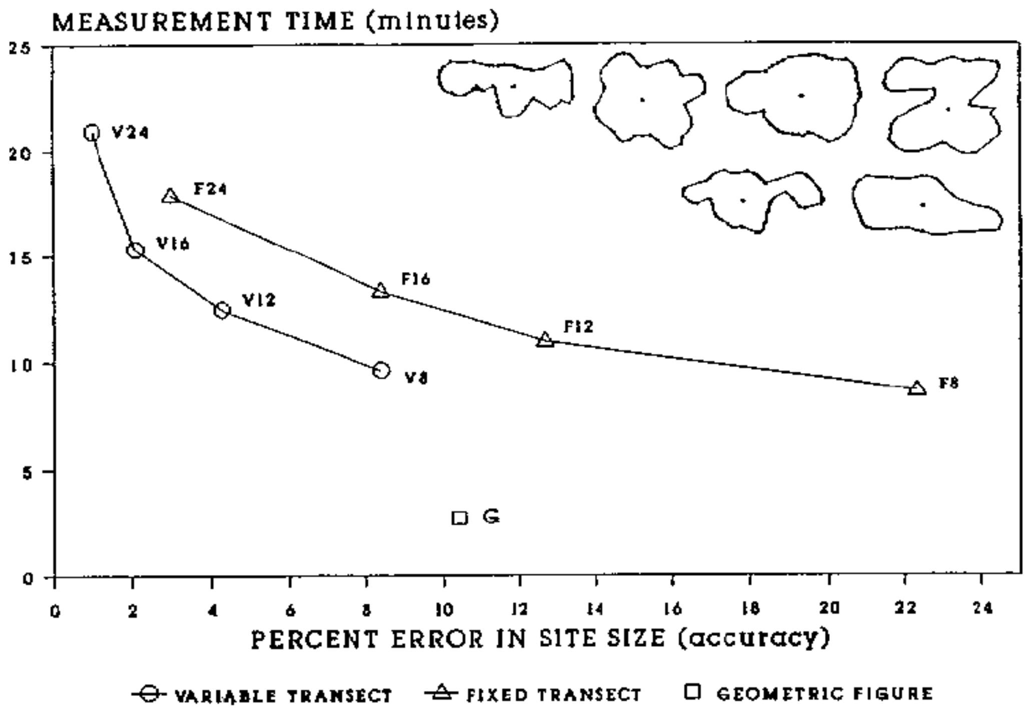


Figure 4.5. A Comparison of Time and Accuracy for Fixed Radial Transect, Variable Radial Transect and Geometric Figure Methods for determining Campsite Area.

Sourced from Marion (1991, p. 20).

Geometric figures were determined to be the most appropriate method for calculating campsite size area for this study due to the complex shape of any undesignated sites. The size is estimated by superimposing an appropriate geometric figure over the area and taking the requisite linear measurements as described in Cole (1989). One first visualises the site as a circle, a rectangle, or some combination of these geometric figures, of which the appropriate dimensions are then measured. While Cole (1989) assigned the resulting area a measurement rating (for example: a rating of 1 for <46 m^2; 2 for 46-186 m^2 or; 3 for >186 m^2), absolute values were recorded for this study for quantitative analysis. A Roto-wheel (100cm) was used to gain more accurate measurements than pacing could provide. Fluorescent flags were used to first create an outline of the various shapes, which were then drawn on the pro forma sheet, and the Roto-wheel then measured the distances between the flags. Other equipment required included: a Garmin Global Positioning (GPS) unit; marker pegs; tape measure; Roto-wheel; data sheets and rubbish bag for litter audit (*Figure 4.6*). The geometric figures method was also employed in measuring out the 10 m^2

control plots, although it was later deemed more accurate to analyse detailed photographs of each site to determine relative and absolute vegetation loss away from the campsites (section 4.4.7) rather than relying on the control sites, which may have been used for pastoral or camping purposes in the past (section 4.4.4).

Table 4.10

Advantages and Disadvantages of the Geometric Figure, Fixed Radial Transect, Variable Radial Transect Methods.

Method	**Advantages**	**Disadvantages**
Geometric figure	Lowest measurement times but intermediate in accuracy*	Difficult to apply on sites with complex shapes and sinuous boundaries Requires excellent judgment to superimpose geometric figures
Fixed radial transect	Only judgments required surround site boundaries Takes less measurement time than variable radial transect method	inaccurate on sites with complex shapes unless large number of transects are used Specific arithmetic procedures required which is not easily accessible but replaces tedious manual calculation methods Less accurate than Variable radial transect method
Variable radial transect	Greatest accuracy in measuring site sizes Errors are reduced when remeasuring sites and subjectivity regarding boundary determinations is minimised. Consistently more accurate than other methods*	High in measurement times when compared to the fixed radial method (due to ID of boundary points) Specific arithmetic procedures required which is not easily accessible but replaces tedious manual calculation methods

Marion (Marion 1991) recommended excluding vegetation ‘islands’ or ‘clumps’ from vegetation measurements within campsites in addition to any individual trees. In this coastal environment, vegetation types that do not exist as islands are predominantly grasses. Many of these islands (a combination of vegetation types, but predominantly spinifex, saltbush and shrubs) display signs of damage by visitors. Islands are often small areas of vegetation, less than $2m^2$ and represent the types of vegetation found within campsite perimeters which may be considered important for management purposes. However, so as to be comparable with other studies in the international literature, these vegetation islands were measured and subtracted from the total campsite area as recommended by Marion 1991 (Marion 1991). They were included however for ‘campsite vegetation type’ (inventory indicators, section 4.4.6.1.1) and ‘campsite vegetation damage’ (impact indicators, section 4.4.6.2.4) to better understand which species were present and which ones displayed the most resistance and resilience to trampling. Additionally, the campsite area measurement included areas where vegetation was heavily damaged as a result of repetitive trampling. Those sites with cleared ground such as in Cluster 4 were considered barren ground for the purpose of this study.

Figure 4.6. Instruments used for the Impact Assessments and Litter Audit.

4.4.6.2.2 Litter and Human Waste

Litter was assessed quantitatively through counts of litter which allocated to size-based categories. This litter was then collected opportunistically during impact assessments to be sorted and inventoried at a later date (Alkalay, Pasternak et al. 2007). Litter from Red Bluff, Three Mile Camp, Cape Range National Park, Blowholes and Warroora was audited. The focus of the audit was on the type of litter collected rather than the quantity. Litter was not audited during the impact assessments due to the extra time requirements. The quantity and type of litter may be unrepresentative because litter type and quantity reflects on who has been there, whether or not rubbish is collected and how frequently this occurs. However, litter is considered to be a highly important issue for campers both at Ningaloo and worldwide (Moore and Polley 2007). It is important to understand the types of litter that exist around campsites, and the influence that management can have on litter reduction. The presence of human waste, through the presence of toilet paper or faecal matter, was also recorded quantitatively.

4.4.6.2.3 Social Trails: Number, Width and Depth

Social trails are often a precursor to campsite expansion and so this is an important consideration for managers. Social trail numbers, widths and depths were measured quantitatively.

The length of social trails was not measured due to time limitations and the fact that many social trails merged together making individual trails unidentifiable. In instances where these smaller social trails had widened out to become part of the camp area, for example to more than one metre this was considered to no longer be a trail, and the area was included as part of the camp area.

Social trails were detected by prominent gaps in vegetation surrounding campsites and leading to a destination – usually another campsite, a portable toilet or the ocean. Two kinds of social trails exist. Some trails present themselves as longer pathways to get to a destination (beach or another campsite) and others as smaller trails such as an extension of a campsite for a toilet, generator or satellite dish. The latter item was most common in Clusters 1 and 2 due to greater use of generators and the requirement to bring a toilet, though they also occurred in Clusters 3 and 4, primarily for those using generators. Both trail types were counted in the data collection process.

Small tracks which appeared to be goat tracks, less than 10 cm in width were not recorded. Social trail width was recorded by running a tape measure across the trail width. Depth was recorded by a tape measure across the trail such that the tape measure was positioned perpendicular to the trail's direction and was resting on the trail edges. The trail depth was then measured as the distance from the tape measure to the ground in the centre of the path (Dixon, Hawes et al. 2004).

4.4.6.2.4 Vegetation Damage and Root Exposure

While vegetation vigour (health), was used to assess the impact of recreation on vegetation, it is also important to assess which types of vegetation appear to resist impact by campers more than others and which species in the area appear hardier for future rehabilitation efforts. The vigour of vegetation was assessed as a measurement scale adapted from within the literature (Marion 1991; Leung and Marion 2000). For the purpose of this study, rather than vigour, vegetation damage was measured by percentage, for analytical purposes. All other impact variables were measured on a sliding scale, with the lower numerical amount representing lower impact and the larger numerical amount representing higher impact. Each vegetation type present at each site was therefore assigned a 'vegetation damage' amount in one of four categories, between no damage (Category 1) and over 60 percent damage (Category 4) (*Table 4.11*), in part to assess if certain vegetation types were more hardy and resilient than others . Indicators from the existing literature not applicable to the Ningaloo coastal environment include: stumps/cut shrubs, campsite substrate type, human waste sites, root exposure, tree damage, and mineral soil loss.

Plant damage is calculated by recording the percentage of plants damaged, or that have reduced vigour, within a campsite. Methodological guidelines (Cole 1989) recommend that islands of vegetation not be included in campsite assessments. While these were not included for determining campsite area, they were incorporated when assessing vegetation damage at a site, because often they were low (within 1 m) to the ground and heavily impacted from trampling. It is useful to understand which species show less damage in order to understand which species are more suitable (resilient and resistant) for future rehabilitation efforts, or for new campsite locations. Vegetation within camp areas was limited due to the low rainfall, high evaporation and the fragile, sandy nature of the soil. However many different species were present within the perimeter locations.

The damage to each vegetation type within the campsites was compared across clusters. Missing entries (those vegetation types that were not present) were not included in the analysis. While there are few trees at Ningaloo, the number of plants or shrubs with exposed roots was also recorded since vegetation damage may pre-empt campsite expansion.

Table 4.11

Vegetation Damage Measurement Scale.

Site Attribute	Method Used	Measurement Scale
Damage (%) for each vegetation type present.	Ocular Estimation	(1) None show any damage (2) 10-30% of shrubs show damage (such as broken limbs, crushed, generally unhealthy) (3) 30-60% of shrubs show damage: 1-2 show reduced vigour as a result of damage (4) >60% of shrubs show damage; 2 show reduced vigour, dead or dying shrubs present.

4.4.6.3 Analysis of Indicators

The survey data was entered into Excel and SPSS (Statistical Package for the Social Sciences) to be analysed. The data were tested for significant differences between camp ground clusters in relation to the inventory indicators and impact indicators. Pearson's Chi-square and ANOVA tests were used to identity significant differences between variables. Pair-wise comparisons were also conducted using the Bonferroni post hoc test. In some instances ANOVA's were selected for count data as the ten impact variables would later be analysed together as part of the indices calculations. Homogeny of variance is an assumption of the one-way ANOVA test. Data was transformed prior to running the tests if data was not normally distributed. Levene's tests were undertaken for each question to test the homogeny of variances. While the Levene's test showed that some questions did not satisfy this assumption, a robust test of equality of mean was instead undertaken which provides more accurate outputs if the assumptions are not satisfied. If a significant difference was found, it was only reported that one group mean is higher or lower than another group mean for the three impact variables involved (an ordinal statement) which reduces error in the interpretation of the findings.

4.4.7 Impact Indices

Impact indicators such as those outlined above (section 4.4.6.2) are critical to management frameworks (Newsome, Moore et al. 2002) and to their consequent monitoring programs (Leung and Marion 2000). In contrast, an index is considered a mathematical combination of two or more indicators (Westman 1985) known to qualify, summarise and therefore facilitate communication among scientists, resource managers, and the public (Leung and Marion 1998). Indices may be classified into four groups (Leung and Marion 2000) (*Table 4.12*). The most relevant to this study are those which provide a summary of site resource conditions (Marion 1991). Area of Vegetation Loss (Cole 1989), Summary Impact Index (Cole and Hall 1992; McEwen, Cole et al. 1996) and the Impact Index (Stohlgren and Parsons 1992) are examples of summary indices (Leung and Marion 2000).

This section focuses on four indices which produce resource condition summaries. Analysis for the first index, Vegetation Cover Loss, was derived directly from the literature (Cole 1992; Monz, Cole et al. 2010). Analyses for the remaining three indices were adapted to suit the Ningaloo coast. As such, the names were changed to the Coastal Vegetation Loss (CVL), Area of Coastal Vegetation Loss (ACVL) and the Coastal Campsite Impact Index (CCII). The first, CVL, is a variation of Vegetation Cover Loss (Monz, Cole et al. 2010). The second, ACVL, is a variation on Area of Vegetation Loss (Cole 1989). The third, CCII is a variation on the Summary Impact Index (McEwen, Cole et al. 1996).

Table 4.12

Description, Examples and References of Indices.

Adapted from Leung and Marion (2000)

	Description	Examples	References
Indices of impact intensity	Constructed to represent the severity of environmental damage through floristic dissimilarity and cover alteration	Shannon-Wiener species diversity index (H), community similarity index	(Cole 1978; Cole 1993),
Indices of spatial qualities	Represents the spatial extent and distribution of impacts	Index of trail area, campsite expansion index, Gini coefficients, linear nearest neighbour index	(Cole, Watson et al. 1997) (Gettinger, Krumpe et al. 1998) (Leung and Marion 1998)
Summary of resource condition of a site	Provides a summary of resource condition of a site	Area of vegetation loss, summary impact index, impact index	(Cole 1989) (Cole and Hall 1992) (McEwen, Cole et al. 1996) (Stohlgren and Parsons 1992)
Environmental sensitivity to impacts	Designed to represent environmental sensitivity to impacts	Resistance and resilience indices, durability Index	(Cole 1995)((Cole 1995) (Cole 1993)

4.4.7.1 Vegetation Cover Loss

'Vegetation Cover Loss', or the difference, in percentage terms, between vegetation cover within the boundary and the campsite areas, is a primary indicator of the amount of human impact (Cole 1992). This is because vegetation loss is among the most obvious changes to occur on campsites (Cole 1992). Through this one quantitative estimate, the relative magnitude of change across different sites can be assessed (Leung and Marion 1999). Throughout the recreation ecology literature, authors have frequently assessed vegetation loss through both relative and absolute measures.

> Because the magnitude of vegetation loss, the first index --absolute difference-- is the measure on the control site minus the measure on the campsite. The second index --relative difference-- is absolute difference expressed as a percentage of the measure on the control site (Cole and Hall 1992, p. 3).

That is, 'relative change expresses loss as a percentage of how much could possibly be lost.' (Cole 1989, p. 1). For example, if there had been only 20 % cover, under undisturbed conditions, if all vegetation is lost, relative loss would be 100 %. Relative loss is of most interest for this study given that even the control areas frequently have sparse vegetation cover. Relative vegetation damage has previously been called 'per cent cover reduction' (Cole 1978) and 'relative change' (Cole 1982) and later 'vegetation cover loss' (Monz and Twardock 2010). Studies of relative amounts of vegetation loss are most applicable to this study because the vegetation cover density tends to be low in coastal areas (Monz 1998), so an absolute figure for vegetation loss could be misleading.

Within the 2010 study by Monz and Twardock, groundcover vegetation was assessed using six cover classes (0–5 %, 6–25 %, 26–50 %, 51–75 %, 76–95 %, 96–100 %). Relative vegetation loss can be derived by dividing the midpoint value of the onsite vegetation cover class by the midpoint value of the corresponding offsite vegetation cover class (Cole 1989; Monz and Twardock 2010) as per the calculation:

$$\text{Vegetation Cover Loss} = 1 - \frac{\%\ \text{cover in campsite}}{\%\ \text{cover in control plots}} \times 100$$

To derive the Vegetation Cover Loss for this study, 'Vegetation Percentage Cover' was first derived from photographs taken for each sampled campsite, from the campsite area, campsite perimeter and campsite boundary and placed into one of six cover classes (Monz and Twardock 2010) (Table 4.13).

Vegetation Percentage Cover was calculated for vegetation cover within: the campsite area, the campsite perimeter area, (classified as vegetation from the edge of the camp area extent, extending for one metre) and the campsite boundary area (classified as vegetation from the edge of the perimeter area extent, extending for three metres). To calculate the Vegetation Cover Loss, the above formula was calculated for each sampled campsite by comparing the vegetation percentage cover between:

1. The campsite area to the campsite perimeter
2. The campsite area to the campsite boundary (considered the 'control' for the purpose of this calculation).
3. The Vegetation Percentage Cover was compared with vegetation cover both within the campsite perimeter and the boundary, to better understand whether or not campsite expansion was occurring as displayed through large differences in vegetation loss between the boundary and the perimeter.

Photographs were considered to be a more time-efficient method of comparing vegetation cover between the campsite and boundary areas (two to five metres from the campsite area border) as photographs could be analysed when out of the field. Vegetation percentage cover loss was calculated for grasses, shrubs and a combination of the two, in order to assess the resistance and resilience of each. In some instances boundary vegetation was less dense than vegetation within the campsite which created a negative value. This value was changed to zero to represent no vegetation loss for the campsites when compared to the boundary areas.

Table 4.13

Vegetation Vigour Measurements.

Site Attribute	Method Used	Measurement Scale
Vegetation cover on campsite area (%)	Ocular Estimation from Photographs	Relative vegetation cover loss categories Six level cover scale, 0-5%;6-25%;26-50%;51-75%;76-95%;96-100%
Vegetation cover on campsite perimeter (%)	Ocular Estimation from Photographs	Relative vegetation cover loss categories Six level cover scale, 0-5%;6-25%;26-50%;51-75%;76-95%;96-100%
Vegetation percentage cover on campsite boundary	Ocular Estimation from Photographs	Relative vegetation cover loss categories Six level cover scale, 0-5%;6-25%;26-50%;51-75%;76-95%;96-100%

4.4.7.2 Coastal Vegetation Loss and Area of Coastal Vegetation loss

Cole's (1989) Area of Vegetation Loss index provides an estimate of the area of vegetation removal from a campsite, incorporating both the proportion of vegetation lost on the campsite and the area of the campsite. It is derived through multiplying absolute loss by area which provides an estimate of vegetation removal from the campsite. Area of Vegetation Loss is considered to be an excellent index for comparing loss across a variety of situations because it incorporates both the proportion of vegetation lost on the campsite and the area of the campsite (Cole 1992). However, this is correct only if estimates of cover are representative of the entire campsite and are not biased toward either the more de-vegetated campsite core, or the more vegetated periphery. Campsites along the Ningaloo coast more often than not comprise both a vegetative area and a barren core area within the campsite area, creating a challenge in applying the Area of Vegetation Loss index.

Methods from Cole (1989) and Monz (2010) were therefore combined to produce an overall Coastal Vegetation Loss (CVL) index for the purpose of this study. As such, the methods have been adapted to record the average relative vegetation loss (percentage) from the campsite, taking into consideration both the vegetated area and the barren core areas within the campsite area (*Figure 4.7*).

This formula can be expressed as:

Coastal Vegetation Loss =

$$\left[\overset{\text{Barren Core}}{\left\{ \text{Proportion of Camp Area (\%)} \times \text{Vegetation Cover Loss (\%)} \right\}} + \overset{\text{Vegetation Area}}{\left\{ \text{Proportion of Camp Area (\%)} \times \text{Vegetation Cover Loss (\%)} \right\}} \right] - \overset{\text{Campsite Boundary}}{\left\{ \text{Vegetation Cover Loss (\%)} \right\}}$$

For example, in a 'campsite', which has a camp area of 87m^2 (*Figure 4.7*) with 60 % barren core area and 40 % vegetated area the vegetation cover loss for the barren core area is 100 %, and the cover loss for the vegetated section is 80 % (such as grass which has been heavily trampled). The vegetation loss and proportion of the camp area are first multiplied for both the barren core area and the vegetated area separately. The two resulting outputs are then summed. The percentage loss already existing in the control area ('Campsite Boundary') is then subtracted. Those sites with cleared ground resulting from a management footprint, such as in Cluster 4, were considered barren ground, with 100 % vegetation loss for the purpose of this study.

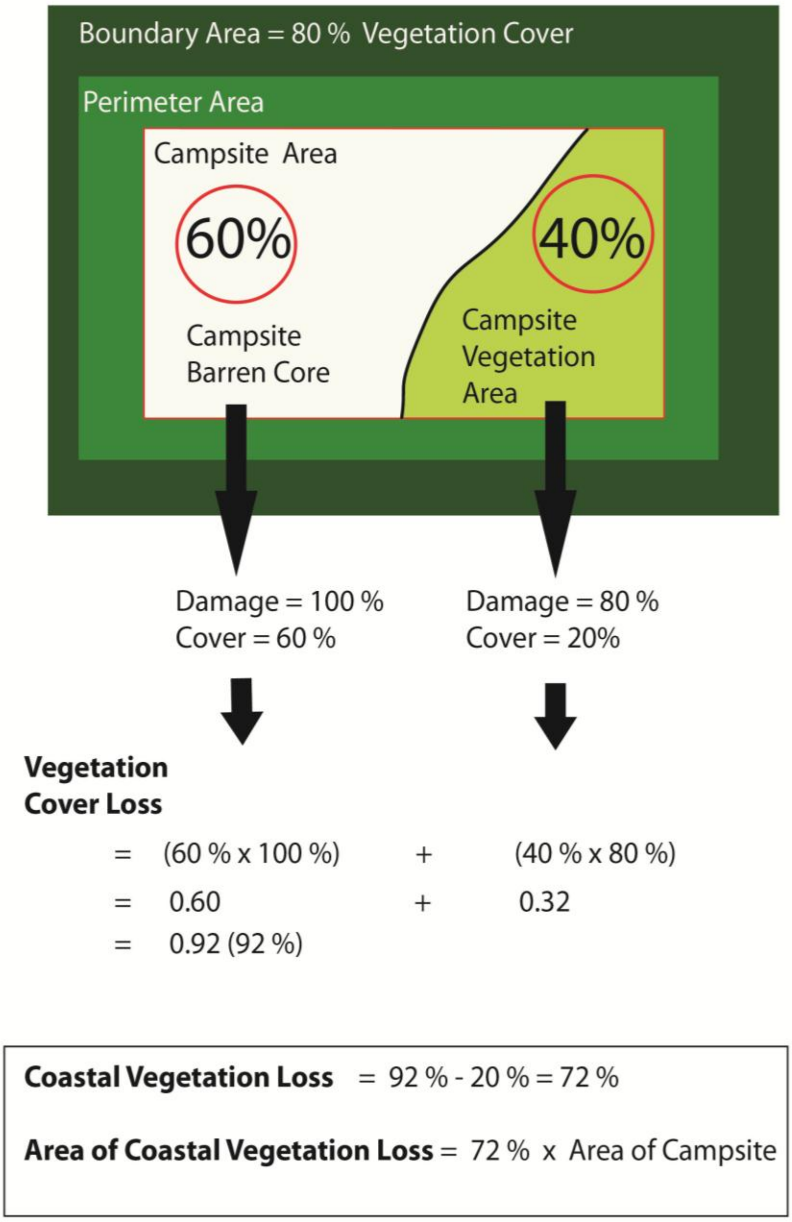


Figure 4.7. Equation to derive both Percentage of Coastal Vegetation Loss and Area of Coastal Vegetation Loss.

The example may also be written as follows:

$$\left\{ \left\{ \begin{array}{ccc} \multicolumn{3}{c}{\text{Barren Core}} \\ 60\% & & 100\% \\ (0.6) & \text{x} & (1.0) \end{array} \right\} + \left\{ \begin{array}{ccc} \multicolumn{3}{c}{\text{Vegetation Area}} \\ 40\% & & 80\% \\ (0.4) & \text{x} & (0.8) \end{array} \right\} \right\} - \left\{ \begin{array}{c} \text{Campsite Boundary} \\ 20\% \\ (0.2) \end{array} \right\}$$

$$= \quad \left[0.6 \quad + \quad 0.32 \right] \quad - \quad 0.2$$

$$= \quad 0.72$$

The relative CVL is therefore 72 %. When this is multiplied by the camp area, this provides the total Area of Coastal Vegetation Loss (ACVL). Therefore:

Coastal Vegetation Loss = 72 %

Area of Coastal Vegetation Loss = 0.72 x x87m^2 = 62.64m^2

Both the indicator of Percentage of CVL and the indices of ACVL will be compared across the management areas to assess differences between them and to address null hypothesis 3, that environmental impacts do not differ across management area.

4.4.7.3 Coastal Camping Impact Index

A study by McEwan (McEwen, Cole et al. 1996) is one of the few to compare campsite impacts across different locations. Three different levels of impact were rated for the variables ‘vegetation loss’, ‘mineral soil increase’, ‘number of trees damaged’, ‘number of trees with roots exposed’, ‘number of fire pits’ and ‘other development’, ‘number of fire pits’, ‘number of social trails’, ‘campsite area’, and ‘barren core area’. The levels of impact were then averaged across the variables. As many of these variables do not apply to the Ningaloo coast, a summary impact rating was adapted for this coastal region, calculated using data from eight impact indicators. Indicators selected for this assessment were: ‘campsite area’, ‘Coastal

Vegetation Loss' (CVL, an index), 'barren core area', 'perimeter vegetation damage', 'number of fire pits', 'number of social trails', 'sum of social trail widths', and 'number of litter items' (*Table 4.15*). To enable comparisons with the international literature, the variables 'campsite area', 'barren core area', 'number of fire pits', and 'number of social trails' were included for analysis in this study. As vegetation integrity along the coastal system is of high importance, the CVL index was also included to represent 'Vegetation Loss' in McEwan et al.'s (1996) study. 'Number of trees damaged' was replaced by 'perimeter vegetation damage'. Many campsites at Ningaloo comprised barren core areas exclusively and so perimeter vegetation damage was considered a more representative variable for all campsites. Where sites did contain vegetation this was comprised predominantly of buffel grass (perhaps due to previous site disturbances, grasses being the first colonisers), and so, while grasses are a stabiliser this was not as detrimental ecologically as loss of dunal vegetation.

The presence of litter was also included due to the importance accorded to it from previous studies along the Ningaloo coast relating to visitor satisfaction. Litter was weighted in value so that large items over 5 centimetres were equal to two, whereas small items less than five centimetres were equal to one. The sum of 'social trail widths' was also included because they were seen to vary to a large extent and may presage campsite expansion.

It was necessary to transform the data before analysis because the variances for each variable were not uniform. Dependent variables (impact indicators) were transformed through square root or log 1 if they contained zeros to encourage a normal data distribution (*Table 4.14*). Only a small number of outliers were present (up to eight out of 225 samples) for individual indicators. Outliers were truncated to the nearest number on the normal distribution curve to maintain as much data integrity as possible.

Table 4.14

Transformations of Impact Indicators.

Impact indicator	Transformation
Coastal Vegetation Loss	Absolute Percentage Loss (Log1)
Camp area	Non-presence ('0' not included in analysis)
Barren core	Non-presence ('0' not included in analysis)
Fire Pits	Count with zeros log10+1
Social Trail widths	Sum ST widths log1
Litter	Total litter (weighted) truncatedLog10+1
Perimeter Vegetation Damage	Average campsite vegetation damage from photos (six categories) no vegetation patches
Social Trail Number	Social trail number log 10

Values were then divided into percentiles. Although Cole (1989) recommends dividing into medians to reduce the challenges from outliers in SPSS, this study strives to identify the outliers and therefore created five groups so that the extremes of the least and most impacted sites along the coast could be identified. Once values were coded into one of five groups by percentiles, they were exported back to Excel. Average values, of between 1 and 5, 1 being the lowest impact and 5 the highest impact, were calculated for each campsite. This purpose of this analysis was to compare those campsites with low and high scores across the Ningaloo coast with each other, as opposed to pre-set groups of data. Therefore, those rated with the lowest impact may still have a large impact when compared with the international literature or those with a high score may actually be low when compared with other studies.

Table 4.15

Impact Assessment Parameters, Assessment Methods and Measurement Scale for Impact Summary Variables.

Campsite area	Method Used	Measurement Scale	Notes
Coastal Vegetation Loss	Ocular Estimation through photographs	Rating: Relative vegetation cover loss categories Six level cover scale, 0-5%;6-25%;26-50%;51-75%;76-95%;96-100%	Derived from methods outlined in section 4.4.1
Barren Core Area	Geometric figure	Measurement in m^2	Derived from methods outlined in 4.3.6.2.1
Perimeter Vegetation Damage	Ocular Estimation	Rating: (1) None to 10% show any damage (2) 11-30% of shrubs show damage (such as broken limbs, crushed, generally unhealthy) (3) 31-60% of shrubs show damage: 1-2 show reduced vigour as a result of damage (4) 61-90%% of shrubs show damage; 2 show reduced vigour, dead or dying shrubs present. (5) 91%-100% of shrubs show damage	Derived from methods outlined in section 4.3.6.2.4
Number of fire pits	Count	Total number of fire pits per campsite	Derived from methods outlined in section 4.3.6.1.3
Number social trails	Count	Total Number of social trails present	Derived from methods outlined in section 4.3.6.2.3
Sum of social trail widths	Count	Measurement in cm	Derived from methods outlined in section 4.3.6.2.3
Amount of litter	Count	Number of both small and large litter items, weighted.	Large items over 5cm = 2, smaller items less than 5 cm = 1.

4.5 REGRESSION ANALYSIS

Regression analyses between impact indicators, and independent and management variables were utilised to test null hypothesis 5, that the current magnitude of environmental impacts is influenced by management variables alone.

As outlined within the literature review (section 3.4.4), studies of the factors that influence the magnitude or intensity of impacts are most useful to management because they seek to explain why impacts are minor in some situations and severe in others (Cole 2004). Knowledge surrounding the factors which influence the intensity of the environmental impacts of camping and recreation in coastal areas is lacking. It is also important to understand whether independent variables rather than regulatory practices are responsible for the findings.

To address null hypothesis 5, the full data set for all impact assessments were combined (N = 225). Impact variables assessed as part of the Coastal Camping Impact Index (section 4.4.7.3) were then correlated using a Pearson two-tailed Correlation Regression against 1, the other impact variables 2, the independent variables and 3, the management variables (Table 4.16). The impacts were correlated against one another to assess which impacts may influence others. The management factors which are often introduced to reduce impacts were also correlated to assess whether these actions exhibit a relationship with certain impact levels. The independent variables included vegetation types and substrate types.

All variables exhibited a combination of counts and ratings. The impact variable measurements are outlined in Table 4.15; the independent variables in Table 4.6 (vegetation type) and Table 4.7 (substrate); Campsite distribution in section 4.4.6.1; Facilities and management intervention in section 0 (facilities) and section 4.2.2 (site hardening and access).

While variables that require repeat evaluation such as 'amount of use' are beyond the scope of this study, a number of variables related to environmental durability and visitor use which are discussed within the literature can be assessed through this method. These include vegetation resistance, wildlife impacts, soil characteristics, topographic characteristics (through 'distance of campsite from ocean', use distribution and mode of travel. Wildlife impacts and mode of travel were not statistically tested but are, instead, discussed in section 9.4.

Table 4.16

Variables Tested to Derive Magnitude of Impact.

Impact Variables	**Independent Variables**	**Campsite distribution**	**Facilities and Management Intervention**
Camp Area	Soft sand	Distance to closest campsite	Garbage bin
Coastal Vegetation Loss	Compact sand	Campsites on camp area total	Toilet
Barren Core Area	Grasses (campsite perimeter)	Number campsites in 50m	Tip
Average Perimeter Vegetation Damage	Spinifex (campsite perimeter)	Beach Profile	Dump point
Camp Fire Number	Saltbush (campsite perimeter)	Distance to ocean	Site Hardening
Number Social Trails	Small shrub (campsite perimeter)	Distance to nearest town	Access
Sum of Social Trail Widths	Large shrub (campsite perimeter)		
Litter found on campsite and campsite perimeter (weighted)	Small tree (campsite perimeter)		
	Large Tree (campsite perimeter)		

4.6 CONCLUSION

Few studies of outdoor recreation have utilised the combined method approach though various studies have suggested reasons for combining methods in a single study. The holistic multidisciplinary methods presented here can, in principle, through cluster analysis, questionnaires, impact assessments and analyses, test the five null hypotheses set out at the introduction of this Chapter.

Null hypothesis 1, that similarities do not exist between the seven management areas within the study area with regard to regulation, access, cost and facilities, may be tested through an adaption of the management area clustering technique. This technique was utilised in past studies to test patterns of campers' preferences across different management regimes.

Questionnaires were designed to answer null hypothesis 2 that there are no differences between management areas with regard to camper preference, and null hypothesis 3 that there are no differences between management areas with regard to resource use. Impact assessments were designed to answer null hypothesis 4 that there are no differences between management areas with regard to environmental impacts. As was experienced by previous studies, one of the challenges in assessing semi-arid areas was the modification of existing campsite monitoring protocols to apply them to non-forested ecosystems. Specifically, these impact variables required significant modifications from the original published methodologies such that several common impact indicators were not included in the study such as tree damage and soil compaction levels. Additionally the vegetation types recorded were altered to suit the Ningaloo coastal environment. Due to the unique Ningaloo environment, analytical techniques were also altered to produce accurate localised results when developing summary impact indices. The development of these analytical techniques is one of the contributions of this thesis.

Regression calculations to better understand whether only the independent variables, comprising vegetation and substrate, correlated with impact variables were undertaken to test null hypothesis 5, that the current magnitude of environmental impacts are influenced by management variables alone. These impact variables were also correlated against other impact variables and also management variables to assess relationships between the different factors.

It is therefore proposed that the five null hypotheses developed after a thorough review of the literature can be tested using this variety of methods through a 'combined approach'. Results for null hypothesis one are presented in Chapter 5, null hypothesis two in Chapter 6, null hypothesis three in Chapter 7, null hypothesis four in Chapter 8 and null hypothesis five in Chapter 9.

Chapter 5: Results Campsite Clusters

Figure 5.1. Lagoon Camp Area, Warroora Station.

5.1 INTRODUCTION

Chapter 2 stated that nine management areas comprise the thesis study area. These management areas/regimes differ with regard to location, size, number of camp areas, facilities, tenure, purpose and ownership. To address the aim of this thesis (to identify the relationship between management and the variables of visitor preferences, resource use and environmental impacts), the relationships between regulation levels and the variables of camper preferences, resource use and environmental impact must be identified. To identify these differences statistically, large sample sizes are desirable, yet the limitations of this study include time and budget, and a geographically large and, at times challenging to access, study area.

To achieve large sample sizes for analytical purposes, this chapter explores the potential for the development of (a) a (statistically verifiable) continuum of management regimes in Ningaloo and (b) the possibility of then comparing data obtained from these internally similar management groups to assess whether they differ in terms of camper preferences, resource use or environmental impact. The null hypothesis tested within this chapter was therefore that similarities do not exist between the seven management areas within the study area, with regard to regulation, access, cost and facilities.

An overview of the camp area clustering methods used in the literature and how these may be applied to the management areas along the Ningaloo coast was highlighted in section 4.2, as were management variables to be analysed and the analytical methods. The results of the clustering analysis results from section 5.2 followed by description of the various management clusters in section 5.3. A combined discussion and conclusion (section 5.4) concludes this chapter.

5.2 RESULTS OF THE CLUSTER ANALYSIS

The sample size (*N*) of the campsites analysed was 225, as further described in section 8.2. Results from the one-way ANOVA reveal that significant differences exist between the clusters on each management variable (*Table 5.1*). However, results from the Bonferroni post hoc test (p = .05) show that some clusters were not significantly different for eight of the management variables. Overall, it was most common that Clusters 1 and 2, and Clusters 3 and 4 to be not significantly different from one another (*Table 5.1*). This is not surprising given that the clusters are located along a continuum. Hence, when two clusters with adjacent numbers are similar on a single variable, this might reasonably be expected. All clusters were significantly different from one another for ‘management presence’ and ‘site hardening’. Changing the significance level for the Bonferroni post hoc test from .05 to both .01 and .001 did not alter these results.

Table 5.1

Significant differences between Individual Clusters by Management Variable.

Regulation Characteristics, Ningaloo coast	**One-way ANOVA significance ($p \leq .05$)**
Management presence	.000 (S)
Site hardening	.000 (S)
Access	.000 (S)
Distance to Toilet	.000 (S)
Distance to Rubbish Bin	.000 (S)
Sewerage Dump Point	.000 (S)
Distance to Rubbish Tip	.000 (S)
Number of other campsites within a 50 metre radius	.000 (S)
Price	.000 (S)

S = Significant NS = Not Significant

All correlations which compared clusters against a management variable were statistically significant (*Table 5.2*), suggesting that all management variable values increase as the cluster numbers increase. As noted above, this is not a surprising outcome given that the clusters are located along a continuum.

Table 5.2

Correlations and Cluster Means for each Management Variable.

Management Variable	**1**	**2**	**3**	**4**	**Correlation (r) and Significance ($p \leq .05$)**
Management presence	1.00	2.55	4.00	4.76	.950 (S)
Site Hardening	1.00	2.55	4.00	4.76	.950 (S)
Access	3.0	2.34	3.00	1.00	.579 (S)
Distance to Toilet	0.00	1.95	3.17	2.98	.454 (S)
Distance to Rubbish Bin	0.00	2.01	3.06	2.98	.449 (S)
Sewerage Dump Point	1.722	1.11	0.00	0.00	.551 (S)
Distance to Rubbish Tip	1.027	0.50	0.00	0.00	.488 (S)
Number of Campsites in a 50m radius	0.92	1.8	2.04	4.04	.427 (S)
Cost	1.00	1.0	2.5	2	.705 (S)

S = Significant NS = Not Significant

5.3 CLUSTER DESCRIPTIONS

In section 5.2, the four clusters derived from management variables proved to be significantly different, and to experience an increase in regulation reflected in the cluster numbers allocated to them. These clusters were therefore a key component in the assessment of the influence of different levels of regulation on the variables of camper preferences, resource use and environmental impacts. A summary of the characteristics of these four clusters is presented below (*Table 5.3*).

5.3.1 Cluster 1

Cluster 1 is the most remote and least regulated of all the clusters. Cluster 1, comprising Cardabia, Warroora (South) and the Defence Lands, has the cheapest prices, and the fewest facilities. These sites are located furthest from paved roads, with access for campers along corrugated dirt tracks accessible by four-wheel drive vehicles only. They have little to no regulation, have the lowest nightly camping fees, if any, and have the least accessible rubbish disposal. There is no limit to length of stay. Campsites are mostly dispersed and no site hardening by management is present.

5.3.2 Cluster 2

Cluster 2 has basic waste facilities and camp hosts are sometimes present. Cluster 2 comprises Fourteen Mile (part of Warroora) and Blowholes, and has slightly more regulation than camp areas in Cluster 1 in that camp hosts are present through the winter period. Prices are still low (less than $5 per night), and a rubbish tip is accessible to campers although campers need to provide their own toilets. The Blowholes management area has a public telephone. Roads into the camp areas are not paved but are graded and accessible by two-wheel drive vehicles. Campsites are fairly contained and social interaction is high. Some site hardening in the form of campsite numbering exists at Fourteen Mile and management presence through signage is present at both sites.

5.3.3 Cluster 3

Cluster 3 has some ablution facilities, and a strong management presence. These sites, namely Quobba Homestead (for questionnaires only as impact assessments were not conducted here), Three Mile and Red Bluff, have the most facilities, and are the most expensive in terms of camping fees though access levels are comparable to those at Cluster 1. Cluster 3 sites are more regulated than those in Clusters 1 and 2, with managers present year-round. Bins and toilets are provided close to the camps. A small shop providing basics is present at each site. A high level of management presence is felt, but there is less regulation than in Cluster 4. For example, dogs and campfires are allowed. Some site hardening through campsite numbers, some campsite definition and fenced trails is observable.

5.3.4 Cluster 4

Cluster 4 is the most regulated, and most accessible of all the clusters and comprises all the camp areas within the State-managed Cape Range National Park. Drop toilets and bins are provided near all the campsites, though the nearest sewerage dump point is 100km away in Exmouth. This cluster is the most accessible within the study area, via a sealed paved road one hour’s drive from the regional centre of Exmouth. Regulation is high with no dogs or campfires allowed and a 14 day maximum stay during busy winter periods. Park entrance fees and camping fees apply, though they are not as high as those for Cluster 3.

Table 5.3

Cluster and Management Area Characteristics.

Camp Area	Management	Access	Cost in 2010	Facilities	Regulation
Cluster 1					
Warroora (not 14mile)	Warroora Station	Corrugated dirt tracks, 25 to 200km from paved road; 100km to 250 km from a town	No cost to $5/night per person	Rubbish tip (1km-50km away) Sewerage dump point (1km-200km away)	NROCA[3] Regulations
Bruboodjoo	Cardabia Station, Baiangu Aboriginal Corporation				
Learmonth Air Weapons Range	Federal Department of Defence				
Cluster 2					
The Blowholes	Shire of Carnarvon	Dirt tracks, 10 m to 25km from main road. 100km from a town	$5 per night per person	Rubbish tip (100m-2km away) Sewerage dump point up to (2km-100km away) Public phone (Blowholes only) Drop toilet (Blowholes	NROCA Regulations
Fourteen Mile (Warroora)	Warroora Station				

[3] Ningaloo Reef Outback Coastal Association. The pastoralist lessees of Ningaloo, Warroora, Cardabia, and Gnaraloo stations, who have formed the Ningaloo Reef Outback Coast Association (NROCA), produced a rehabilitation plan for the recreational use of the coastal strip through National Heritage Trust funding. CALM has signed a Memorandum of Understanding with NROCA for management of the coastal strip Department of Environment and Conservation (2005). Management plan for the Ningaloo Marine Park and the Muiron Islands Marine Management Area 2005-2015,. Prepared for Marine Parks and Reserves Authority by the Department of Environment and Conservation. Perth, Western Australia**:** 112.

. Code of Conduct includes such regulations as: Respect the land; follow instruction signs; do not litter; no Firearms; do not remove shells; 1 kg fish per person per day; and no firewood collection.

				only)	
Cluster 3					
Quobba Homestead	Quobba Station	Corrugated dirt tracks, 15 to 150km from paved road. 95 to 250 km from Carnarvon.	Unpowered $8, to $20 adult (powered sites at Quobba Homestead only, $10). Dogs free to $2.50 per night.	Powered and unpowered sites Public phone Compost or flush toilets Rubbish bins at camps Small store Gnaraloo only: Brackish water showers Wireless internet Alcohol licence	Collecting firewood prohibited Dogs allowed if follow rules Campfires allowed Generators tolerated
Red Bluff camp	Quobba Station				
Three Mile camp	Gnaraloo Station				
Cluster 4					
CRNP	State Government Department of Environment and Conservation	100km from Exmouth	$10 per person per night	Compost toilets Management presence Numbered and hardened camp sites Bins near campsites/rubbish collection One public phone Refreshments at visitor centre	No dogs No campfires allowed Generators tolerated at certain times No driving on beaches/dunes Max stay 4 weeks No removal of natural material

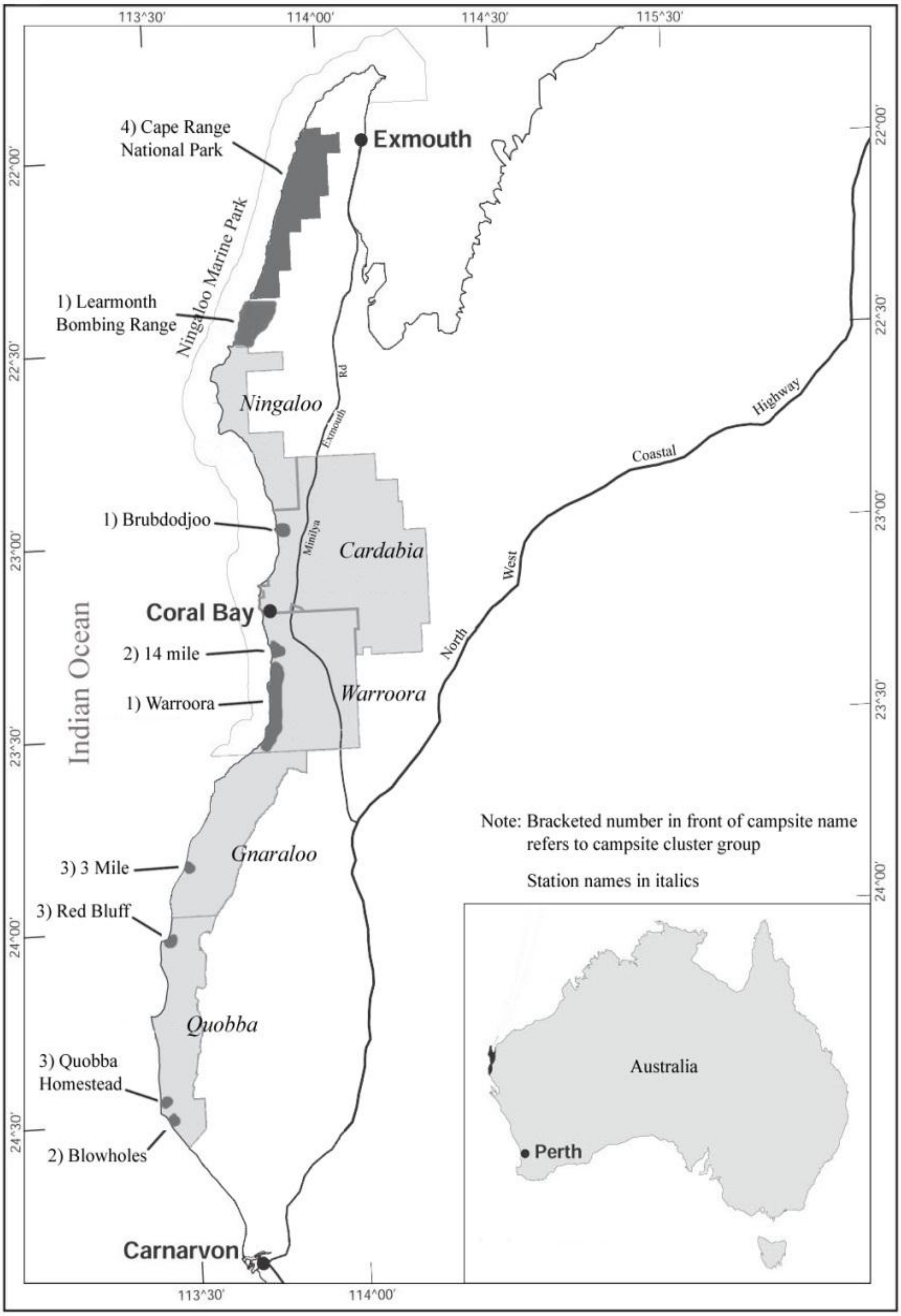


Figure 5.2. Study area, showing the Nine Camp Areas and their Associated Clusters, Cluster 1 (least regulated) to Cluster 4 (most regulated).

Map adapted from Wood (2006).

5.4 DISCUSSION AND CONCLUSION

The null hypothesis explored in this chapter that similarities do not exist between the seven management areas within the study area, with regard to regulation, access, cost and facilities was rejected. The nine management areas within the study area were grouped into one of four clusters based on nine management variables. Significant differences were found between the clusters for each management variable. All variables also had significant positive correlations when compared across all clusters thus supporting four a (statistically verifiable) continuum of management regimes in Ningaloo in the form of four campsite clusters. It is therefore possible to compare the clusters in the following chapters to see if they differ in terms of camper preferences, resource use levels and environmental impacts.

This research therefore argues that it is more important to understand the preferences and behaviours at sites as associated with management regimes than those of individual campers in recreational ecology. The basis for this argument is that understanding the impacts as site-specific and associated with management regimes (1) is accurate and provable, (2) emphasises the importance of tenure and management to the social-ecological systems that produce and are produced by recreation, and (3) places responsibility for impacts with management rather than individual campers. The independent variables are elements that management should take into account, not caveats that disprove the importance of this division. These points are examined and argued for within the following results chapters (Chapters 6 through 9).

The method of clustering used in this study builds on previous research, which emphasises the analytical importance of grouping campsites with similar characteristics together in order to avoid the construction of the mythical 'average camper' (Shafer 1969)through random camp area surveys. Determining average results only may cause management problems since management practices and/or remedial actions may not tally with the wishes or the impacts of distinctive camper groups, in turn providing inaccurate information for decision-makers. Grouping similar campsites therefore avoids the problem of the mythical 'average camper'. In addition to grouping similar campgrounds for analysis, Shafer (1969) also recommends stratifying the survey temporally into monthly intervals. This was in response to data between the different camp areas varying by up to 35 % between two given months. Research within this thesis conducted questionnaire sampling at a time when broad representation of demographics was present. However, due to time limitations of this study, the additional temporal analysis by was not practicable. Therefore some bias may exist for both questionnaires and impact assessments with regard to the limited time frame for data collection.

The results resulting from analysis within this study are unique in that all seven of the management variables used to differentiate clusters shoed significantly differences. Research undertaken by Choi and Dawson (2002) found only four of their seventeen management variables had significant differences. In addition, all correlations in this study were significantly correlated along a management continuum reflecting level of regulation. This proves useful for analytical purposes to determine the influence of management and regulation on camper demographics and preferences, resource use and environmental impacts. This form of clustering analysis could be applicable to other coastal areas as long as the ecological environment ad history of use is similar. For example, all management areas along the Ningaloo coast are semi-arid and have a pastoral history, enabling direct comparisons of human impacts across clusters to be possible.

Chapter 6: Results Camper Preferences

Figure 6.1. Neds Camp, Cape Range National Park.

6.1 INTRODUCTION

It was stated in the Literature review in section 3.2 that, despite this being a growing market there has been little research undertaken on the preferences of vehicle-based campers. Additionally, despite previous studies by Shafer (1969) and Choi and Dawson (2002) who state that it is important to compare preferences across different camp areas with different characteristics in order to avoid constructing the 'average' camper, very few studies have done this. On the Ningaloo coast no studies have compared camper preferences across the length of the coastline. To answer these questions, the null hypothesis that camper preferences do not differ across management areas was proposed (section 4.1). The purpose of this chapter is therefore to support or reject this null hypothesis. The method used to answer this was a self-completed questionnaire (section 4.1). This chapter compares campsite data collected from the nine remote camping areas, grouped into four clusters which have been categorised by campsite characteristics (Chapter 5:), along the Ningaloo Reef coast. As highlighted in section 5.4, this research argues that it is more important to understand the preferences at sites as associated with management regimes than those of individual campers in recreational ecology. This emphasises the importance of tenure and management to the social-ecological systems that produce and are produced by recreation.

The sample size is first discussed in section 6.2, followed by camper demographics (section 6.3) in a section which also incorporates shelter and transport and sources of supplies. Activities undertaken by the campers are described in section 6.4, while preferences surrounding the importance of campsite attributes, and management regimes are presented in sections 6.5 and 6.6 respectively. These are followed by a summary of results (section 6.7), and a combined discussion and conclusion which highlights similarities and differences between clusters (section 6.8).

6.2 SAMPLE SIZE

Questionnaires were distributed in person throughout the nine study sites, between May 28 and July 14, 2010. Of 790 questionnaires distributed, 712 (90.1 %) were collected on site while 22 were returned by mail giving a total response of 734 surveys (92.9 %). Cluster 1 returned 175 questionnaires, Cluster 2 returned 193 questionnaires, Cluster 3 returned 164 questionnaires and Cluster 4 returned 202 questionnaires.

Table 6.1

Number of Questionnaires completed per Management Area and Cluster.

Cluster	**Management Area**	**Campsites Assessed**
1	Cardabia	15
1	Warroora Excluding Fourteen Mile	147
1	Learmonth Air Weapons Range	13
Cluster 1 Total		175
2	Blowholes	84
2	Warroora Fourteen Mile	109
Cluster 2 Total		193
3	Gnaraloo	75
3	Quobba Homestead	16
3	Red Bluff	73
Cluster 3 Total		164
4	Cape Range National Park	202
Cluster 4 Total		202

6.3 CAMPER DEMOGRAPHICS

Most (95.5 %) respondents were Australian. Of these, 76.7 % were from Western Australia and 18.8 % were from interstate. The cluster that had the most Western Australians was Cluster 2 (80 %), followed by Cluster 1 (79.5 %), Cluster 3 (75.2 %) and Cluster 4 (49.3 %). The majority of International visitors camped at Cluster 4 (8.9 %), the least at Cluster 1 (0.5 %). Most international visitors were from the USA, France, Germany, United Kingdom, New Zealand, Netherlands and Thailand. 69 % of all respondents had camped in the Ningaloo Region before while 31.1 % were first time campers (*Table 6.2*). The ratios of repeat and first time visitors were similar across all Clusters. Of all respondents, 8.71 % were permanent travellers and 38.5 % were retired. Clusters 1 and 2 had the highest proportions of retiree campers.

Table 6.2

Camper Repeat Visitation, Transport and Shelter.

Survey Question	**Mean**	**1**	**2**	**3**	**4**	**Significant difference ($p \leq .05$) across Clusters**
Camped in the Ningaloo Region Before?						.051(NS)
Y	68.9	77.2	72.7	69.3	57.5	
N	31.1	22.8	27.3	30.7	42.5	
If Yes, number of times camped in Region						.000 (S)
1-2	29.7	18.9	29.7	29.6	41.9	
3-5	27.5	21.7	29.7	31.6	26.9	
6-10	19.1	20.8	21.6	16.3	17.2	
10-20	16.4	25.5	12.6	16.3	10.8	
21-40	5.6	8.5	6.3	4.1	3.2	
41-100	1.7	4.7	0	2.0	0	
Number of nights staying at Current campsite this time						.000 (S)
1-2	5.5	6.4	4.8	4.4	6.6	
3-5	16.0	12.2	4.8	20.0	26.2	
6-10	21.9	26.9	13.1	30.0	18.6	
10-20	23.8	29.5	21.4	27.5	18.0	
21-40	16.5	14.7	18.5	7.5	24.0	
41-100	12.9	7.1	31.0	9.4	4.4	
101-400	3.3	3.2	6.5	1.3	2.2	
Number of nights staying at Ningaloo Region this time						.000 (S)
1-2	0.6	2.0	0	0.7	0	
3-5	8.8	4.6	3.9	10.5	15.1	
6-10	21.2	23.7	15.8	26.3	19.2	
10-20	29.9	39,5	17.1	36.8	26.7	
21-40	18.8	15.8	20.4	13.2	25.0	
41-100	15.9	9.2	34.2	9.9	11.0	
101-400	4.8	5.3	8.6	2.6	2.9	
Shelter used at Campsite						.000 (S)
Campervan/Motorhome	12.7	7.2	10.2	7.5	24.6	
Caravan	40.0	27.5	65.9	30.8	34.4	
Camper trailer	16.2	22.8	9.7	14.5	18.0	
Tent	27.3	36.5	12.5	42.8	19.7	
Other	3.8	6.0	1.7	4.4	3.3	
Type of Vehicle						.008 (S)
Car	8	3	5.6	6.1	16.7	
Wagon/All-wheel drive	6.7	4.2	5.6	7.9	9.1	
Four-wheel drive	73.6	89.2	76.5	74.5	55.9	
Camper/Motorhome	11.6	3.6	12.3	11.5	18.3	

(S) = Significant differences, (NS) = No significant differences

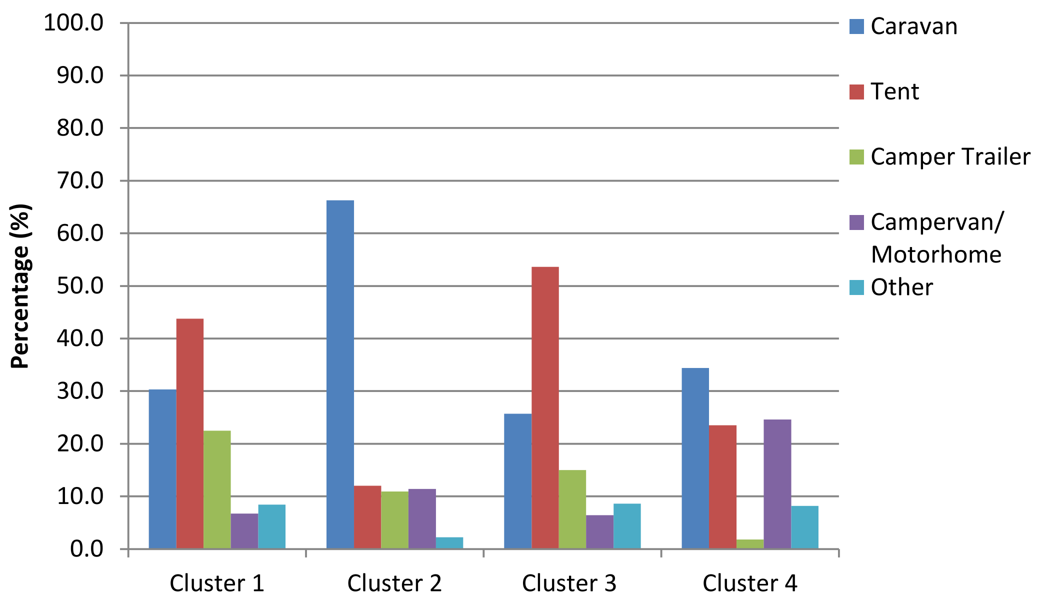
While Clusters 4 and 1 had fairly even age distributions between 25 and 66 years, the majority of campers in Cluster 3 were under 55 while most campers in Cluster 2 were over 55 years of age (*Table 6.3*). Overall, respondents were primarily travelling with their partners (55.4 %), friends (28.5 %) or family (25.2 %). Few were travelling alone (5.4 %) or with a tour group (0.3 %). Travel group size ranged from 1 to 17 people with an average of 3.5 people per group.

Table 6.3

Camper Demographics.

Survey Question	**Mean**	**1**	**2**	**3**	**4**	**Significant difference ($p \leq .05$) across Clusters**
Age						.000 (S)
18 to 25	9.5	14.7	2.9	11.0	9.7	
26-40	24.8	29.4	9.9	40.5	20.5	
41-55	23.8	23.9	18.1	33.1	20.5	
55-70	38.0	28.8	62.6	12.9	45.4	
Over 71	4.0	3.1	6.4	2.5	3.8	
Gender						.676 (NS)
M	56.2	59.9	58.3	59.3	48.1	
F	43.8	40.1	41.7	40.7	51.9	
Retired?						.000 (S)
Y	38.7	28.7	63.6	20.5	39.8	
N	61.3	71.3	36.4	79.5	60.2	
Permanent Traveller						.019 (S)
Y	8.7	6.3	10.2	4.7	12.9	
N	91.3	93.7	89.8	95.3	87.1	
Who Travelling with						.552 (NS)
Oneself	5.4	3	7.3	6.6	4.9	
Partner	55.3	51.5	71.9	32.5	63.2	
Friends	20.8	27.2	11.2	31.9	14.1	
Family	18.2	18.3	9.6	28.3	17.3	
Tour group	0.3	0	0	0.6	0.5	
Number in Travel group						.000 (S)
1-2	53.0	34	72.9	37.9	65.6	
3-5	30.0	41	14.6	3.6	26.3	
6-10	15.7	21.5	12.5	21.4	8.1	
10-20	1.3	3.5	0	2.1	0	
Number People at Campsite?						.000 (S)
1-2	54.1	36.8	71.2	37.8	67.3	
3-5	27.3	34.7	16.0	35.8	23.8	
6-10	14.9	20.8	11.5	21.6	7.1	
10-20	2.8	6.3	0.6	3.4	1.2	
21-40	1.0	1.4	0.6	1.4	0.6	

Most respondents were travelling with a caravan (40.1 %) or tent (31.8 %); smaller proportions used a camper trailer (16.6 %) or campervan/motor home (12.7 %) (*Graph 6.1*). The category of 'other' for accommodation (6.7 %) comprised a swag, tarp, gazebo or car. Caravans were the most popular shelter for Cluster 2, while tents were the most popular for Cluster 3. Cluster 4 respondents used a variety of different shelters.

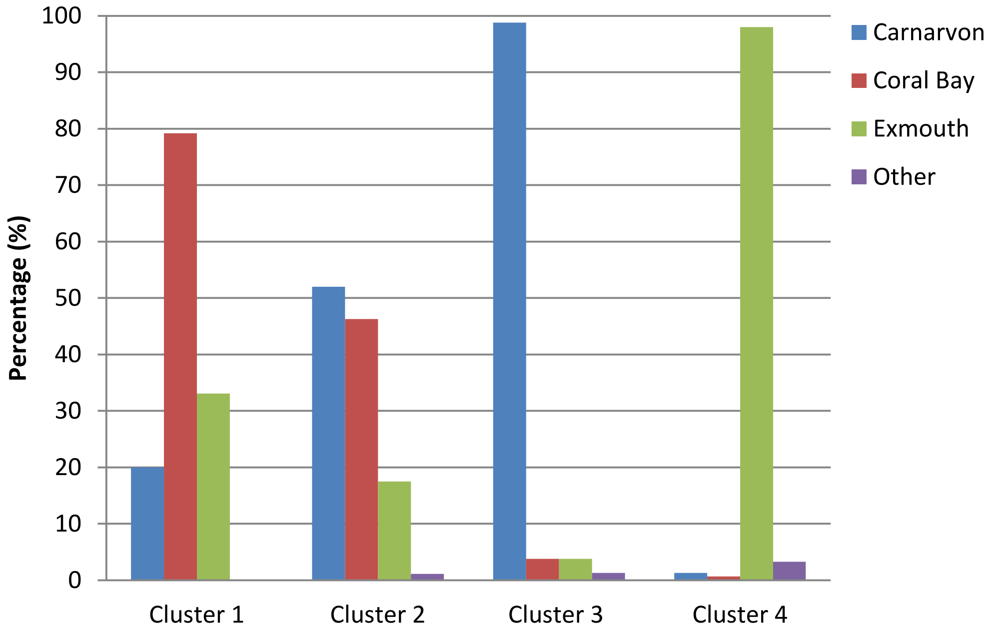


Graph 6.1. Shelter used by Remote Campers along the Ningaloo Coast.

The data indicated that four-wheel drive vehicles (73.6 %) were the most popular form of transport for all respondents (*Graph 6.2*). However, more respondents in Cluster 1 used four-wheel drive vehicles than was the case in other clusters, while Cluster 4 campers used a greater variety of transport, presumably related to the higher road accessibility of campsites in this cluster. Other modes of transport used across all clusters included motor home/camper trailer (11.6 %), car (8.0 %) and wagon/all-wheel drive (6.7 %). The majority of vehicles were 6 cylinders (56.5 %) or 4 cylinders (36.3 %). Only 7.2 % of vehicles were 8 cylinders.

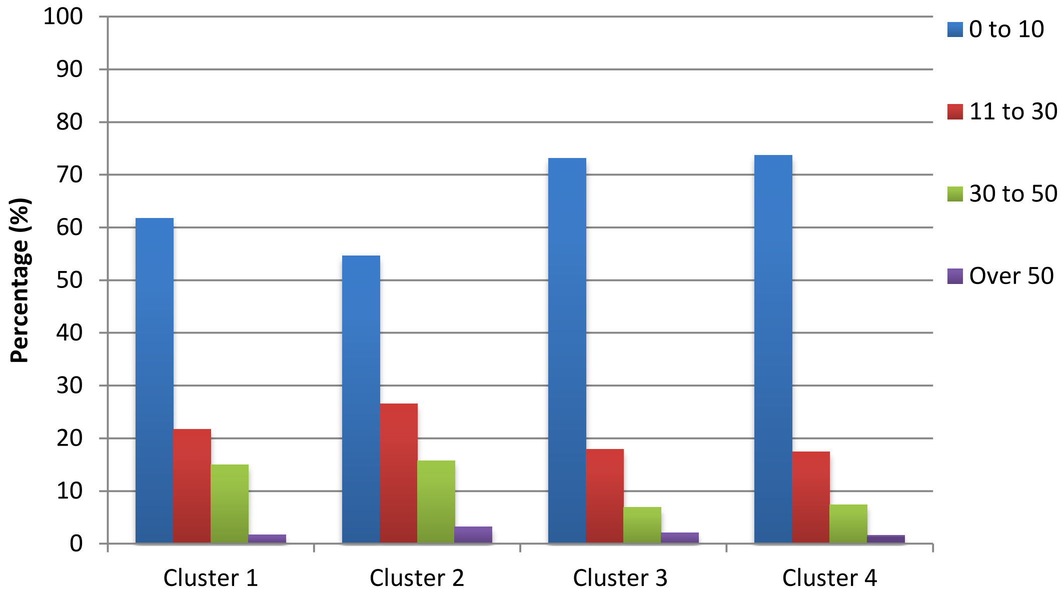
Graph 6.2. Type of Vehicle used by Visitors while travelling along the Ningaloo Coast.

Some campers brought provisions etc. for their entire stay, with those from Cluster 2 were most likely to restock on supplies (92.1 %), followed by respondents from Cluster 4 (78.8 %), Cluster 1 (70.9 %) and Cluster 3 (53.1 %) respectively. Cluster 3 campsites were the only locations possessing small shops selling basic foods. Of those who travelled to restock, campers from Cluster 1 and Cluster 3 tended to travel every 8 to 14 days (50.9 % and 62.9 % respectively), while those from Clusters 2 and 4 generally restocked every 1 to 7 days (38.7 % and 70.4 % respectively). Overall, only 12.6 % of all Ningaloo campers travelled every 15 to 30 days and 5.3 % over 30 days. Campers most often restocked in the towns nearest to where they were camping. Cluster 4 respondents primarily restocked in Exmouth (98.0 %) and those from Cluster 3 in Carnarvon (98.8 %) (*Graph 6.3*). In Clusters 1 and 2, the Camp areas are spaced out along the Ningaloo coast some campers may have alternated between service centre locations. Cluster 1 respondents usually stocked up at Coral Bay (79.2 %) and Exmouth (33.1 %) and those from Cluster 2 in Carnarvon (52 %) and Coral Bay (46.3 %). For ‘other’, 1.5 % answered ‘nearest location’ and ‘Yardie Creek Caravan Park’.



Graph 6.3. Restock Location for each Cluster.

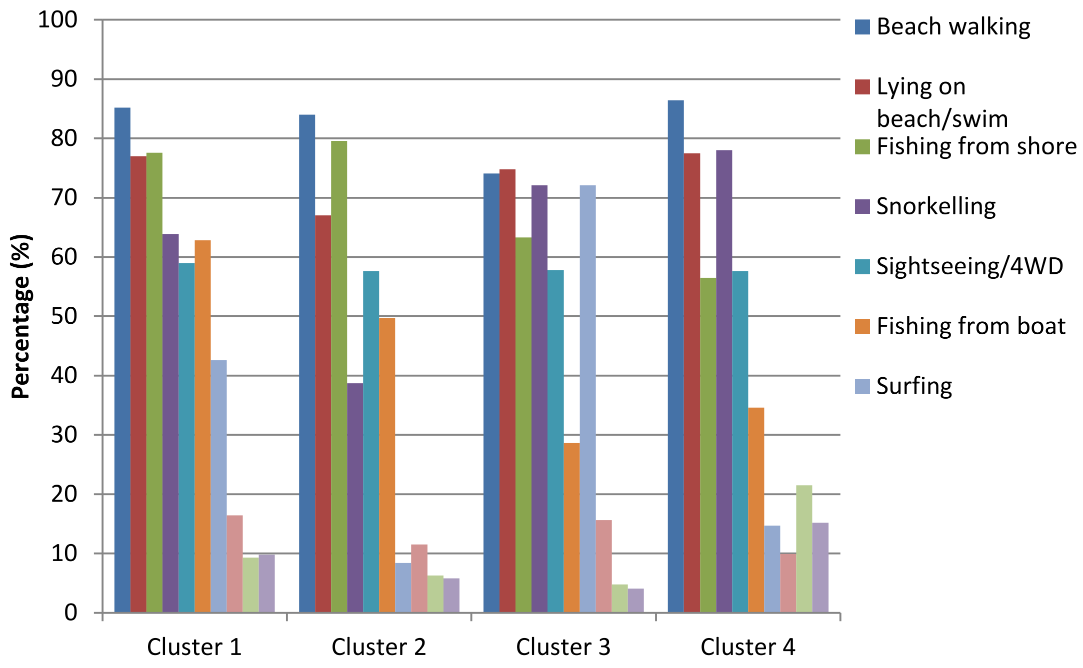
For all Ningaloo campers, only 15.3 % noted that they had difficulty finding certain supplies in the region. Responses related to the difficulty of obtaining supplies, citing: price; freshness; and variety of food goods and mechanical supplies. When asked how much food was caught or grown when camping, the majority (65.4 %) indicated only 1-10 % of their food was caught or grown by them. Only 2.1 % said they caught or grew over 50 % of their food. Campers from Clusters 1 and 2 were the most self-sufficient (*Graph 6.4*). When asked how much food was caught or grown when camping, the majority (65.4 %) indicated only 1-10 % of their food was caught or grown by them. Only 2.1 % said they caught or grew over 50 % of their food. Campers from Clusters 1 and 2 were the most self-sufficient.



Graph 6.4. Percentage of Food Caught or Grown within each Cluster.

6.4 ACTIVITIES

For most common daily activities (*Graph 6.5*), campers could choose as many activities as they liked from a list of ten options. A Pearson Chi-square test revealed that there were significant differences between the clusters (p = 0.00, df = 30). The most popular activities on average were: ‘beach walking’ (83 %), ‘lying on beach/swimming’ (74 %), ‘fishing from shore’ (69.5 %), ‘snorkelling’ (62.6 %), ‘sightseeing/four-wheel drive’ (58 %), ‘fishing from boat’ (44.7 %), ‘surfing’ (32 %), ‘SCUBA diving’ (13.2 %) and ‘commercial tours’ (9 %). For ‘other’ (10.8 %), answers included kayaking/canoeing; reading; relaxing; socializing and bush walking. When individual activities were compared across the clusters, the largest differences between clusters were for ‘snorkelling’ (38.7 % for Cluster 2, and 78 % for Cluster 4), ‘surfing’ (8.4 % for Cluster 2 and 72.1 % for Cluster 3), ‘fishing from boat’ (28.6 % for Cluster 3 and 62.8 % for Cluster 1), and ‘commercial tours’ (4.1 % for Cluster 3 and 15.2 % for Cluster 4). Photographs of some of these activities are presented in *Figure 6.2*.



Graph 6.5. Activities Undertaken by Campers.

Plate 6.1 Snorkelling

Plate 6.2 Boating

Plate 6.3 Kayaking

Plate 6.4 Relaxing and Socialising

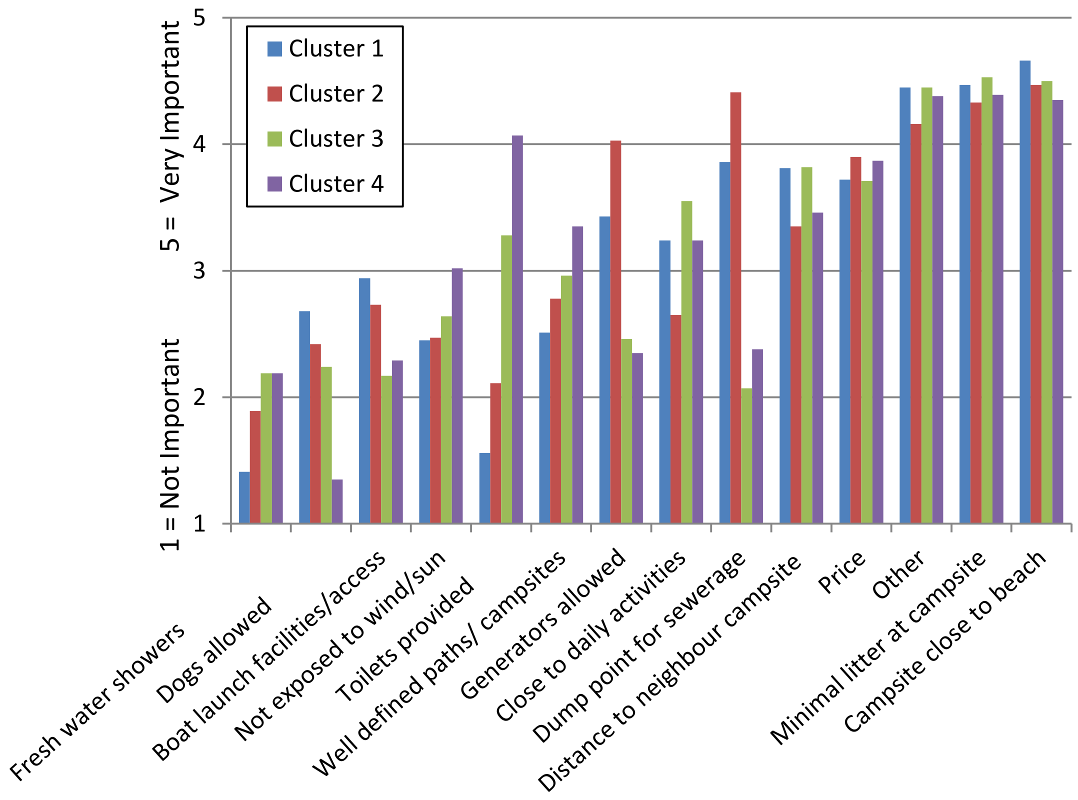
Figure 6.2. Popular Activities for Campers.

6.5 IMPORTANCE OF CAMPSITE ATTRIBUTES

The four most important campsite characteristics for all clusters were ‘campsite close to beach’ (mean 4.49 out of a maximum of 5), ‘minimal litter’ (4.42), ‘price’ (3.81) and ‘distance to neighbour campsite’ (3.59) (campers prefer a greater distance from the neighbour campsite). The attributes ‘campsite close to beach’ and ‘minimal litter’ were in the top four responses for every cluster. This indicates that the natural coastal environment is of high importance to all remote campers at Ningaloo. Such reactions are consistent with Choi and Dawson's (2002) findings that some common themes for preferences across campsites occur regardless of differences in their development levels. Other attributes considered to be within the four most important attributes for individual clusters included 'toilets provided' (Cluster 4), 'generators allowed' (Cluster 2), 'dump point for sewerage' (Clusters 1 and 2) and 'close to daily activities' (Cluster 3). When the means for the different clusters were compared using a one-way ANOVA post hoc test, no significant differences (p = 0.481-1.00) were found between the clusters regarding the importance of 'litter' or 'price' (*Graph 6.6*). The results for 'other' received a wide variety of responses, including: 'dirt roads', 'large/soft ground/level campsite', 'quiet', 'isolated', 'less restrictions', 'well-managed', 'security', 'potable water', 'pleasant scenery', 'happy people' and 'wilderness experience'. Attributes considered to be within the four most important attributes for *individual* clusters included 'toilets provided' (Cluster 4), 'generators allowed' (Cluster 2), 'dump point for sewerage' (Clusters 1 and 2).

The four least important characteristics overall included 'fresh water showers provided' (mean 1.91), 'dogs allowed' (2.16), 'boat launch facilities/access' (2.55) and 'campsite not exposed to wind or sun' (2.65). The only attribute present in the least important four attributes for all clusters was 'fresh water showers'. When the means for the different clusters were compared using a one-way ANOVA post hoc test, only Cluster 1 was significantly different (p<0.01) from all the other clusters for 'importance of fresh water showers provided'. For 'importance of dogs allowed' and 'campsite not exposed to wind/sun', only Cluster 4 was significantly different (p<0.01 and p<0.001), respectively) from all the other cluster means. Other attributes considered to be in the four least important attributes for *individual* clusters included 'dogs allowed' (Clusters 2, 3 and 4), 'boat launch facilities/access' (Clusters 3 and 4), 'campsite not exposed to wind/sun' (Clusters 1 and 2), 'toilets provided' (Clusters 1 and 2), 'well defined paths/ campsite areas' (Cluster 1), 'generators allowed' (Cluster 4) and 'dump point for sewerage' (Cluster 3).

When the means for the different clusters were compared using a one-way ANOVA post hoc test, only Cluster 1 was significantly different (p<0.01) from all the other clusters for 'importance of fresh water showers provided'. For 'importance of dogs allowed' and 'campsite not exposed to wind/sun', only Cluster 4 was significantly different ($p<0.01$ and $p<0.001$), respectively) from all the other cluster means.



Graph 6.6. Importance of Campsite Attributes for Different Clusters.

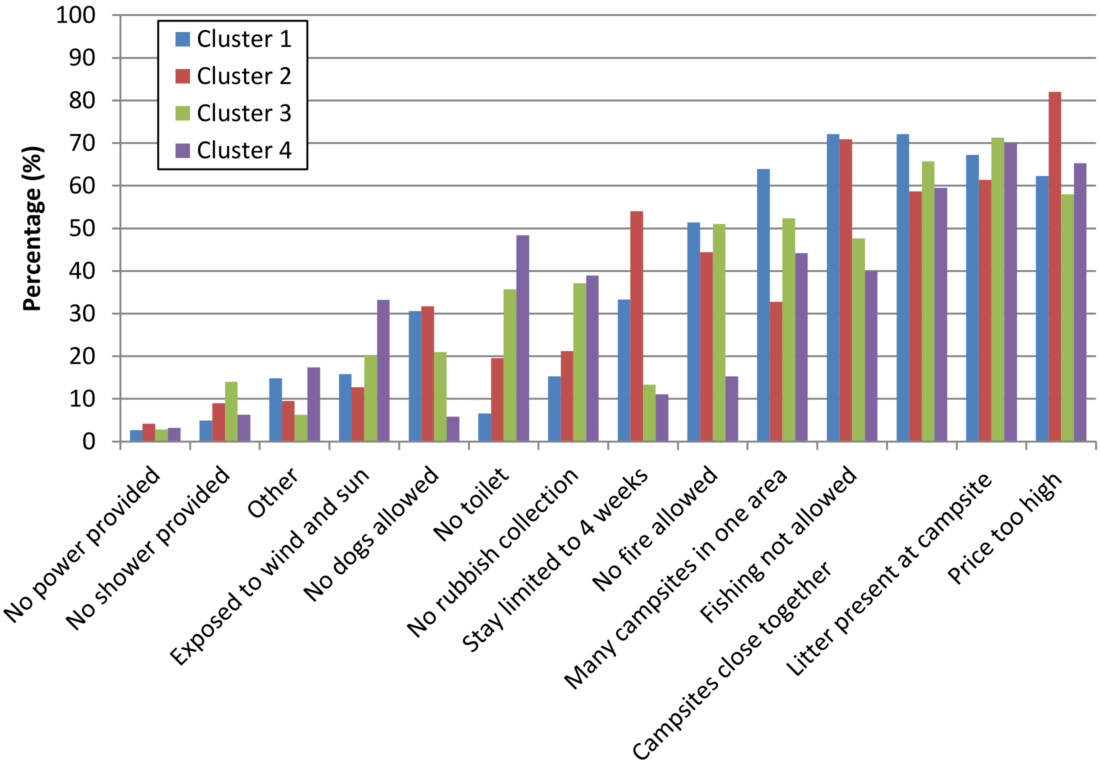
There is potential for a relationship to exist between a cluster's level of regulation and the importance ratings for certain campsite attributes. As previously mentioned, Cluster 1 has the least amount of regulation while Cluster 4 has the most. The importance of some attributes increases linearly from Cluster 1 to Cluster 4. This means that some attributes were least important for Cluster 1 and most for Cluster 4. Those attributes which have a positive linear trend from Cluster 1 to Cluster 4 include 'campsite close to beach', 'well defined paths and campsite areas', 'toilets provided', 'campsite not exposed to wind or sun' and 'fresh water showers provided'. Negative linear trends were also found for the attributes 'dogs allowed', and 'access to boat launch facilities/access', whereby an attribute is most important for Cluster 1, but least for Cluster 4.

For the question ‘What makes you NOT want to camp at a campsite’ (*Graph 6.7*), ‘price’ was the most important overall (67.5 %). Remote campsites at Ningaloo are often perceived as a cheap place to camp, creating a sense of freedom. High fees may be considered as an infringement on this freedom. Next in importance was ‘litter present at campsite’ (67.2 %), ‘campsites close together’ (63.8 %) and ‘fishing not allowed’ (52.8 %) respectively. The four least common responses overall were ‘no dogs allowed’ (22.30 %), ‘exposed to wind and sun’ (20.6 %), ‘no shower provided’ (8.2 %) and ‘no power provided’ (3.30 %). Many of these findings mirror those from *Graph 6.6*. For example, overall, the three most important and least important attributes for *Graph 6.7* were the same as the three most important and three least important attributes in Graph 6.6.

The remaining middle of the range responses included ‘many campsites on one area’ (47.9 %), ‘no fire allowed’ (39.7 %), ‘stay limited to 4 weeks’ (28.8 %), ‘no rubbish collection’ (27.70 %) and ‘no toilet’ (27.2 %) and ‘other’. Responses for ‘other’ (12.3 %) included ‘noise’, ‘generators’, ‘dogs’, ‘overregulation’, ‘litter, ‘unsuitable campsite’ and ‘un-aesthetic campsite’. A Pearson Chi-square test demonstrated that significant differences exist between the clusters for the question ‘What makes you NOT want to camp at a campsite’ ($p = 0.00$). Those attributes with the largest differences were: ‘Price too high’ (58.0 % Cluster 3, 82 % Cluster 2), ‘no fire allowed’ (15.3 % Cluster 4, 51.4 % Cluster 1), ‘many campsites in one area’ (32.8 % Cluster 2, 63.9 % Cluster 1), ‘stay limited to 4 weeks’ (11.1 % Cluster 4, 54 % Cluster 2) and dogs not allowed, (5.8 % Cluster 4, 31.7 % Cluster 2). Attributes for which all clusters were descriptively similar were: ‘No shower provided’, ‘many campsites in one area’, ‘no power provided’, and ‘litter present at campsite’.

Decreasing and increasing linear trends corresponding to cluster number, as observed in *Graph 6.6*, were also observed for why campers would not want to camp at a campsite. Increasing trends with level of management regulation (least important for Cluster 1, most important for Cluster 4) can be seen for ‘exposed to wind and sun’, ‘no toilet’ and ‘no rubbish collection’. Deceasing trends can be seen for ‘fishing not allowed’, and ‘no dogs allowed’.

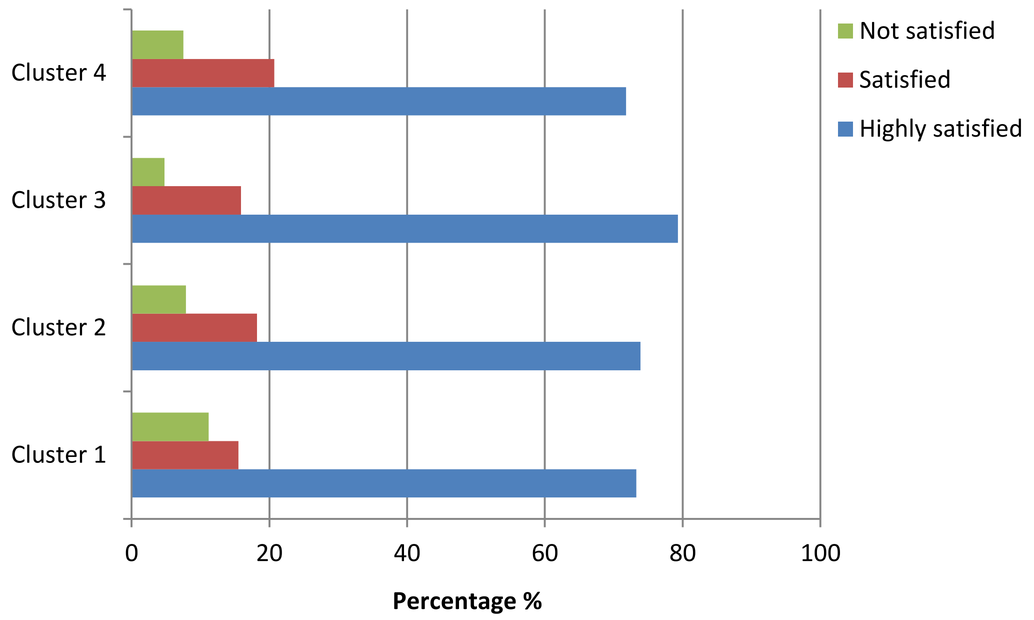
Interestingly, some campers' preferences were not representative of their camping location. For example, from Cluster 4, 15.3 % indicated they would not camp if there was no fire, 5.8 % if dogs were not allowed and 11.1 % would not want to camp at site if the maximum stay was four weeks. These preferences contradict the regulations at Cluster 4, which do not allow fires, dogs or a stay over 4 weeks. Similarly, in Cluster 2, 9 % of campers would not want to camp at a campsite where no shower was provided. No showers are provided at Cluster 2.



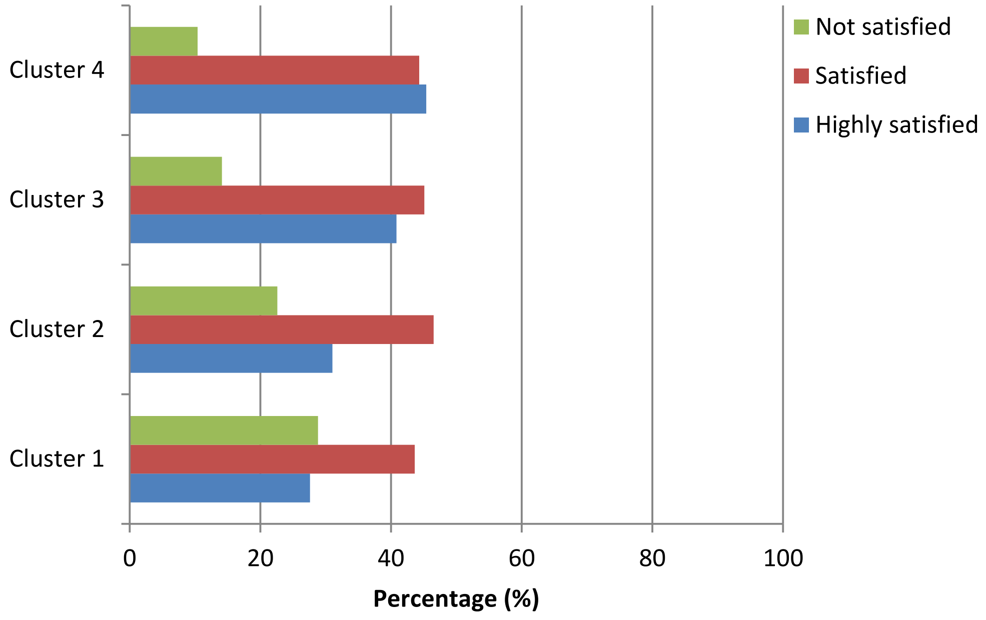
Graph 6.7. What makes Campers *not* want to Camp at a Campsite?

When respondents were asked how satisfied they would be with varying campsite distance from the ocean, the average number of 'highly satisfied' campers decreased with increasing distance from the ocean for all Clusters (*Graph 6.8, Graph 6.9* and *Graph 6.10*). Overall, 74.4 % of campers would be highly satisfied to camping 25 metres from the ocean, a satisfaction level which decreases linearly to the 11.4 % of highly satisfied campers located on a ridge 400m from the shore. This result supports other findings within the literature (Lucas 1970; Lime 1971), namely that distance from a water body is a very important attribute for most campers.

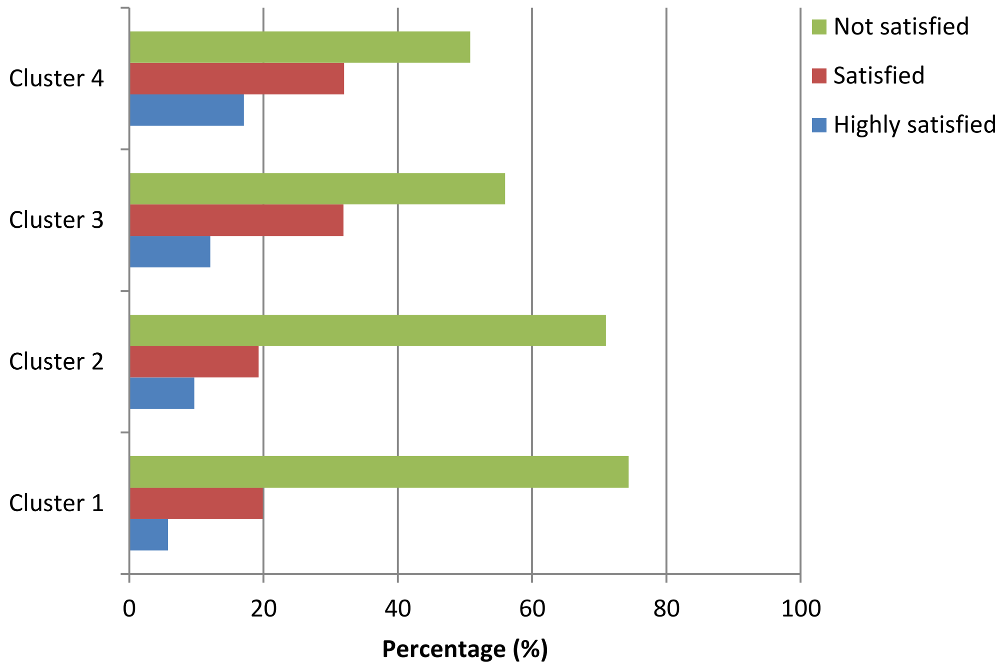
A Pearson chi-square test (p = 3.98, df = 6) revealed no significant differences in satisfaction levels between clusters for a campsite 25m from shore. For all other categories, satisfaction levels in Clusters 1 and 2 were not significantly different from each other for campsites 50 and 100m from shore, and 200m and 400m inland on a ridge overlooking the ocean. The responses for Clusters 3 and 4 were also not significantly different for these categories. This may indicate that campers at less regulated sites (Cluster 1 and Cluster 2) place more importance on camping close to the water than those in more regulated areas (Cluster 3 and Cluster 4 trend being greater at the less managed sites).



Graph 6.8. Satisfaction of a Campsite 25 m from Shore.



Graph 6.9. Satisfaction of a Campsite 100 m from Shore.



Graph 6.10. Satisfaction of a Campsite on a ridge overlooking the ocean 400 m from Shore.

6.6 MANAGEMENT PREFERENCE

Respondents were requested to rank campsite management style preferences from 1 to 5 (5 being most desirable) between caravan parks with full amenities, Department of Environmental and Conservation sites, shire-run sites, station-run sites and side of road/free campsites. Overall, station-run campsites were most preferred (score of 3.10), followed by side of road/free campsites (2.55), DEC run campsites (2.45) and Shire-run sites (2.24). Least popular was Caravan Parks with full amenities (1.25). The preference for station camping may be due to the large number of campers surveyed from stations. Only Blowholes (Shire-run) (Cluster 2) and Cape Range National Park (Cluster 4) and Learmonth Air Weapons Range (Cluster 1) were not station managed. No significant difference (p = 0.61 to 1.00) existed between the clusters for 'caravan parks with full amenities', which was the least popular option for all the clusters.

Most campers were located at sites with the management regimes that they claimed to prefer. That the Blowholes site was Shire run may not have been clear to some campers, but for 'free', 'DEC' or 'station-run' campsites, over 65.7 % had ranked their current location as their first preference. No more than 7.2 % ranked their current preference as third choice or lower. Those seemingly happiest with their location were at the Bombing range, with 83.3 % of respondents ranking their location number one. However, there were only six returned questionnaires from that location due to a lower presence of campers than at other sites within the study area.

6.7 SUMMARY OF RESULTS

When comparing preferences across management areas, the null hypothesis was both supported and rejected as two levels of camper preferences were identified through campsite cluster comparisons, those that were common across all campers, for which no significant differences were found, and those which varied between clusters. All campers valued the natural environment, solitude and beach access. Significant differences were found between campers at different clusters for a variety of campsite attributes and activities. These included ablution and sewerage dump point facilities, allowance for dogs and campfires, and length of stay allowed. The activities surfing, snorkelling, fishing from a boat and participating in organised tours also differed across Clusters.

Table 6.4

Significant Differences of Camper Preferences between Clusters.

(✓ = significantly different)

What would make you *not* want to Camp at a Campsite				
	Exposed to wind and sun	✓	Campsites close together	✓
	Price too high	✓	Many campsites in one area	✓
	No fire allowed	✓	No rubbish collection	✓
	No dogs allowed	✓	Stay limited to 4 weeks	
	No toilet		No power provided	
	No shower provided	✓	Litter present at campsite	✓
	Fishing not allowed	✓		✓
Campsite Attribute's Importance				
	Toilets provided	✓	Boat launch facilities / access	✓
	Fresh water showers provided	✓	Well defined paths and campsite area	✓
	Dogs allowed	✓	Generators allowed	✓
	Minimal litter		Dump point for sewerage	✓
	Price		Campsite not exposed to wind / sun	✓
	Campsite close to beach	✓	Distance to neighbour campsite	✓
	Close to daily activities	✓		
Satisfaction with campsite Distance to the Beach				
	25m from the shore		200m from shore	✓
	50m from the shore	✓	400m from shore	✓
	100m from the shore	✓		
Preferred Campsite Management style				
	DEC-run campsites	✓	Station-run campsites	✓
	Caravan parks with full amenities		Shire sites	✓
	Side-of-road / free	✓		
Preferred Activities				
	Lying on beach / swim		Sightseeing / four-wheel drive	
	Beach walking		Fishing from shore	✓
	Snorkelling	✓	Fishing from boat	✓
	Scuba diving		Commercial tours	✓
	Surfing	✓		
Distance Travelled from Campsite to Preferred Activities				
	Lying on beach / swim	✓	Sightseeing / four-wheel drive	✓
	Beach walking		Fishing from shore	✓
	Snorkelling	✓	Fishing from boat	✓
	Scuba diving	✓	Commercial tours	
	Surfing	✓		

6.8 DISCUSSION AND CONCLUSION

This chapter has evaluated null hypothesis 2, that there are no attitudinal differences between campers in the different management areas with regard to their campsite preferences. As outlined in section 6.7, two levels of campsite attribute preferences exist. The first are preferences common to all clusters/management areas, which reflect the remote region's pervasive wilderness-experience camping style. The second set represents preference differences between the clusters, which in turn identify different groups of campers with different needs and expectations, thus disproving the null hypothesis. These differences suggest that, while remote campers at Ningaloo do share some opinions, the different clusters also contain camper subgroups as outlined by previous research on campers at different campsites along the Ningaloo coast (Jones Lang Wooton 1993; Davies, Tonts et al. 2009).

Along the Ningaloo coast, the differences in campsite attributes and activity preferences are presumably the result of both the level of regulation of the management regimes, especially with reference to the length of stay and facilities provided, and the natural environment which in turn provides different activity possibilities (such as surfing or snorkelling) within the remote setting favoured by all campers. The differing demographics of the campers also plays a role as does the time of year as indicated by other Ningaloo research studies. These findings support the argument of this chapter that it is more important to understand the preferences at sites as associated with management regimes than those of individual campers in recreational ecology.

As highlighted in the literature review (section 3.2), understanding camper preferences is a necessary first step to the planning and design of campsites (Foster and Jackson 1979). Protected areas within Australia, such as National Parks, enact policies which value both the natural environment and the need to provide satisfying experiences for visitors (Winter 2005). This is often done through providing a range of different camping and recreational opportunities (Winter 2005).Through careful planning, knowledge of the attributes desired by different camping subgroups may aid in reducing conflict between the conservation goals held by managers and the experiential goals of the campers (McCool, Stankey et al. 1985). However, there are disagreements within the literature as to whether camper preference themes are consistent or inconsistent across different recreational settings (LaPage 1966; Zuckert 1980; Bumgardner, Waring et al. 1988). Through the identification of two different levels of preferences within this research, both schools of thought may be argued for.

That common preference themes can be found between different camper groups is supported by the fact that those attributes important to all Ningaloo campers aligned with important campsite attributes discussed in other worldwide studies. For example, desirable factors for most visitors in worldwide studies include seclusion at campsites (Stankey 1973), and campsites either immediately adjacent to, or within view of, water bodies (Lucas 1970; Lime 1971; Lucas 1990). These align with the highly important ‘distance to ocean’ and ‘distance to other campsites’ results in this study.

The four most popular campsite attributes were found to be similar across all clusters. Similarities found between clusters may exist for a number of reasons, including attraction to the region for its consistent feature (remoteness) (Bumgardner, Waring et al. 1988) and the dominant physical landscape feature of the camp area (in this case the ocean) (Shafer 1969). However, through segmenting the responses between management clusters, areas containing campers with different preferences were identified. Clear subgroups of campers, were differentiated through their demographics, repeat visitation patterns and preferred activities (Davies, Tonts et al. 2009).

Additionally, other camper studies within the Ningaloo region indicate that the natural environment, solitude and the potential for self-reliant camping rated highly among all surveyed campers, while the need for facilities rated low (Moore and Polley 2007; Galloway and Northcote 2008; Polley, Northcote et al. 2008; Jones, Hughes et al. 2009) (Appendices C and D). Structuring the questionnaire in a manner analogous to others used along the Ningaloo coast was therefore useful for comparative purposes. However, issues arose when comparing these results to other Ningaloo coast findings due to different study areas and, as a result of differing timing of surveys, different demographics. As mentioned in the last chapter (section

5.4), bias may therefore exist due to the limited time frame for data collection. Whilst the questionnaire was effective in answering null hypotheses two and three, campers surveyed, Question 1a and 1b was not as clear and effective as it could have been. Confusion was created when ‘why did you choose this campsite’ was mistaken for ‘camp area’, resulting from questionnaire miswording. The environmental resource load impacts placed on the Ningaloo environment by campers are discussed next in Chapter 7:.

Chapter 7: Results Resource Use

Figure 7.1. Red Bluff Campsite, Quobba Station.

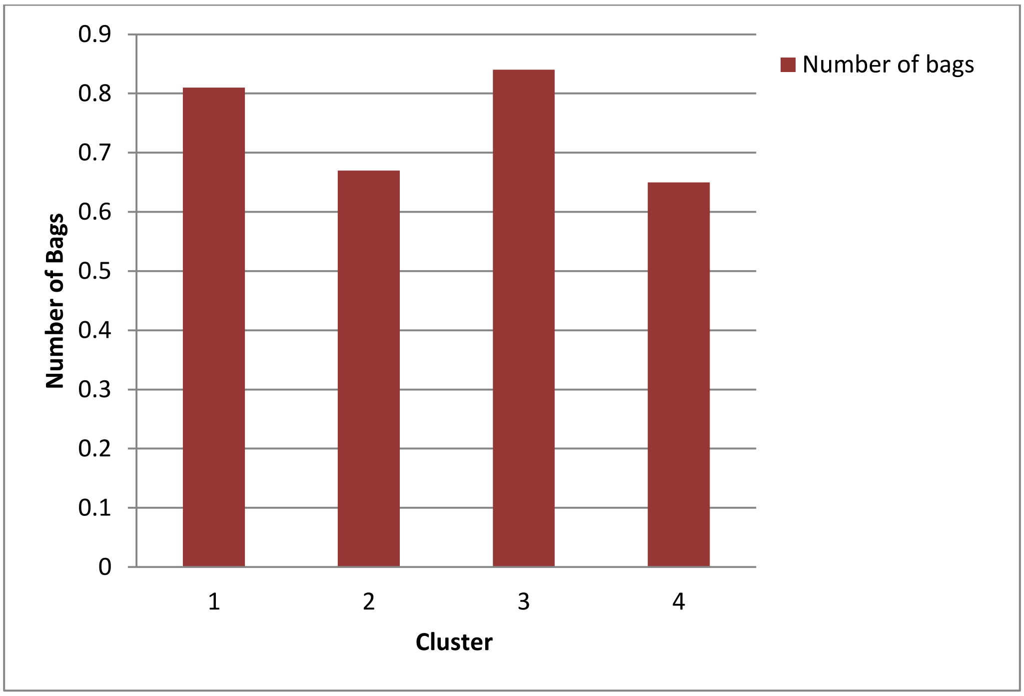
7.1 INTRODUCTION

Resources such as water, energy and waste disposal options are limiting development along the Ningaloo coastline (Western Australian Planning Commission 2004) as highlighted in section 2.6.2. Hundreds of remote campsites along the Ningaloo coast are self-sufficient, requiring that campers supply their own water, food, energy and waste disposal. Water and energy are sourced from elsewhere and rubbish and sewerage are characteristically disposed of along the coast (Department of Planning and Infrastructure 2003). The environmental load this imposes on both the regional centres and the coastline is therefore of considerable importance. Additionally, if different types of tourist development are encouraged in current camping locations, then the differences between camping and the proposed development with regard to additional—or lessened—environmental load stress will be of relevance in the resultant planning processes. In addition to resource use, the campers' habits relating to portable toilet use and sewerage disposal may also pose environmental and human risks.

The purpose of this chapter is to disprove the null hypothesis that resource use is not significantly different across the management regimes. Section 7.2 discusses rubbish content and disposal followed by water consumption and its sources (section 7.3), power sources and energy use, (section 7.4), sewerage disposal (section 7.5). Following these findings is a summary of results (section 7.6) and combined discussion and conclusion (section 7.7).

7.2 RUBBISH CONTENT AND DISPOSAL

Litter found on the ground was audited as part of the initial impact assessment (section 4.4.6.2.2). The questionnaire sought data on rubbish produced per person. Respondents were asked how many bags of rubbish they produced per campsite per day. The bag was described as an average 12 L, supermarket-style shopping bag. What comprised the rubbish was categorised as 'packaging', 'aluminium and glass', 'organic matter', 'fish offal', and 'household items and scrap metal'. Campers were also surveyed on their rubbish disposal locations. The rubbish total per campsite was divided by the number of individuals thein the campsite to determine the amount of rubbish produced per person per day (section 4.3.5). There was no significant difference (p = 1.00) between the clusters with regard to rubbish produced per person per day. Additionally, a Bonferroni post hoc test showed no significant differences when the clusters were compared with one another. Cluster 4 produced the smallest amount of rubbish person per day (0.65 bags), while Cluster 3 produced the most (0.84 bags). Cluster 1 produced 0.81 and Cluster 2 produced 0.67 bags of rubbish.



Graph 7.1. Plastic Bags (12 L supermarket size) of Rubbish Produced per person per day.

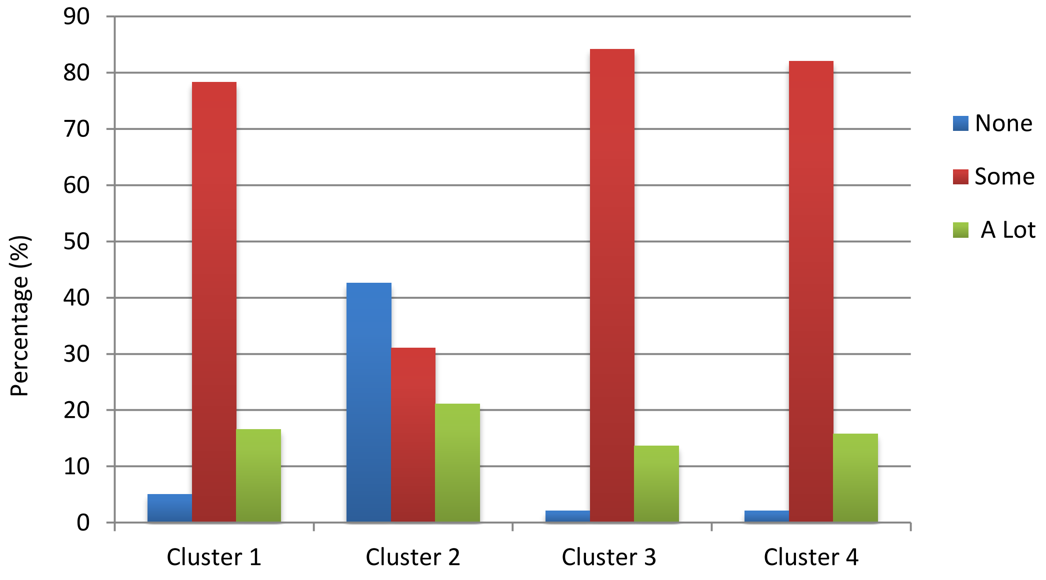
Similar amounts of packaging, recyclables (aluminium and glass), organic matter and fish offal and household items and scrap metal appear to have been produced by each cluster (*Graph 7.2* through to *Graph 7.6*). However, a chi-square test identified significant differences (p = < .05) between the clusters for each category with the exception of household items and scrap metal (p = .034) as shown in *Table 7.1*. The majority of campsites in all clusters disposed of 'some' packaging, aluminium and glass and organic matter. Between 10.5 % (Cluster 4) and 27.3 % (Cluster 3) had 'a lot' of aluminium cans and glass, while between 10.4 % (Cluster 1) and 17.2 % (Cluster 3) produced 'a lot' of organic waste. While the majority of campsites for all clusters had no fish offal in their rubbish, between 16.3 % (Cluster 2) and 32.8 % (Cluster 3) produced some. Also, between 29.1 % (Cluster 3) and 36.5 % (Cluster 2) disposed of 'some' household items and metal. In the 'other' category, 20 % of respondents noted nappies, sanitary items or 'dog waste' bags. These items, if not dealt with correctly, may pose health risks. The highly significant (p = <.01) correlations of rubbish type against cluster number would suggest that aluminium and glass is disposed of in greater quantities in the less regulated areas (Clusters 1 and 2), while organic waste is more prevalent in more regulated sites (Clusters 3 and 4) which have greater accessibility to grocery stores.

Table 7.1

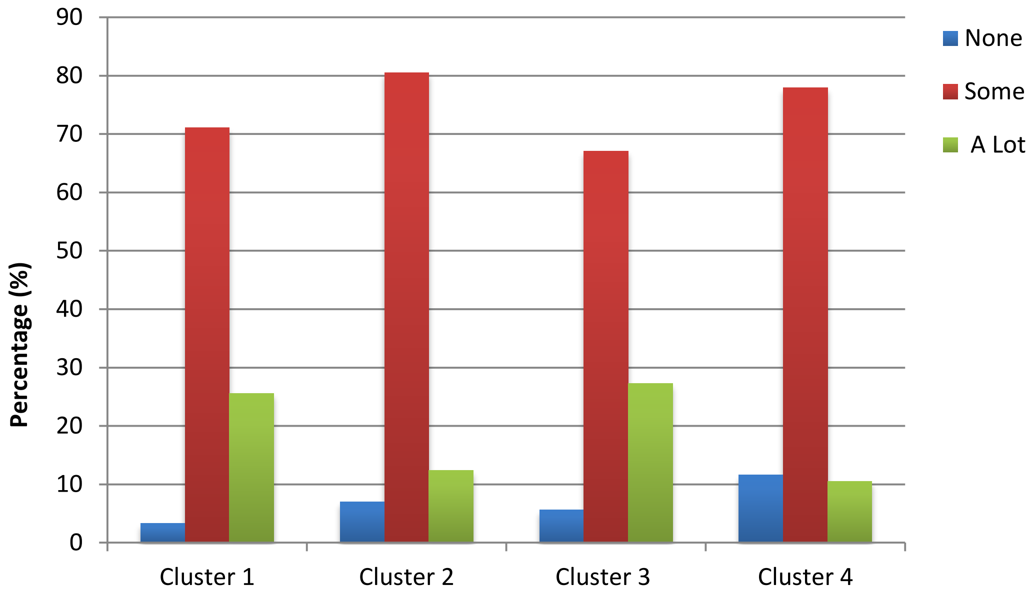
Significance and Correlations between Clusters for different Rubbish Types.

	Pearson chi-Square ***(p≤.05)*** **Significance**	**Correlation (*r*) and Significance** ***(p≤.05)***
Packaging	.001 (S)	.045 (NS)
Aluminium and Glass	.000 (S)	-.143 (S)
Organic matter	.000 (S)	.152 (S)
Fish offal	.006 (S)	-.076 (NS)
Household items and scrap metal	.304 (S)	-.039 (NS)

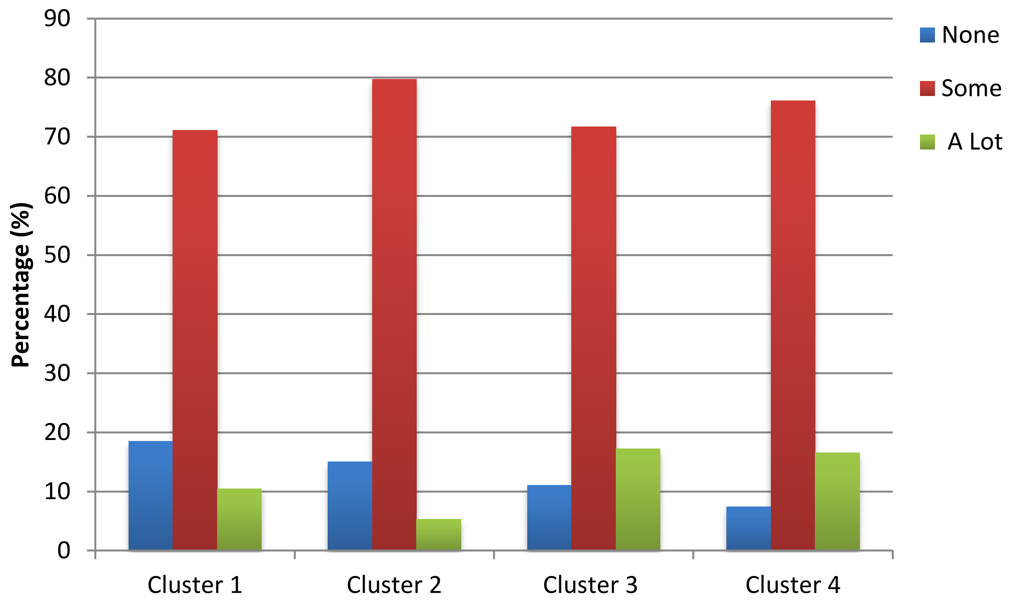
(S) = Significant, (NS) = Not Significant



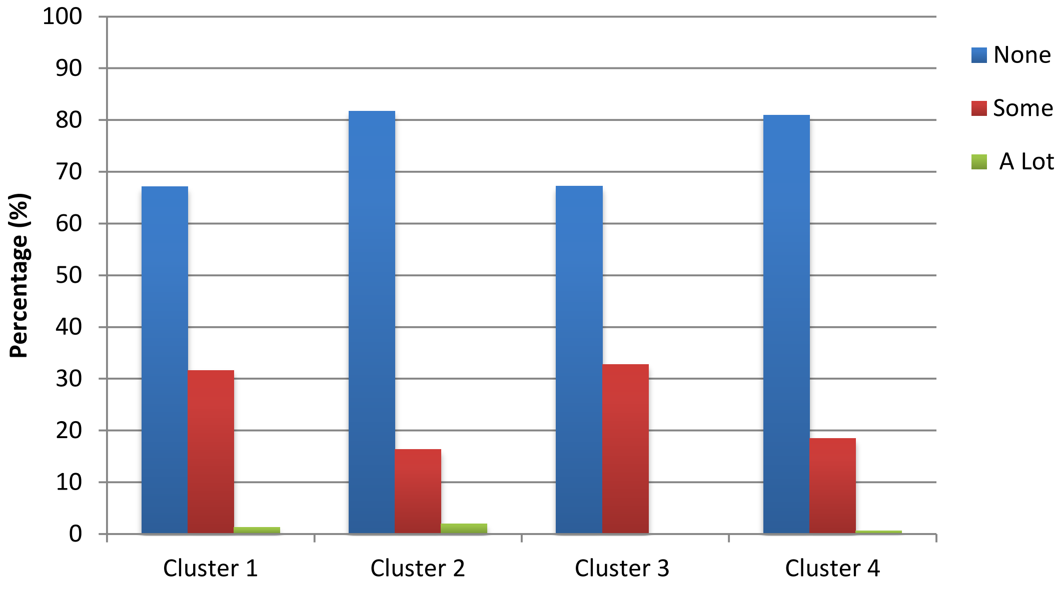
Graph 7.2. Amount of Packaging within Camper's Daily Waste.



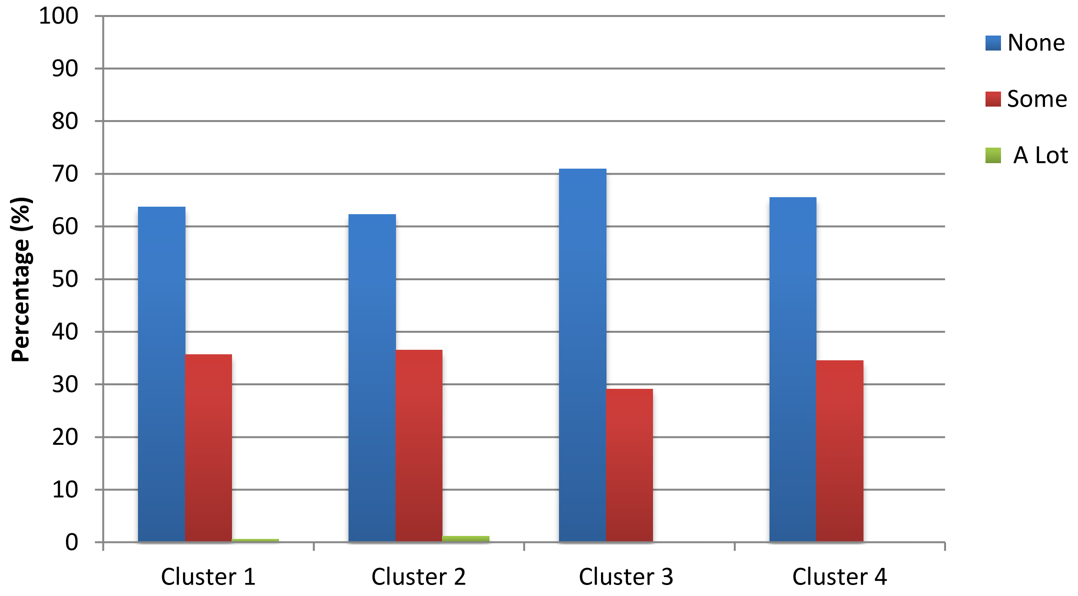
Graph 7.3. Amount of Aluminium and Glass within Camper's Daily Waste.



Graph 7.4. Amount of Organic matter within Camper's Daily Waste.



Graph 7.5. Amount of Fish Offal within Camper's Daily Waste.



Graph 7.6. Amount of Household Items and Scrap Metal within Camper's Daily Waste.

Respondents were asked where they disposed of their rubbish, and were provided with the options of 'bin at campsite', 'tip provided by camp area', 'in dunes/on beach/at sea', 'take Home', 'nearest town' and 'other'. For each category, a Pearson Chi-square identified significant differences between the clusters for all categories with the exception of 'on dunes/at sea/on beach' (p =.129). The most common methods of rubbish disposal overall were 'bin at campsite' and 'dump area provided by station' (*Graph 7.7* and *Figure 7.2*). When combined these were selected by 94 % of respondents (n = 685). A chi-square test suggests no significant difference between clusters (p = .152) in this regard. Alternatively, 'Shire dump points' and 'nearest town' were selected by only 4 % of respondents (n = 42). Again, no significant difference was found between clusters. However, there may be a bias here in that respondents might not admit they dump rubbish in the dunes or at sea as this may be seen as 'wrong'.

This suggests that the majority of litter produced by campers is disposed of by campers on-site at their coastal camping areas, while only 4 % disposed of their waste in a town where developed waste disposal infrastructure is available. The exceptions to this are Cape Range National Park, where waste is removed from campsite bins and taken to a tip in Exmouth, and Blowholes management area where the Carnarvon Shire supplies a removable skip bin, later to be disposed of in Carnarvon. As described in section 2.6.2 however, landfill is used in all major sub-regions Of most environmental concern, respondents reported that between 0.5 % (Cluster 2) and 3.10 % (Cluster 4) dump their rubbish in dunes, at sea or on the beach (which could well be an underestimate since respondents are unlikely to confess to this). Results for 'other' (2.5 % of respondents) included burning, burning organic and fish matter, recycling cans and digging deep holes to dispose of wastewater.

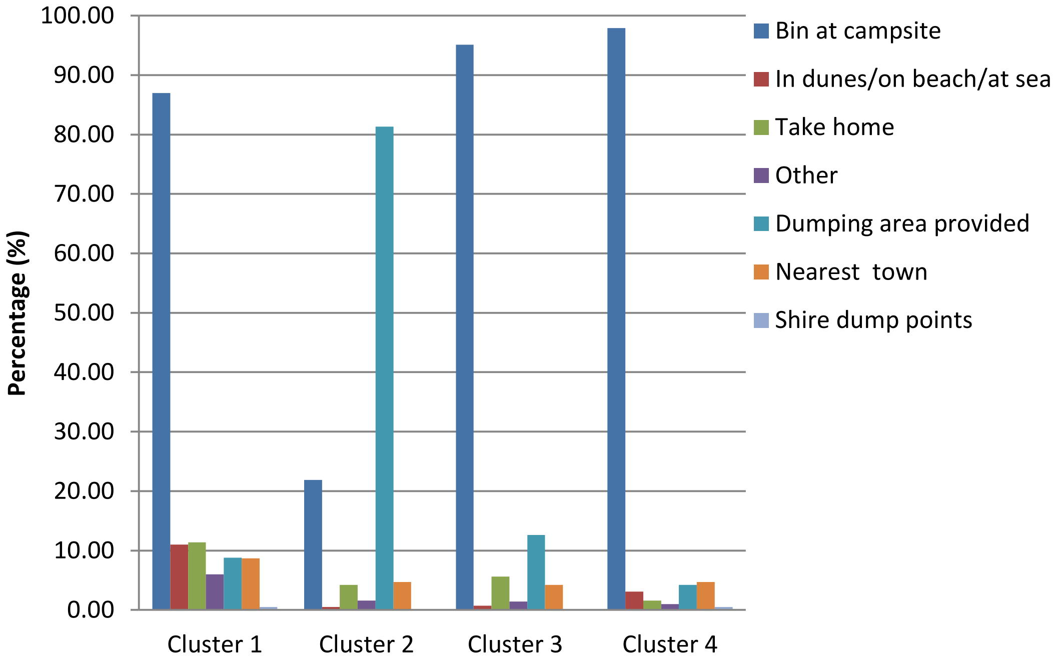
Plate 7.1 Skip bin, Blowholes Camp Area (Cluster 2)

Plate 7.2 Rubbish tip, South Warroora (Cluster 2)

Plate 7.3 Bin, Blowholes Camp Area (Cluster 2)

Plate 7.4 Rubbish Incinerator, Bruboodjoo Camp Area (Cluster 1)

Figure 7.2. Methods of Rubbish Disposal.



Graph 7.7. Location of Rubbish Disposal by Campers.

7.3 WATER USE AND SOURCE

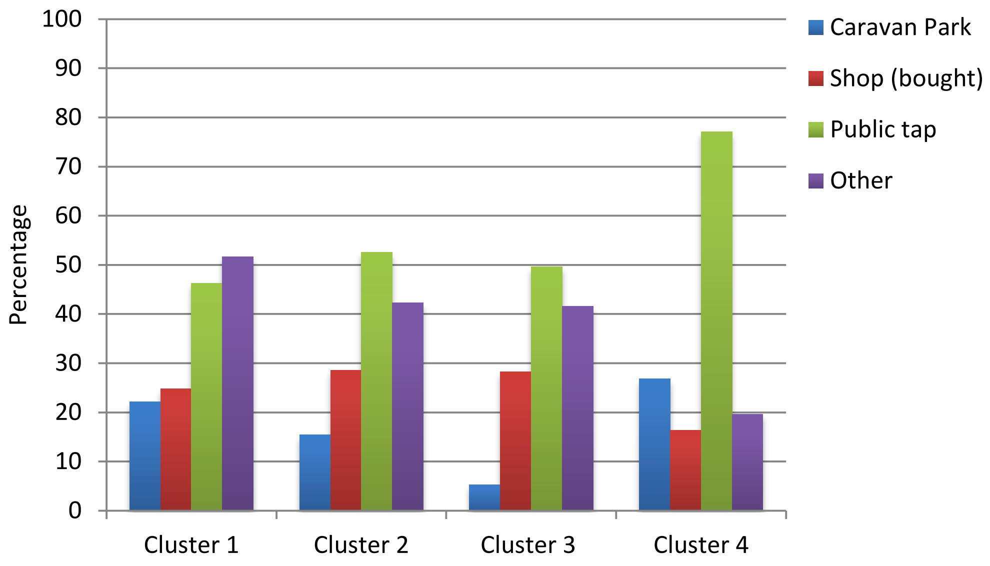
Campers were asked how much fresh water was consumed at their campsite daily and the locations from which this water was derived. All fresh water is supplied by campers with drinking water being sold at sites in Clusters 3 and 4. The amount of water consumed in litres (L) per campsite was represented by categories '1-5,'6-10', '11-20', '20-50', 'over 50'. Water consumption per campsite was then divided by number of individuals per campsite to derive water use per person. Water sources had the categories 'caravan park', 'shop (bought)' 'public tap' and 'other'. No management areas supply fresh water for campers, though bore water taps are provided at DEC sites and on some stations. Gnaraloo is the only management area which provides showers and flush toilets with non-potable bore water. This non-potable water was not taken into account for this survey, which focuses on fresh water.

Water use per person displayed significant differences between the clusters. Significant differences (p = .02) were found from a one-way ANOVA test. Campers at Cluster 4 used the least amount of fresh water per person (6.35 L per day), while those at Cluster 3 used the most (9.6 L per day) (*Graph 7.8*). Cluster 1 consumed 7.15 L per person per day, while Cluster 2 consumed 6.45 L.

Graph 7.8. Litres of Water Consumed per Person per Day.

Sources of water is an important consideration for remote campers, since large quantities can be consumed during peak periods and even regions and sub-regions can face water shortage difficulties in this part of the country. There were significant differences in the location of the sources of water between the clusters as indicated by a Pearson Chi-Square test (p = 0.00, df-12). The most popular option for all clusters was using a 'public tap', which may refer to Shire taps (e.g. the tap outside the visitor centre in Exmouth) or Caravan Park taps. Cluster 4 was more likely to refill at caravan parks as a second option, while Clusters 1, 2 and 3 were more likely to buy water as a second option.

Answers for 'other' included 'brought from home' (103 responses), a 'station bore' (38 responses), and 'catch rainwater' (8 responses). Those who brought their water from home were principally from Clusters 1 and 3. This suggests that residents from the Gascoyne region are the primary visitors to these clusters. Those who got their water from station bores were almost exclusively from Cluster 2, which raises management issues such as environmental degradation through access to the bores and the health standards of the water.

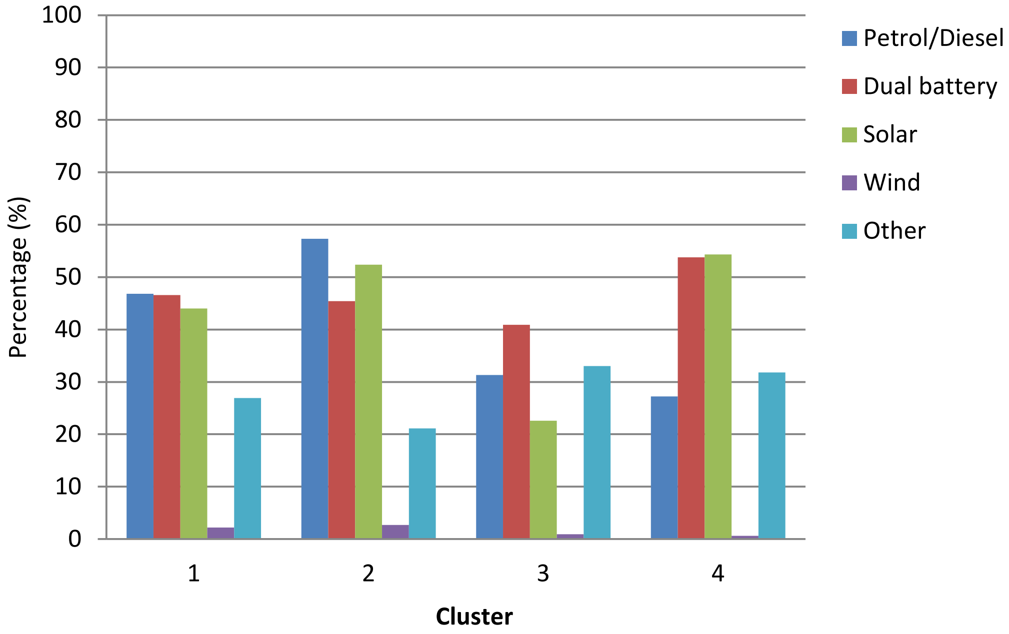


Graph 7.9. Source of Water for different Clusters.

7.4 POWER SOURCE AND ENERGY USE

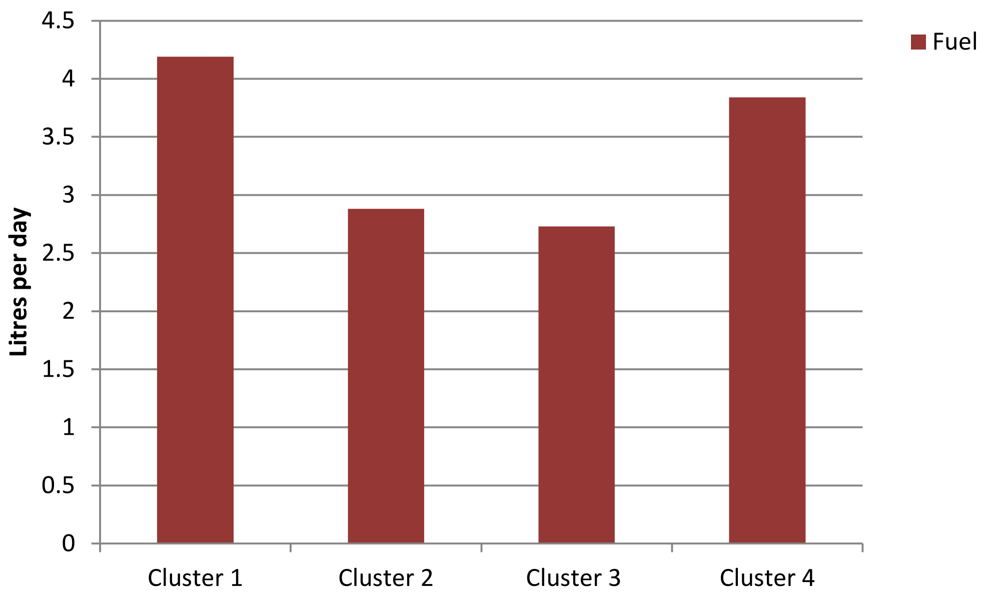
Campers were asked to select which technologies they used for power generation. Choices provided were 'dual batteries', 'solar', 'petrol/diesel', 'wind' and 'other'. When 'petrol/diesel' was selected, the quantity of fuel was also requested. Many campers chose more than one source, indicating that they utilised a range of power sources. Answers for 'other' included 'generators', which were then added to the 'petrol/diesel' category.

Overall, the power sources for Ningaloo campers were 'petrol/diesel' (27.9 %), dual batteries (27.6 %) and solar (27.0 %), followed by 'other' (16.3 %) and wind (0.9 %). Significant differences between the clusters existed only for the use of 'solar' (p = 0.00), 'dual battery' (p = .026) and 'petrol/diesel' (p = 0.00). The most popular power source for Clusters 1 and 2 was 'petrol/diesel', for Cluster 3 'dual battery' and for Cluster 4 'solar' and 'dual battery' (*Graph 7.10*). These results suggest that there is more incidence of fuel and generator use in the less regulated clusters, than by those in the more regulated clusters. This may be due to the larger energy requirements for appliances such as fridges at the lesser regulated clusters due to the longer length of stay. These selections reflect both the different length of stay and the remoteness of each cluster because petrol/diesel generators can produce large amounts of energy on demand.



Graph 7.10. Power Sources used by Campers.

For those campers with a generator, power use varies between 6.45 KwH per person per night (Cluster 4) and 14.6 kWh per person per night (Cluster 1) (*Table 7.2*). Of those campsites that used diesel/petrol, the average amount used overall per person per day was 0.96 L (*Graph 7.11*). Cluster 3 used the most per person per day (1.48L), followed by Cluster 1 (0.87 L), Cluster 4 (0.81 L) and Cluster 2 (0.68 L). When calculated per campsite, Cluster 1 is shown to use the most (4.10 L per day), followed by Cluster 4 (3.84 L), Cluster 2 (2.88 L) and Cluster 3 (2.73 L). This suggests that larger groups, present in Clusters 4 and 2, are more likely to be selecting generators for power use. Answers for 'other' included 'batteries', 'car battery', 'gas/LPG', 'rechargeable lamps' and 'open fire'. 'Gas' was the most common type of other source, receiving 62 responses.



Graph 7.11. Litres of Petrol used per person per day, for Campers using Generators.

Table 7.2

Energy use per person per day for Campsites using a Generator (L, MJ and kWh).

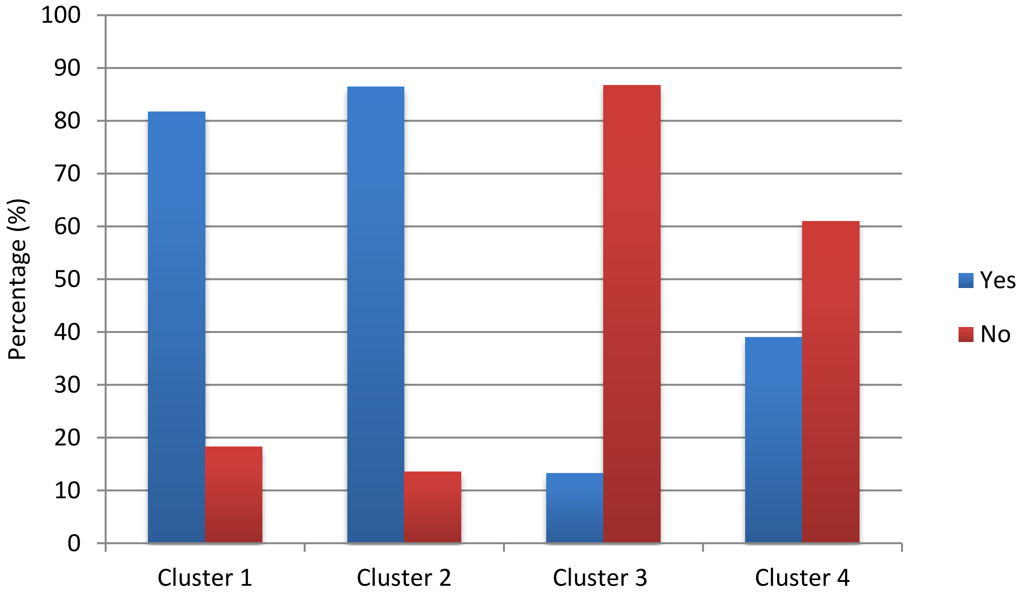
	Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**
Petrol (L)	1.48	0.87	0.81	0.68
MJs [4]	50.61	29.75	27.70	23.25
kWh [5]	14.06	8.26	7.695	6.45

7.5 SEWERAGE DISPOSAL

Given that only Clusters 3 and 4 provide toilet facilities, human waste disposal presents both environmental and public health challenges along the Ningaloo coast. Campers at Clusters 1 and 2 are expected to carry portable toilets under the NROCA agreement[6] and this is expected by station managers at Warroora. Dump points for

[4] Source: http://www.derm.qld.gov.au/register/p01295al.pdf
[5] Source: http://www.unitconversion.org/energy/megajoules-to-kilowatt-hours-conversion.html
[6] The pastoralist lessees of Ningaloo, Warroora, Cardabia, and Gnaraloo stations, who have formed the Ningaloo Reef Outback coast Association (NROCA), produced a rehabilitation plan for the recreational use of the coastal

sewerage are located in Carnarvon, Coral Bay and Exmouth. Within the study area, Warroora station is the only management area which provides dump points. This section examines whether campers carry portable toilets, and where the sewerage is deposited. Of all Ningaloo campers, 81.7 % carry a portable toilet. Clusters 1 and 2 do not have toilets supplied at their campsite and campers are required to have their own portable toilet. When asked whether they had a portable toilet, 18.3 % from Cluster 1 and 13.6 % from Cluster 2 did not (*Graph 7.12*).



Graph 7.12. Portable Toilet Ownership.

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strip through National Heritage Trust funding. CALM has signed a Memorandum of Understanding with NROCA for management of the coastal strip Department of Environment and Conservation (2005). Management plan for the Ningaloo Marine Park and the Muiron Islands Marine Management Area 2005-2015,. Prepared for Marine Parks and Reserves Authority by the Department of Environment and Conservation. Perth, Western Australia**:** 112.

Plate 7.5 Drop Toilets at Red Bluff Camp Area

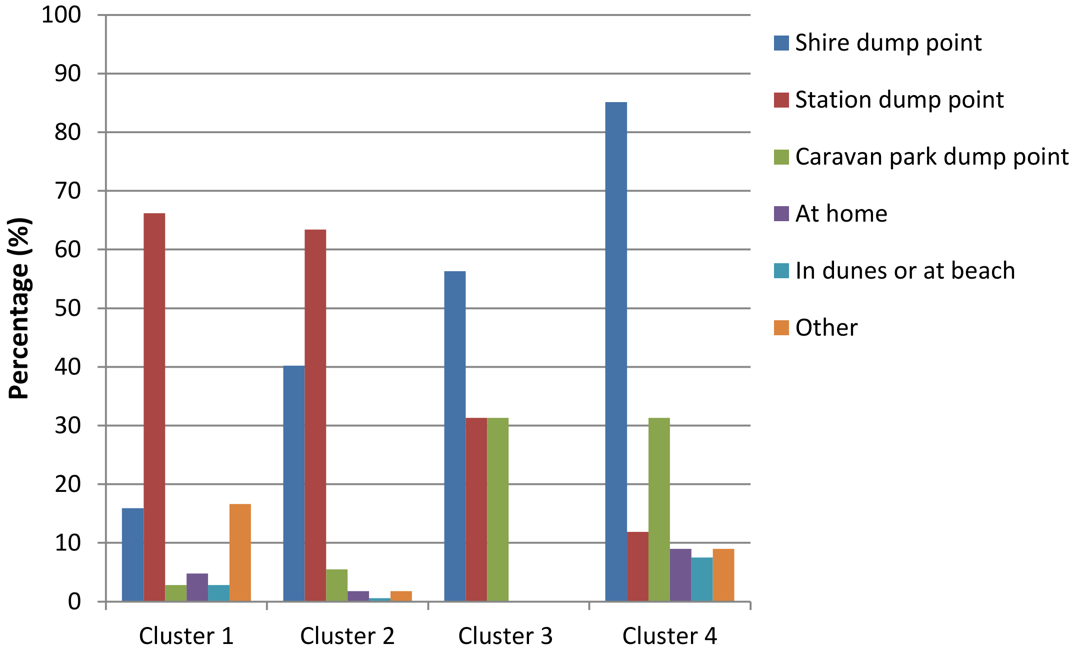
Plate 7.6 Chemical Toilet Dump, Southern Warroora Station

Plate 7.7 Toilets at Red Bluff Camp Area

Figure 7.3. Sewerage Disposal Techniques.

To dispose of sewerage, most (54.3 %) campers within the study area who have a portable toilet empty them at ‘station dump points’ (*Graph 7.13*). ‘Shire dump points’ were also popular (39.5 %), followed by ‘caravan dump points’ (9.90 %), ’other’ (8.40 %), ‘at home’ (4.10 %), and ‘in the dunes or at beach’ (2.60 %). Significant differences (p = <.05) existed between clusters for all disposal methods with the exception of ‘in the dunes or at beach’. Use of ‘Shire dump points’ was most common for Cluster 3 and 4 campers, while station dump points are used primarily by Cluster 1 and 2 campers. Within Clusters 1 and 2, only Warroora Station has sewerage dump points at both Fourteen Mile (Cluster 2) and the Lagoon (Cluster 1). Within Cluster 1, neither Cardabia station nor Learmonth Air Weapons Range have dump points. Likewise, in Cluster 2, the Blowholes management area does not have a dump point and campers from the Blowholes indicated that they used a shire dump point. This would explain why ‘shire dump point’ ranked second for Clusters 1 and 2. Respondent’s ‘other’ comments, for Cluster 1 respondents, included: ‘Side of road’, ‘long deep toilet’, ‘ditch’, and ‘pit on side of tip’. These comments strengthen the argument for better-managed sewerage disposal and disposal facilities in remote camp areas.

Caravan park dump points are heavily utilised by campers from Clusters 3 (31.3 %) and 4 (31.3 %), the most costly of all clusters. These campers may be willing to pay a higher price for camping and associated facilities for sewerage disposal. Interestingly, those who selected ‘in dunes or beach’ were from the most regulated Cluster 4 (7.5 %), followed by Cluster 1 (2.8 %) and Cluster 2 (06 %). No campers from Cluster 3 selected this answer. Cluster 4 does not have a sewerage dump point because drop toilets are provided at these camp site locations. However, many campers use their own facilities, the nearest dump point being Exmouth, one hour’s drive away.



Graph 7.13. Disposal Locations of Portable Toilet contents by Campers.

7.6 SUMMARY OF RESULTS

When comparing camper resource levels across the management areas, the null hypothesis was rejected because only a few variables failed variables failed to exhibit significant differences between the clusters (*Table 7.3*). These included rubbish generation per person per day, disposal of rubbish and sewage in dunes, disposal of sewage at home, and wind and generators as power sources. All other factors exhibited significant differences between the clusters. Significant differences existed between the types of rubbish produced, sources of water and frequency of supply restock. Cluster 3, the cluster with the most resources locally available, used the highest amount of water and produced the most rubbish. However, the amount of resources used by all the remote campers was far less than those for other accommodation types (listed in section 3.3.3).

When comparing camper resource use levels across management areas, the null hypothesis was also supported because significant differences existed between the clusters for all Impact variables. However, as with the preferences, two different levels of impact were found relating to those variables which correlated with regulation levels and those which did not.

Table 7.3

Significant Differences of Resource Use Variables between Clusters.

(✓ = significantly different)

Resource Use per Person				
	Bags of rubbish filled daily		Litres of petrol required for generators daily	✓
	Litres of fresh water consumed daily	✓		
Amount In Rubbish				
	Packaging	✓	Fish offal	✓
	Aluminium cans and glass	✓	Household items and metal	
	Fruit, veg, and organic matter	✓		
Where dispose of Rubbish				
	Bin provided by campsite	✓	Nearest large town	✓
	On dunes / at sea / on beach		Shire Tips	
	Take home	✓	Other (bury/burn)	
	Dumping area provided by campsite	✓		
Ownership and Disposal of Toilet Waste				
	Have a chemical toilet Y/N	✓	In dunes at the beach	
	Septic system in caravan park	✓	At home	
	Septic system provided by station	✓	Shire dump	✓
Source of Power				
	Solar	✓	Generator	
	Wind		Gas	✓
	Dual Battery	✓	Other	✓
Source of Water				
	Caravan park	✓	Public tap	✓
	Shop bought	✓	Other (Bore, Rain, home)	✓
How often Restock on Supplies				
	1-7 days	✓	15-30 days	✓
	8-14 days	✓	Greater than 30 days	✓
Where Restock?				
	Carnarvon	✓	Exmouth	
	Coral Bay	✓		

7.7 DISCUSSION AND CONCLUSION

Management and facilities in this remote system dictate where resources are drawn from and where waste is deposited. As highlighted in section 7.6, when comparing camper resource use across management areas, the null hypothesis was rejected because some factors were not significantly different across the clusters. These included rubbish use per person per day, the disposal of rubbish and sewage in dunes, the disposal of sewage at home, and the use of wind and generators as power sources. Reasons for these differences and similarities are discussed within this section. The main finding was that the amount of resources used by all remote campers was far less than is the case for all other accommodation types. Comparisons across clusters, while significantly different statistically, were still small. Real environmental challenges related to water, rubbish and sewerage were also identified. This section discusses the reasons why a number of significant differences were found between the clusters and considers those challenges caused by resource use which warrant attention in remote camping locations.

As one would expect, remote camping overall uses vastly less water than any other accommodation type in remote areas, as discussed in the literature review (Chapter 3:), including full amenity caravan parks, backpacker accommodation, holiday homes and hotels. For example, a full-facility caravan park within the Ningaloo region consumes 132 L of water per guest night; while hotels in the Ningaloo Region consume 605 L of water per guest night (Jones and Lewis unpublished data). Remote campers within this study consume between 6.35L (Cluster 4) and 9.6 L (Cluster 3) per person per day. Surprisingly though, those campers who used petrol generators consumed more power per person per night (23.25 MJ, Cluster 4 to 50.61 MJ, Cluster 1) than did residents at a full-facility caravan park (16 MJ) and Cluster 1 used more power per person per night than one would while staying in a hotel room (38.9 MJ) (Jones and Lewis 2009). This may be due to variations in calculation methods, inefficiency of small-capacity generators, or the greater need for power at some camping locations for freezers, televisions and other appliances. They also lack the economies of scale provided by central facilities (kitchens, laundries etc.) by other accommodation types.

The Strategic Waste Management Plan (Gascoyne Development Commission 2009) estimated that visitors to town centres produced approximately 1.93kg of rubbish per visitor per day which is comparable to the approximately one 12L bag of rubbish produced per person per day in the remote campsites.

No significant differences were found between the clusters on a number of variables including rubbish amount per person per day, disposal location of rubbish, and the amount of sewage disposal both in dunes and at home. The similar levels of rubbish production presumably stem from the access that all campers enjoy through vehicle-based camping, with packaging and waste food waste comprising most of the rubbish. The most common methods of rubbish disposal for all clusters overall were ‘bin at campsite’ and ‘dump area provided by station’, meaning that the majority of rubbish produced is deposited back into the coastal zone which raise environmental concern. The majority of campers camp at one location for over two weeks. They are therefore more likely to dump refuse in designated areas near the camp rather than in a regional centre. Other findings suggest that only 6 % of remote campers utilise caravan park and shire facilities to dispose of their rubbish. Assuming 500 coastal campers at one time along the length of the Ningaloo coast this converts to approximately 1 tonne of rubbish (Gascoyne Development Commission 2009) entering the coastal landfill areas per day along the Ningaloo coast.

Warroora station has designed its own waste disposal facility incorporating a buried enclosure (water tank or wire gates) with a wire mesh top that reduces wind-blown rubbish, prohibits burning and excludes feral animals (Gascoyne Development Commission 2009) (*Figure 2.10*). On-site rubbish bins only work well only if they are covered, the rubbish is frequently collected and rubbish is placed by campers in bags and is not deposited loose as occurs at Red Bluff (Cluster 3). Also of environmental concern is the feedback that a small number (2.6 %) of campers in all clusters dump their sewerage from chemical toilets into dunal areas. Of all the management areas, Warroora station is the only camp area which provides dump points for sewerage. In camp areas where drop toilets are provided (Clusters 3 and 4), many campers choose to use their own facilities for comfort, However dump points are not provided at these locations. Furthermore Warroora is a large station and as such some campers may choose not to utilise the relatively distant dump points. Bias may have resulted from questionnaire responses surrounding waste management due to the stigma of the 'right' thing to do, especially for question surrounding the location of sewerage disposal. Therefore the dumping of sewerage in locations considered 'wrong' such as 'in the dunes' may be more prevalent than what is presented in these results.

All other values for water and energy use and waste production had significant differences across the clusters. Significant differences between clusters existed for the composition of rubbish, presumably a reflection of different length of stay between campers. Much of the waste being disposed of in the study area is recyclable or compostable. For example, 67.1 % (Cluster 3) to 80.5 % (Cluster 2) of campers had 'some' aluminium and glass in their rubbish. These findings are supported by a waste audit which also determined that the Carnarvon caravan parks' rubbish comprised approximately 40 % of recyclables which currently go to landfill (Gascoyne Development Commission and A Prince Consulting 2008). Key barriers to greater resource recovery in the Gascoyne region include: transport costs; distance from markets; relatively small volumes and lack of landfill pricing (Gascoyne Development Commission 2009). The greatest opportunity for the region identified within the Gascoyne Waste Management report (Gascoyne Development Commission and A Prince Consulting 2008) is to improve recovery of garden organics, given the poor soil health in the region. This may be suitable for remote coastal campsites in areas of high camper concentration given 71.1 % (Cluster 1) and 79.7 % (Cluster 2) of campers had 'some' organic waste in their rubbish.

Although water use by remote campers is low in comparison to that of other accommodation types, water use per person displayed significant differences between the clusters. Cluster 3 had the highest water use probably due to the availability of brackish water on-site. Water is most commonly accessed by all campers from public taps, such as those outside shire buildings which are free and accessible. Therefore, as remote camping becomes more popular, Shires should factor in demand from 46.3 % (Cluster 1) to 77.1 % (Cluster 4) of remote campers requiring approximately 10L of water per person per day from public sources. Cape Range National Park alone (Cluster 4) has approximately 110 sites which are full over the winter period and hold approximately three people each. For one week in peak season, Exmouth Shire should therefore factor approximately 18 cubic metres of water (17,787L) for camper consumption at CPNP alone.

Sewerage disposal is one of the biggest environmental challenges along the Ningaloo coast, particularly for five of the nine management areas which do not provide toilets. For those areas not providing toilets, 18.3 % of campers from Cluster 1 and 13.6 % from Cluster 2 did not have a portable toilet. Many of these campers were unaware that they needed one or dug holes for their human waste. While the presence of toilet paper around campsites is primarily an aesthetic issue (Bridle and Kirkpatrick 2005), human waste around campsites can also be a health hazard with one study (Temple, Camper et al. 1982), suggesting that areas that do not provide toilet facilities are likely to be harbouring dangerous faecal bacteria. Research from the United States (Gajda, Brown et al. 2000) South Africa (Campbell and Bate 1998) and Tasmania (Kirkpatrick and Bridle 2005) have found that human waste disposal near the beach zone has the potential to cause ecological disturbance as well as human health hazards. For Clusters 3 and 4, shire dump points bear the brunt of the sewerage disposal followed by Caravan Park dumps which were used by around 30 % of respondents. It seems that water sources and sewerage dump points are therefore the most needed facilities in remote camping areas. Access to such facilities is the most important reason for travel in addition to stocking up on food and other provisions. Since inappropriate sewerage disposal presents the greatest health and environmental risks, it is recommended that the provision of greater numbers of dump points or toilets be considered. The drop toilets at Red Bluff, which provide sawdust and hand sanitiser, represent the most aesthetic and efficient waterless toilet system in the region. The environmental impacts placed on the Ningaloo environment by campers are discussed in Chapter 8: below.

Chapter 8: Results Impact Assessments and Indices

Figure 8.1. Red Bluff Beach, Quobba Station.

8.1 INTRODUCTION

A review of the literature (section 3.4.3) revealed that information on the environmental impacts of coastal campsites is very limited, with the majority of literature in the field of recreation ecology referring to forested environments. As such, research methods from the literature were adapted (Chapter 4:) to suit the semi -arid coastal conditions at Ningaloo. The purpose of this chapter is to evaluate the null hypothesis that no significant differences exist with regard to the environmental impacts of camping across the clusters using impact variables and summary indices. How these may have been influenced by both independent variables and management regimes will be further explored in in Chapter 9. Since the environmental impacts of camping are the primary concern of this study, the analysis was conducted in detail. This chapter argues that understanding the impacts as site-specific and associated with management regimes rather than individuals places responsibility for impacts with management rather than individual campers, as outlined in section 5.4. Whilst the previous two chapters examined the differences between management regimes with regard to what campers do, who they are and the waste they produce. This section will explore the differences between clusters with regard to their environmental impacts.

The sample size chosen for this impact assessment is outlined in section 8.2. The inventory variables from the campsite pro forma are first compared against the management clusters (section 8.3), followed by the impact variables from the field pro forma (section 8.4). Results from three impact indices are then compared across the four management clusters (section 8.5), followed by a summary of results (section 8.6), and combined discussion and conclusion (section 8.7).

8.2 SAMPLE SIZE

In the three week period of March 15-April 9, 2009, 100 campsites were assessed. A second assessment of campsites 101 campsites was undertaken at the same time of year in 2010 increase the data set. A total of 201 impact assessments were completed representing all four campsite clusters. Approximately one in three of the campsites were sampled. For the data analysis, large unnumbered sites which could hold more than one group of people were divided into individual campsites based on the numbers of campers present at these locations during peak periods. This produced a final number of campsites for analytical purposes of 225.

Overall, Cluster 2 had the largest number of sampled sites (83) while Cluster 1 (Bruboodjoo and Fourteen Mile) had the smallest number (36 sites). These were proportionally similar in sample size to the other areas allowing for their greater isolation and smaller number of sites. For the impact assessments, Cluster 1 comprised only Warroora (excluding Fourteen Mile) and Cardabia. Within Cluster 3, 64 sites were sampled and in Cluster 4, 42 sites (*Table 8.1*).

Table 8.1

Number of Campsites Assessed per Management Area and Cluster.

Cluster	**Management Area**	**Camp Area**	**Campsites Assessed (*n*)**
1	Cardabia		
		Nine Mile	18
1	Warroora Excluding Fourteen Mile		
		Bulbarli	1
		Elle’s	3
		Lagoon	2
		Between Lagoon & Southern Boundary	1
		Pelican Point	1
		Steve’s	4
		Southern Boundary	2
		SP	4
Cluster 1 Total			36
2	Blowholes		
		Blowholes	37
2	Warroora Fourteen Mile		
		Fourteen Mile (Beach)	14
		Fourteen Mile (Dunes)	15
		Fourteen Mile (Ridge)	17
Cluster 2 Total			83
3	Gnaraloo		
		Three Mile Camp	32
3	Red Bluff		
		Red Bluff Camp	32
Cluster 3 Total			64
4	Cape Range National Park		
		Lakeside	5
		Mesa	5
		Neds Camp	5
		Ocean Beach	8
		Pilgramunna	4
		T bone	3
		Tulki	5
		Yardie Creek	7
Cluster 4 Total			42
Total Sample			225

8.3 INVENTORY VARIABLES

8.3.1 Vegetation Type, Dispersion and Distribution

8.3.1.1 Vegetation Type Campsite and Perimeter

A series of ANOVA means tests compared vegetation type and cluster within the camp areas. Five vegetation types exhibited significant differences across the clusters; 'grass', 'spinifex', 'saltbush', 'small tree' (less than two metres high) and 'large tree' (over two metres tall) (*Table 8.2* and *Graph 8.1*) while two were not; 'small shrub' (less than one metre high) and 'large shrub' (over one metre high).

Grasses were the predominant vegetation for all clusters with the exception of Cluster 2. Grasses are colonisers so they tend to be the first type of plant established in disturbed ecosystems. The predominant grass type present was buffel grass, which is an introduced species and was used to recover bare ground quickly to provide feed for livestock. Cluster 2 campsites are located predominantly in primary dune areas where little grass is present. The least common vegetation types were 'small tree' and 'large shrub'.

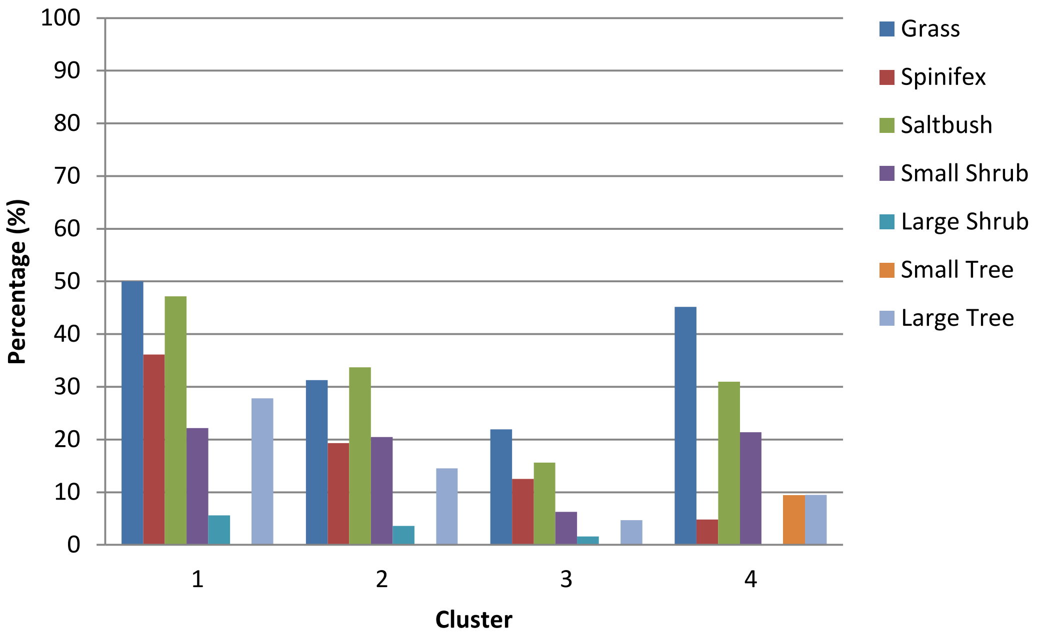
These vegetation types are most likely to have been removed from a campsite area to make more room, or to create natural buffers to campsite expansion, and thus to be located on the periphery of a campsite. In the second instance, the shrubs would therefore have been classified 'campsite perimeter'. Large trees were more common than these two plant types since they could be more easily incorporated into a campsite due to the low area taken up by their trunks and their desirability for shade provision.

Table 8.2

Percentage of Campsites which contain the Vegetation Types for each Cluster.

Cluster	Grass	Spinifex	Saltbush	Small Shrub	Large Shrub	Small Tree	Large Tree
1	50.0	36.1	47.2	22.2	5.6	0	27.8
2	31.3	19.3	33.7	20.5	3.6	0	14.5
3	21.9	12.5	15.6	6.3	1.6	0	4.7
4	45.2	4.8	31.0	21.4	0	9.5	9.5
Significance for ANOVA means test ($p \leq .05$)	.012 (S)	.002 (S)	.007 (S)	.064 (NS)	.412 (NS)	.000 (S)	.009 (S)

(S) = Significant, (NS) = No Significant



Graph 8.1. Percentage of Campsite Vegetation types for each Cluster.

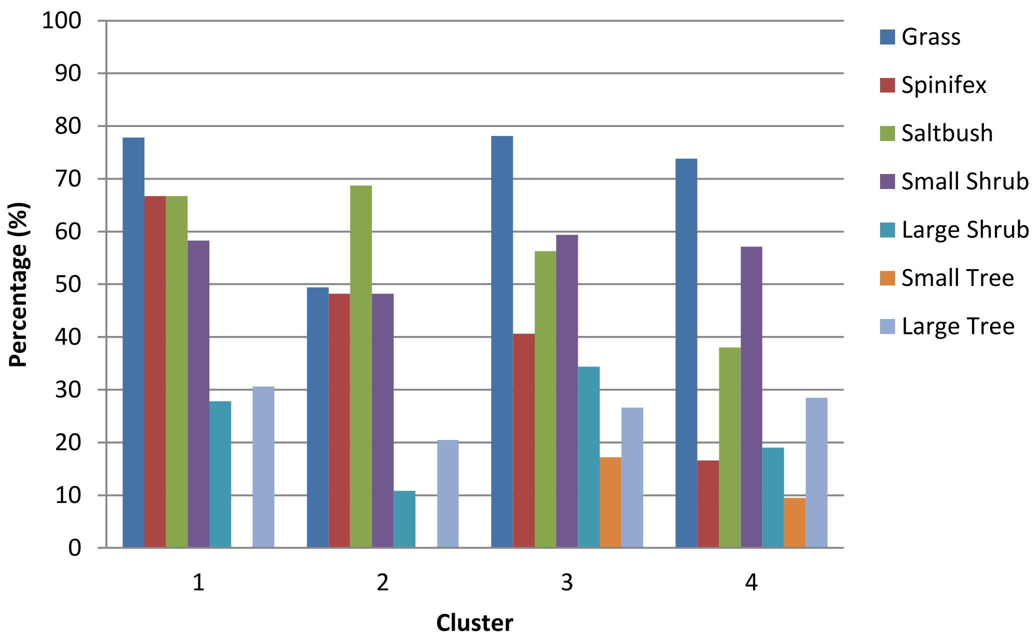
A series of ANOVA means tests compared vegetation type and cluster along the campsite perimeter (*Table 8.2* and *Graph 8.2*). Five vegetation types exhibited significant differences across the clusters; grass, spinifex, saltbush, large shrub and large tree, while small shrub and small tree were not significantly different. All vegetation types decreased in percentage between the campsite area and the campsite perimeter, for all clusters. This means that, within every cluster, there is a larger amount of every vegetation type in the campsite perimeter than in the campsite area. This is what would be expected given that the campsite is more disturbed by anthropogenic impacts.

Table 8.3

Percentage of Perimeter Vegetation Types for each Cluster.

Cluster	**Grass**	**Spinifex**	**Saltbush**	**Small Shrub**	**Large Shrub**	**Small Tree**	**Large Tree**
1	77.8	66.7	66.7	58.3	27.8	0	30.6
2	49.4	48.2	68.7	48.2	10.8	0	20.5
3	78.1	40.6	56.3	59.4	34.4	17.2	26.6
4	73.8	16.6	38.0	57.14	19.0	9.5	28.5
Significance for ANOVA means test ($p \leq .05$)	.000 (S)	.000 (S)	.001 (S)	.210 (NS)	.037 (S)	.147 (NS)	.045 (S)

(S) = Significant,(NS) = No Significant



Graph 8.2. Percentage of Perimeter Vegetation Types for each Cluster

Vegetation dispersion related to the density pattern of vegetation within the campsite area, while vegetation distribution identified whether the vegetation is evenly distributed, increasing from the core, increasing from the road or patchy across the whole campsite. Additionally, any soil and vegetation modifications made to campsites by campers were noted. Vegetation dispersion and distribution results did not contribute important findings to this study and so are not described here in detail. Campsites in Clusters 3 and 4 which had a high management footprint contained no vegetation while vegetation removal patterns in Clusters 1 and 2 were related directly to vehicle access to the site and the size of the camp infrastructure. Vegetation dispersion was related to the vegetation species, with ‘spinifex’ typically denser when present than other vegetation types. No soil or vegetation modifications were noted except for some campers digging moats around their campsites at Pilgramunna (Cluster 4) and one the beach at Fourteen Mile to protect camps from sea water at high tides.

8.3.2 Substrate and Distance to Ocean

8.3.2.1 Substrates

A variety of substrates were observed across the Ningaloo campsite areas including compacted sand, loose sand, red clay, gravel, limestone and rock. Monz (2010) considers that substrate type may be associated with the extent and /or amount of environmental impact on a site, in part due to the particular plant species supported by different substrates. The presence of loose sand in coastal environments signifies fragility and produces different impacts and vegetation types as compared with those on hard soils (Cole 1989). A Chi-square test revealed significant differences in substrate types between the clusters ($p = 0.00$), though 41 (78 %) had an expected count of less than 5, an assumption of the statistical test.

All clusters contained campsites with substrates of compacted or loose sands. However, loose sand was the dominant substrate in Clusters 1 and 2 (63.9 % and 53 %, respectively) while compact sand was dominant for Clusters 3 and 4 (43.8 % and 51.1 %). Campsites within Clusters 1 and 2 are located predominantly within dunal areas, whereas Cluster 3 has many campsites set back from the beach on ridges. Cluster 4 contained substrates modified to make them more suitable for two wheel drives, reflecting site hardening undertaken by the site managers.

Other than sand, Cluster 2 also contained campsite substrates dominated by red clay, Cluster 3 by red clay and rock and Cluster 4 by gravel and limestone. In most instances, the predominant substrates were not uniform and were often mixed with sand.

Table 8.4

Percentages of Substrate types across Clusters.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Compacted sand	36.1	25.3	43.8	51.1
Loose sand	63.9	53	39.1	16.7
Red clay	-	1.2	3.2	-
Gravel	-	-	-	4.8
Limestone	-	-	-	28.6
Rock	-	-	14.1	-

Note: Blank cells represent substrate not present

8.3.2.2 Distance to Ocean

Distance to the ocean was considered to be an important factor in site satisfaction, both at Ningaloo (Moore and Polley 2007) and elsewhere in the literature (section 3.2). Distance from the ocean may therefore reflect use intensity of a particular site. Distance from the ocean was measured in seven categories: (1) 5-10 m (2) 10-20 (3) 20-50 (4) 50-100 (5) 100-200 (6) 200-500 (7) greater than 500. A Pearson chi-square test indicated that there were no significant differences between the clusters with regard to campsite distance from the ocean (p = .055). Also, no significant correlations were found when conducting a Pearson's correlation between cluster number and distance of campsites form the ocean (r = -.039).

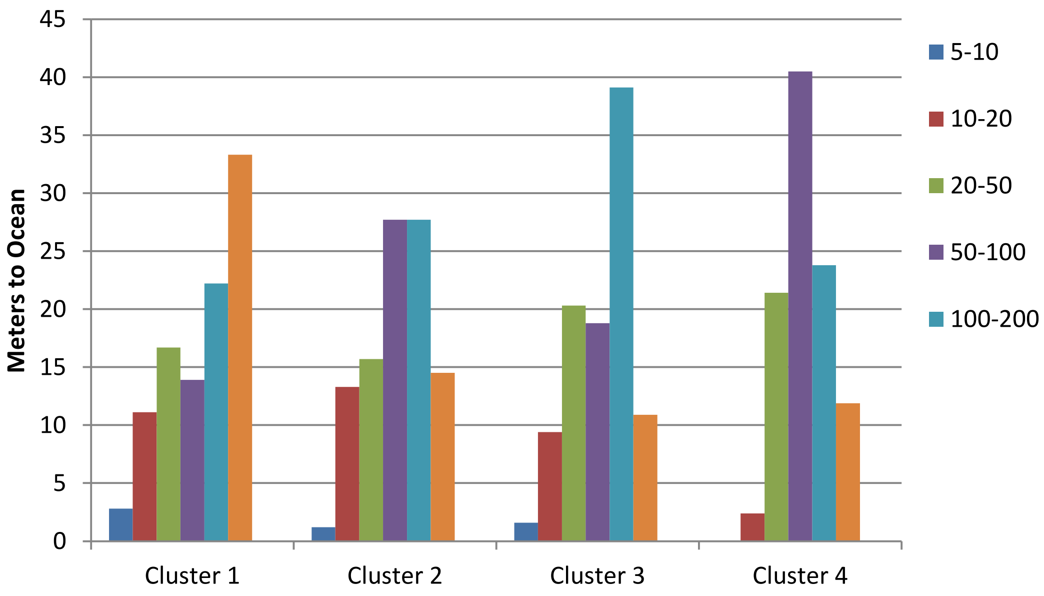
The average campsite distance from the ocean, for all clusters, was between 50 and 100 m (13.9 % to 40.5 %). The least common distance was 5-10m from the ocean (1.2 % to 2.8 %) (*Graph 8.3* and *Table 8.5*). All sites at this distance were in Clusters 1, 2 and 3. While Cluster 4 did not have any campsites recorded at 5-10 m from the ocean, Pilgramunna campsite has no vegetation boundary between the campsite and ocean, and is separated from it only by sand. Flooding events from seawater resulting from a spring tide were observed at this location during July 2010. All clusters therefore contain some campsites currently vulnerable to storms and sea level rise. Cluster 1 contained the most sites at the farthest distance from the ocean (200-500m) (33.3 %) while Cluster 3 contained the least (10.9 %) (*Figure 8.2*). No clusters had sites greater than 500 m away from the ocean. This is probably because even the most regulated Cluster 4 campsites are likely to be based on pre-existing campsites; hence management did not move them from the sites where they were originally developed. Additionally, the geology of Cape Range would prevent the campsites from being developed too far inland in Cluster 4.

Table 8.5

Average distance of Campsites to the Ocean (%) for each Cluster.

Metres	**Cluster 1**	**Cluster 2**	**Cluster 3**	**Cluster 4**
5-10	2.8	1.2	1.6	-
10-20	11.1	13.3	9.4	2.4
20-50	16.7	15.7	20.3	21.4
50-100	13.9	27.7	18.8	40.5
100-200	22.2	27.7	39.1	23.8
200-500	33.3	14.5	10.9	11.9
More than 500	-	-	-	-
Mean/Std Dev	**72.1**	**70.55**	**70.85**	**71.05**

Note: Blank cells represents that the distance specified was not present within these clusters



Graph 8.3. Distance to the Ocean by Cluster.

Plate 8.1 Cluster 2 0-5m from high tide, Sandy Point,

Plate 8.2 Cluster 3 Campsite 200-500m from the coast,

Figure 8.2. Distance from the Ocean, Examples of Campsites.

8.3.3 Facilities and Access

8.3.3.1 Facilities

The facility indicators recorded at each campsite incorporated: toilet distance, sewerage disposal distance, tip distance and presence of fire pits (*Table 8.6*). Within each cluster, the provision of facilities such as the distance to toilets, varied slightly based on management regimes, yet all facility indicators exhibited significantly positive correlations when compared across clusters. A one-way ANOVA also suggests that there are significant differences (p = 0.00) between clusters for each of the facility indicators.

Only Clusters 3 and 4 had toilet facilities in all management areas, located 10-20 m away from each campsite in Cluster 3 and 5-10 m away in Cluster 4. While Blowholes has three toilets at the campsite entrance and one in the middle of the camp area, from observations and interviews they were rarely used due to campers' perceptions of lack of maintenance.

Garbage removal services, in the form of bins emptied regularly for campers, were only provided at Clusters 3 and 4. Within Cluster 3 the average garbage bin distance from a campsite area was 10-50 m for Red Bluff and 50-200 m for Gnaraloo, while in Cape Range National Park they averaged 10-50 m from each campsite.

Sewerage disposal facilities were not uniform, with only Warroora Fourteen Mile (Cluster 2) and Warroora excluding Fourteen Mile (Cluster 1) providing dump points. These dump points were on average 5-10 km from each camp site. This study has shown that many campers (52.8 %) were travelling with a caravan or motor home. During on-site data collection, requests for more dump points from campers were high.

Rubbish tips for refuse disposal by campers near camp areas were present in Clusters 1 and 2 as described in section 2.3. All rubbish tips were on average less than 5km from the campsites.

Table 8.6

Facilities per Cluster and their Mean Distance from Campsites.

Cluster	**Management Area**	**Drop toilet Distance (m)**	**Garbage Bin (m)**	**Sewerage Disposal (km)**	**Tip (km)**
1		-	-	-	1-5
	Bruboodjoo	-	-	-	1-5
	Southern Warroora	-	-	5-10	1-5
2		-	-	-	<1
	Blowholes	20-50	-	-	<1
	Fourteen Mile	-	-	5-10	1-5
3		10-20	50-200	-	-
	Red Bluff	10-20	10-50	-	-
	Gnaraloo	10-20	50-200	-	-
4	CRNP	5-10	10-50	-	-
ANOVA		0.00	0.00	0.00	0.00
Correlation (r)		-.479 (S)	.449 (S)	.551(S)	.480 (S)

(S) = Significant, (NS) = Not significant
Note: Blank cells represents that the variable specified was not present

Fire pits, constructed by both management and campers, were present in Clusters 1, 2 and 3 (*Figure 8.3*) and were not allowed in Cluster 4. An ANOVA (2-tailed) therefore shows that a significant difference (p = <.01) exists between clusters. Cluster 1, on average, has the largest number of fire pits per campsite (2.08), followed by Cluster 3 (1.41) and Cluster 2 (1.15). However, by area Cluster 1 had the least number of fire pits (one fire pit per 271.70 m^2 per site), then Cluster 2 (150.83 m^2 per site) and Cluster 3 (139.96 m^2 per site). In Clusters 1 and 2, many fire pits had no infrastructure and fires were created in many different areas. Cluster 3 had more developed fire pits, often made from bricks or stone. Campfires in Cluster 4 were not allowed and as such no fire pits were present. Cluster 4 sites have a high density of campers and high management presence, perhaps discouraging campers from lighting fires.

Table 8.7

Average number of Fire Pits per Cluster and mean Area per Campfire.

Cluster	**Fire Pit average (count) ± SD**	**Area (m^2) of campsite area per fire pit**
1	2.08 ± 1.270	271.70
2	1.15 ± 1.081	150.83
3	1.41 ± 0.757	139.96
4	0.00 ± 0.00	0
Average	1.16	140.63.2
Correlation (r) and Significance (p = <.01)	-.524 (S)	-

(S) = Significant, (NS) = Not significant

Plate 8.3 Management-built fire pit at Gnaraloo, Cluster 3

Plate 8.4 fire pit, Cluster 2

Figure 8.3. Different Types of Fire Pit.

8.3.3.2 Access and Distance to Nearest Town

Ease of access and the distance to the nearest town (isolation) may have a large impact on visitation levels. As highlighted in *Table 4.2*, Access was calculated through a rating system for each study site whereby:

1. Represents only accessible by four-wheel drive,
2. Represents a road not sealed but accessible by two-wheel drive,
3. Represents a sealed road

A one-way ANOVA (2-tailed) suggests there are significant differences (p = 0.00) between clusters with regard to both isolation and road access. Cluster 4 (Cape Range National Park) is the most accessible with sealed roads leading to the campsites. The second-most accessible cluster is Cluster 2, where one management area has sealed road access (Blowholes), and another (Fourteen Mile) a combination of two-wheel drive accessible and four-wheel drive accessible roads. Access was negatively correlated (r = - 0.579) across the clusters, suggesting that they become more accessible as the cluster number increases (*Table 8.8*).

Both Cluster 1 and Cluster 3 have unsealed roads accessible only by four-wheel drive vehicle. Cluster 3 is considered the most isolated of all clusters, with an average distance of 145 km. from a town, in part by four-wheel drive track. While Cluster 1 is on average the least isolated (41.53 km), it can only be accessed by four-wheel drive tracks. Isolation and access, in addition to other inventory variables are correlated against impact indicators in Chapter 9 to indicate the effect of these factors on environmental impacts along the Ningaloo coast.

Table 8.8

Access Type and Distance to Nearest Town for each Management Area and Cluster.

Cluster	**Management Area**	**Access**	**Nearest Town**	**Distance from Nearest town ± SD**
1				**41.53 ±20.93**
	Bruboodjoo	4x4 only	Coral Bay	24
	Warroora excluding Fourteen Mile	4x4 only	Coral Bay	59.94
2				**53.88 ± 17.25**
	Blowholes	Sealed	Carnarvon	73
	Fourteen Mile	4x4 only; two-wheel drive accessible	Coral Bay	39
3				**145.00 ± 15.1**
	Red Bluff	4x4 only	Carnarvon	130
	Gnaraloo	4x4 only	Carnarvon	160
4				**70 [0]**
	CRNP	Sealed	Exmouth	70

(S) = Significant, (NS) = Not significant

8.3.4 Proximity to other Campsites and Campsite Definition

‘Distance to closest campsite’ and ‘number of campsites in a 50m radius’ were both recorded using categories, while ‘total number of campsites in one barren core area’ was assessed quantitatively. When comparing clusters in relation to each of the three proximity measurements above, a one-way ANOVA (2-tailed) suggests there are highly significant differences between clusters (p = <.01) (*Table 8.9*). The correlations suggest that campsites increase in density as the level of management intervention increases, especially with regard to ‘number of campsites in a 50m radius’ (r = .422).

Cluster 4 campsites (Plate 8.5) are, on average, closest to one another (7.5m apart), while Cluster 1 campsites are the furthest (27.5m) apart (Plate 8.6). Campers in Cluster 1 are therefore surrounded by fewer campsites, averaging none to 1-3 campsites within a 50m radius (Plate 1). Cluster 4 has the largest number of campsites, approximately 3-5, within a 50 metre radius. In Cluster 4, the campers can also expect to be sharing a large barren core area, with the greatest number of other users (5.33 on average) (Plate 8.5). This is due to DEC management decisions to limit the damage to vegetation by having smaller sites that are close together, while in Cluster 1 campers spread themselves along the coast. Cluster 3 contains the least number of campsites in barren core areas not separated by vegetation, averaging 1.95 campsites per paved space. This is because all campsites are managed but have a different spatial configuration to those in Cluster 4. Cluster 4 has up to 14 sites in one barren core area, while Cluster 3 has approximately 3, but these mostly comprise single campsites. ‘Numbers of campsites in a 50m radius’ and ‘number of campers in one barren core camp area’ increase as might expected with increased management presence. Cluster 4 is the most densely occupied cluster, with an average of 4.04 campsites within a 50m radius, while Cluster 1 has only 0.92 campsites.

Table 8.9

Distance to Closest Campsite; Number of Campsites in a 50m radius; and Number of Campsites in one Barren Core Campsite.

Cluster	**Distance to closest Campsite (m)**	**Number of Campsites in a 50m Radius**	**Campsites in one Barren Core Campsite ± SD**
1	27.5	0.92	2.16 ± 2.26
2	8.2	1.8	3.05 ± 4.39
3	10.28	2.04	1.95 ± 2.03
4	7.5	4.04	5.33 ± 4.38
Average	13.37	2.2	3.12 ± 3.74
Correlation (*r*) and Significance (p = <.05)	-0.243 (S)	0.422 (S)	0.190

(S) = Significant, (NS) = Not significant

Plate 8.5 Containment Strategy, Cluster 4

Plate 8.6 Dispersal Strategy Cluster 2

Figure 8.4. Containment and Dispersal Strategies.

8.4 IMPACT VARIABLES

8.4.1 Campsite, Vegetation and Barren Core Area

The campsite area comprises the visually damaged area of a campsite, the product of combining both the barren core area (vegetation free areas) and surrounding areas of damaged vegetation, as discussed in section 4.4. All three measurements (campsite area, barren core area and vegetation area) exhibit significant differences (p = <.01) between the clusters in a 2-tailed ANOVA test (*Table 8.10* and *Graph 8.4*).

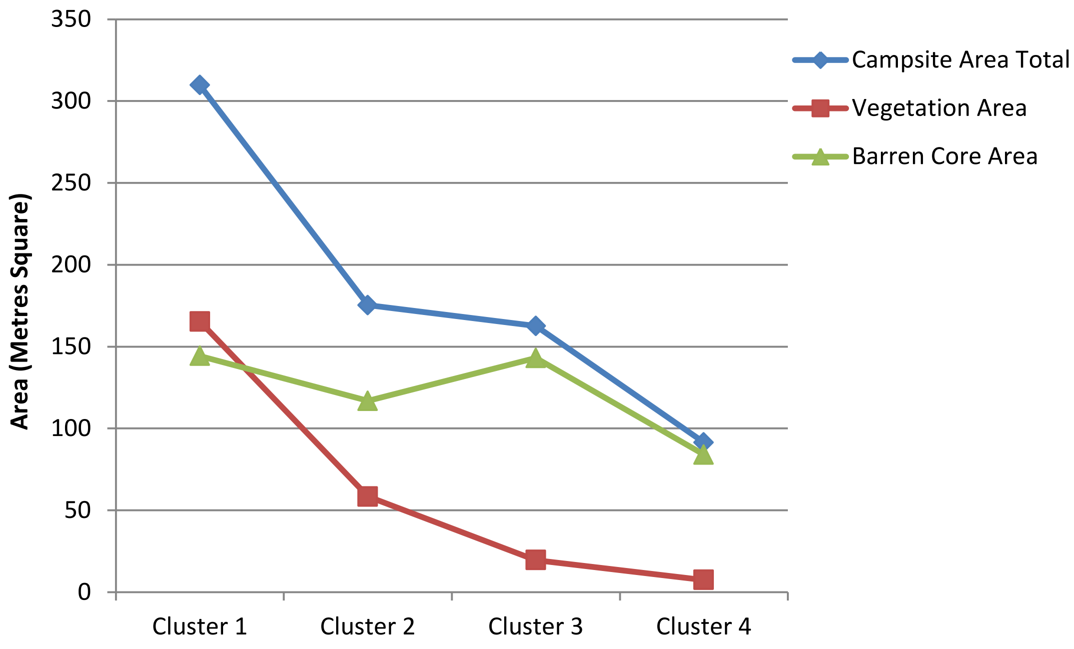
Table 8.10

Campsite Area, Vegetation Area and Barren Core Area.

Cluster	**1**	**2**	**3**	**4**	**Average Values**	**Significance for 2-tailed ANOVA (*p*≤.05)**
Vegetation Area	165.3 ± 312.9	58.4 ± 111.1	19.5 ± 49.8	7.5 ± 19.2	54.9	.000 (S)
Barren Core Area	144.3 ± 126.2	116.8 ± 96.2	143.0 ± 100.4	83.9 ± 30.7	122.5	.008 (S)
Campsite Area	309.6 ± 274.1	175.2 ± 114.2	162.6 ± 133.0	91.4 ± 34.1	177.5	.000 (S)

(S) = Significant, (NS) = Not Significant.

As shown in *Table 8.10*, campsite area size decreases with increasing regulation. Campsites from Cluster 1 average 309.67 square metres, whereas campsites in Cluster 4 average 91.4 square metres. Cluster 4 is more regulated and utilises more site management such as creating campsite barriers. Across all clusters however, campsites contain a higher percentage of bare barren core area than damaged vegetated area. This is probably a reflection of the sensitivity of the coastal vegetation within Clusters 1 and 2. In this environment, vegetation requires little disturbance to incur damage but takes up to two years to revegetate (Leung and Marion 2000). Within Clusters 3 and 4, the management footprint is high and vegetation has been purposefully removed. Within Cluster 4, the only vegetation within campsite areas consists of tamarisk trees, planted for shading and screening purposes. As outlined in section 4.2.3, vegetation islands are considered important for management purposes and so have been included in the vegetation area calculations within this section. However, vegetation islands have been excluded from the data analysis within the impact indices (section 4.4.7) to render this study comparable with the international literature.



Graph 8.4. A Comparison of Campsite Area, Vegetation Area, and Barren Core Area.

Plate 8.7 A campsite with a small Campsite Area, , Cluster 4

Plate 8.8 A campsite with a large Campsite Area, Cluster 2

Figure 8.5. Examples of Campsites with large and small Campsite Areas.

8.4.2 Litter and Human Waste

8.4.2.1 Litter Audit

There were two components to the litter audit. The first was measured with other indicators as part of the impact assessment process. This measurement comprised the number of small and large litter items found in each campsite and campsite perimeter. The second component of the audit was an independent litter audit whereby litter was collected opportunistically from campsites and campsite perimeters across all four clusters. The amount of individual litter items was not recorded but the type of litter was recorded as per the Clean Coast Index as described in 4.4.6.2.2.

Litter items smaller than 5 cm were located predominantly at Clusters 2 and 4 (*Figure 8.6*). These comprised mostly miscellaneous small plastic items (Cluster 2) and cigarette butts (Cluster 4).

Figure 8.6. Litter at Campsite, Cluster 2.

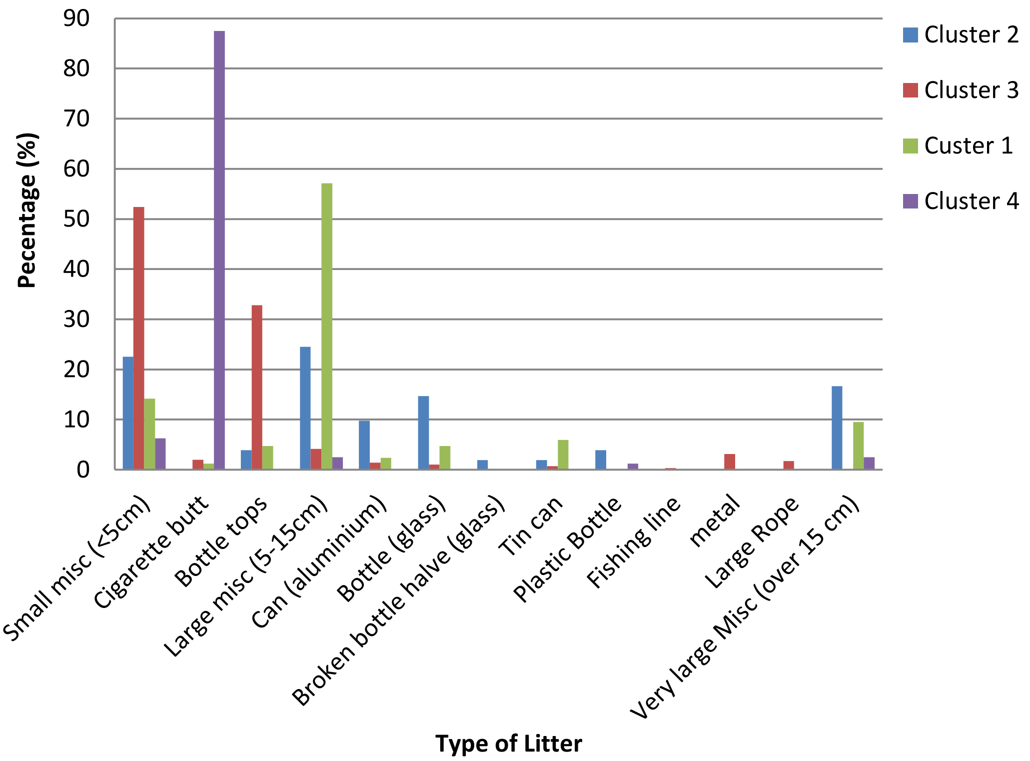
Litter items over 5cm were collected from Clusters 1 and 2. These miscellaneous items consisted of plastic and packaging. Cluster 4, which has a higher level of use than the other clusters, had large amounts of small litter (*Table 8.11* and *Graph 8.5*).

Table 8.11

Litter for each Cluster, both on Campsite and Perimeter Mean ± SD.

Cluster	**1**	**2**	**3**	**4**	**Average**	**Significance for 2-tailed ANOVA ($p \leq .05$)**
Campsite						
Litter <5cm	1.89 ± 4.09	3.74± 11.917	2.55± 2.99	5.14± 8.49	3.36± 8.455	.295 (NS)
Litter >5cm	2.06± 4.388	3.06± 7.904	0.59± 1.255	0.38± 1.098	1.69± 5.28	.010 (S)
Clean Coast Index Categories	1.11± 0.398	1.20± 0.512	1.25± 0.535	1.67± 1.052	1.28± .662	.000 (S)
Campsite Perimeter						
Litter <5cm	0.28± 1.16	2.43± 4.96	1.92± 6.43	0.7143± 3.26	1.92± 5.63	.560 (NS)
Litter >5cm	0.527± 1.71	2.73± 6.06	1.93± 2.92	0.190± 0.671	1.88± 5.81	.020 (S)

(S) = Significant, (NS) = Not Significant.



Graph 8.5. Amount and Type of Litter Items recorded for each Cluster.

Overall, ‘small miscellaneous’ (<5cm) rubbish items were the most common litter type across all clusters (23.8 %), followed by ‘cigarette butts’ (22.65 %) and Large Miscellaneous > 5cm (22.08 %) and ‘bottle tops’ (10.37 %) (*Graph 8.5*, *Figure 8.7* and *Table 8.12*). ‘Very large miscellaneous items’ over 15cm were predominantly found in Clusters 1 and 2, though within Cluster 2 there were differences in rubbish size between management areas. This is related to the presence or absence of caretakers and the stewardship, or lack of stewardship of an area by the campers themselves. Hence in the less regulated regimes larger litter items were more likely to be present. This is despite assumed lower levels of campsite use than at the more regulated sites. Larger items such as the plastic bottles and aluminium cans found in Cluster 1 and 2 were very faded, suggesting that they had been there for many months without being collected and disposed of. Note in *Figure 8.7* the large rubbish present in Cluster 2, the high proportion of bottle caps from Cluster 3 and cigarette butts from Cluster 4. Cluster 1 litter was similar to that from Cluster 2.

Plate 8.9 Litter from Cluster 1

Plate 8.10 Litter from Cluster 2

Plate 8.11 Litter from Cluster 3

Plate 8.12 Litter from Cluster 4

Figure 8.7. Litter Recorded at Different Clusters.

Table 8.12

Percentage of Rubbish Types found in each Management Area.

	Custer 1	**Cluster 2**	**Cluster 3**	**Cluster 4**	**Average for whole sample (*N*)**
Small miscellaneous (<5cm)	14.2	22.5	52.4	6.2	23.8
Cigarette butt	1.2	-	2.0	87.5	22.6
Bottle tops	4.7	3.9	32.8	-	10.3
Large miscellaneous (5-15cm)	57.1	24.5	4.1	2.5	22.1
Can (aluminium)	2.3	9.8	1.4	-	3.4
Bottle (glass)	4.7	14.7	1.0	-	5.1
Broken bottle (glass)	-	1.9	-	-	0.5
Tin can	5.9	1.9	0.7	-	2.1
Plastic Bottle	-	3.9	-	1.2	1.3
Fishing line	-	-	0.3	-	0.1
Metal	-	-	3.1	-	0.8
Large Rope	-	-	1.7	-	0.4
Very large miscellaneous (over 15 cm)	9.52	16.66	-	2.5	7.2

Note: Blank cells represents that the variable specified was not present

8.4.2.2 Toilet paper and Human Waste

As noted in section 3.4.3.2, human waste can be dangerous for both humans and the environment. In Cluster 1, five campsites had toilet paper present within the campsite. There may or may not have also been human waste associated with this toilet paper (*Figure 8.8*). Each site had four pieces each. Cluster 2 had only one campsite which contained toilet paper, of which there were two counts. Cluster 3 contained no traces of toilet paper, while Cluster 4, which also has toilets, had one site at Osprey Bay which contained five counts of toilet paper. This paper may have blown from a nearby camp toilet.

Along the campsite perimeter, Cluster 1 had two sites which contained toilet paper, both of which also contained toilet paper in the campsite. Each of these perimeter sites had a count of eight pieces each. In the Cluster 2 perimeters, six sites contained toilet paper, with an average of 3.5 pieces. Cluster 3 contained no toilet paper in the campsite perimeter area. Cluster 4 however had five sites with toilet paper in the perimeter, each with an average of three counts of toilet paper. In only two instances were human waste recorded; in one site at the Blowholes perimeter and one site at a Cluster 4 Perimeter (Neds Camp).

Plate 8.13 Toilet Paper, Cluster 1

Plate 8.14 Toilet Paper, Cluster 2

Figure 8.8. Evidence of Human Waste.

8.4.3 Social Trails: Number, Width and Depth

Social trail number, width and width sums yielded similar results for each cluster, namely that the most and least regulated sites in Clusters 1 and 4 exhibited less impact than that which was apparent in Clusters 2 and 3 (*Table 8.13* and *Figure 8.9*).

Table 8.13

Social trail Number, Width, Sum of Width and Depth for all Clusters.

Cluster		**1**	**2**	**3**	**4**	**Average**	**Significance for one-way ANOVA (p≤.05)**
Social Trail Number	Mean	1.6± 1.78	2.67± 2.49	2.46± 2.2	1.98± 1.79	2.31± 2.22	.068 (NS)
Width	Mean	60.04± 57.71	71.11± 37.59	65.53± 55.30	43.28± 38.47	62.69± 47.63	.018 (S)
Width Sum	Mean	143.84± 166.00	213.75± 256.90	205.61± 213.15	121.57± 117.12	183.04± 197.93	.039(S)
Depth	Mean	2.42± 6.69	2.52± 3.96	1.02± 1.33	2.09± 5.04	2.0± 4.27	.177 (NS)

(S) = Significant, (NS) = Not Significant.

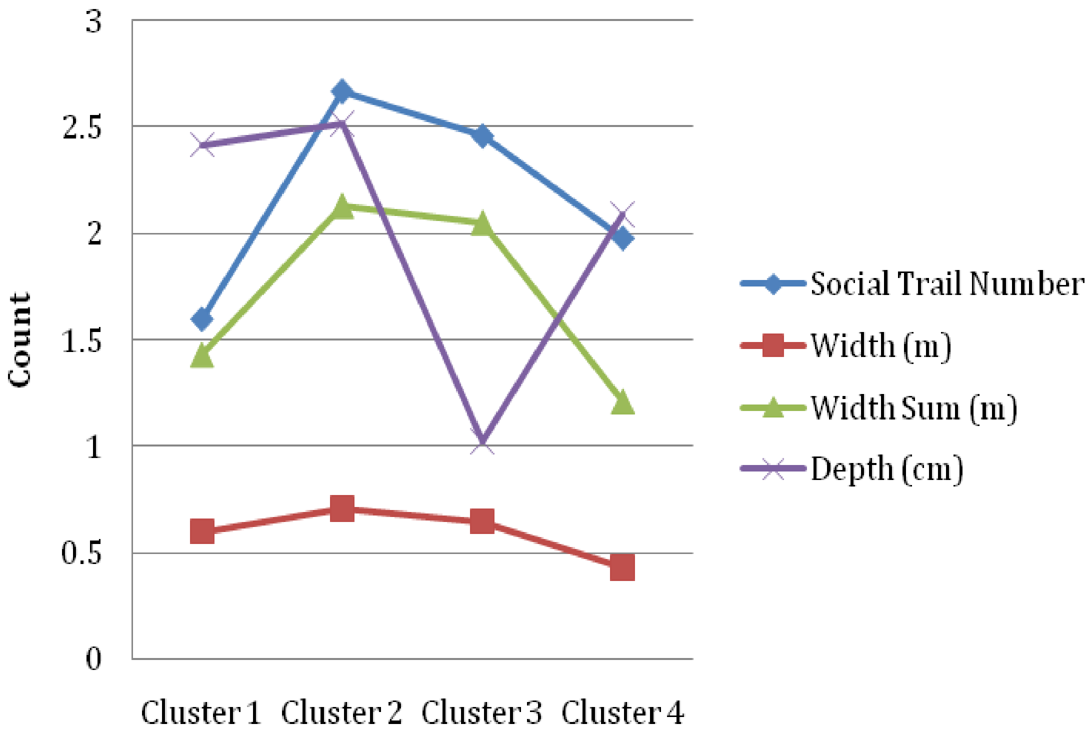


Figure 8.9. Social trail number, Sum of Social Trail Width, and Social Trail Depth across Clusters.

The cluster with the most damage from three of the values for social trails was Cluster 2. This may be because Cluster 1 presumably has a lower density of campers, while Cluster 4 receives large numbers but also has site hardening strategies in place. Clusters 2 and 3 receive large numbers of visitors without the level of site hardening undertaken in Cluster 4. Additionally it is more common to see goats and sheep in Clusters 2 and 3, and they can contribute to or instigate some social trails. Cluster 4 has on average 1.98 social trails per site, but with a maximum of only five, while Clusters 2 and 3 have only slightly higher average social trail numbers (2.67 and 2.46 respectively) yet maximum numbers of ten and twelve respectively.

For the widths and sums of widths, Cluster 4 has the lowest average and maximum number for both. This suggests that social trails in this cluster are managed through rehabilitation or closing (as seen in Yardie Creek) before they spread. For example, the widest social trail within Cluster 4 is 140cm, while in all other clusters they range between 182 and 200 cm in width (*Figure 8.10*). Efforts to keep visitors within trail width boundaries can be seen at Blowholes, through strategically placed tyres, and at Yardie Creek, through boardwalks. One of the newest campsites at Cluster 4 (Kurrajong) has a higher intensity of hardened trails.

The depth of the social trail may predetermine of anthropogenic-related soil erosion. Cluster 2 had the largest average depth (2.52 cm) while Cluster 4 had the largest maximum depth (7.13 cm). Cluster 3 had the smallest overall depth probably due to the hard, limestone-based substrates which are less prone to erosion. However while these sites were not included in the sample, a few visible signs of sand erosion of campsites in sandier dunal areas to the west at Gnaraloo were visible. It was clear across all clusters that a few samples recorded large depths. These slightly skewed the averages but brought to light instances where there were some erosion challenges.

Plate 8.15 Cluster 1, Trails over Campsite to Ocean

Plate 8.16 Cluster 2, Trails to Viewpoint (Dune Blowout)

Plate 8.17 Cluster 3, Trails between Neighbouring Campsites

Plate 8.18 Cluster 4, Trails to Ocean

Figure 8.10. Social Trails at Different Clusters.

8.4.4 Vegetation Damage

No significant differences in vegetation health between the clusters existed for grasses, small shrubs or large shrubs. However, significant differences existed for the health of spinifex, saltbush, small trees and large trees (*Table 8.14*). These differences may reflect different behaviours or group sizes of campers who inflict different levels of stress on these vegetation types. Only those campsites which had vegetation within their campsite area were included in the analysis. This is because the focus was on the health of the vegetation for the purpose of understanding the resilience of different plant species, not its presence or absence. Clusters 3 and 4 had a large management footprint, including campsite hardening, which would have skewed results had all sites been included.

The average damage for each campsite, incorporating all plant species, was also calculated. These averages were significantly different across the clusters (p = .01), despite them all falling within the same average category with regard to damage (10-30 % damage). Categories of damage were derived from the original onsite data sheet.

The vegetation types that experienced the least damage overall, for all clusters, were saltbush, small shrubs, large shrubs and large trees (only 0-10 % damaged). Those vegetation types which exhibited the most damage were grasses and spinifex (*Figure 8.11*). This suggests that, for recolonisation, larger plants, once established, may be more resilient to recreation impacts.

Plate 8.19 Damaged Spinifex within the campsite area, Cluster 2

Plate 8.20 Saltbush damage around campsite border, with vehicle tyre mark within shot

Figure 8.11. Vegetation Damage to both Grass and Spinifex.

Table 8.14

Vegetation Damage (%) for Different Vegetation Types within the Campsite Area.

	Grass	**Spinifex**	**Saltbush**	**Small Shrub**	**Large Shrub**	**Small Tree**	**Large Tree**
Cluster 1	30-60	30-60	0-10	0-10	0-10	10-30	0-10
Cluster 2	30-60	10-30	0-10	0-10	10-30	-	-
Cluster 3	30-60	10-30	10-30	0-10	0-10	0-10	0-10
Cluster 4	30-60	-	10-30	10-30	-	10-30	-
Significance for Pearson Chi-Square ($p \leq .05$)	.205 (NS)	.000 (S)	.044 (S)	.631 (NS)	.844 (NS)	.003 (S)	.004 (S)

(S) = Significant, (NS) = Not Significant

Note: Blank cells represents that the variable specified was not present

The average level of plant damage was calculated for the perimeter of each campsite. The average damage levels were significantly different across the clusters (p = .05). The cluster with the highest perimeter vegetation damage value was Cluster 4 (10-30 % damage on average). Clusters, 2 and 3 both had the same perimeter vegetation damage of 0-10 %. When comparing perimeter damage across the clusters, two vegetation types, Grass and Spinifex, exhibited significant differences (*Table 8.15*). The damage to saltbush, small shrubs, large shrubs, small trees and large trees did not exhibit significant differences between the clusters.

The perimeter vegetation type with the most vegetation damage was salt bush, followed by grasses and spinifex (*Table 8.15*). Salt bush is characteristically located adjacent to campsites within the primary dune, nearest to the ocean. It is highly susceptible to damage and as such is not present within those campsite areas which often comprise a barren core area only with no vegetation. The vegetation types which incurred less damage on campsite perimeters are small trees, large shrubs and large trees, as was the case within campsites. Native species of these larger vegetation types are therefore recommended for more long-term regeneration strategies.

Table 8.15

Vegetation Damage (%) for Different Vegetation Types within the Campsite Perimeter.

Cluster	Grass	Spinifex	Saltbush	Small Shrub	Large Shrub	Small Tree	Large Tree
1	10-30	10-30	0-10	0-10	0-10	0-10	0-10
2	0-10	0-10	30-60	0-10	0-10	-	0-10
3	10-30	10-30	0-10	0-10	0-10	0-10	0-10
4	10-30	10-30	0-10	10-30	0-10	0-10	0-10
Significance for Pearson Chi-square ($p \leq .05$)	.000 (S)	.000 (S)	.069 (NS)	.561 (NS)	.197 (NS)	.055 (NS)	.174 (NS)

(S) = Significant, (NS) = Not Significant.
Note: Blank cells represents that the variable specified was not present

8.5 IMPACT INDICES

8.5.1 Percentage Cover and Percentage Cover Loss

8.5.1.1 Vegetation percentage cover

Percentage vegetation cover, for both grasses and shrubs, was compared across the clusters for campsite area, campsite perimeter and campsite boundary. The campsite boundary is also considered as a control area for this study since few suitable control areas exist away from the campsites due to the long term pastoral use of land. Values were calculated through median values of the cover classes (Monz and Twardock 2010) for campsite, perimeter and boundary as documented in the methods (section 4.4.7.1). Significant differences existed between the clusters for all categories with the exception of 'shrubs within campsite areas' (*Table 8.16*). For all clusters, the boundaries contained the most vegetation, followed by the perimeter and finally the campsite area, which contains the least vegetation. This was to be expected and supports the argument of (Hammitt and Cole 1998) that campsites fall into these three distinct categories of impact. For all clusters, the campsite areas contain on average 50 % less vegetation cover than do the boundary areas, which are located two to five metres from the campsite area border.

When the clusters were combined into one data set (N = 225), almost twice the amount of shrubs than grasses were present in the boundary areas (61.15 % compared with 38.68 %) and perimeters (45.19 % compared with 29.35 %). The campsite areas had similar amounts of shrubs and grasses, containing 8.41 % and 10.71 % respectively. This indicates that the more disturbed an area of land, the more likely it is to be recolonised by grasses as documented in the literature (McHarg 1992).

Table 8.16

Vegetation Percentage Cover for Campsite, Perimeter and Boundary Areas.

Cluster		**1**	**2**	**3**	**4**	**Significance for Pearson Chi-square ($p \leq .05$)**
Grasses	Campsite	16.04	12.47	5.93	8.41	.006 (S)
	Perimeter	44.02	19.84	30.41	23.13	.000 (S)
	Boundary	54.86	21.46	45.53	32.90	.000 (S)
Shrubs	Campsite	10.45	11.02	7.67	4.5	.221 (NS)
	Perimeter	43.25	56.19	39.14	42.19	.001 (S)
	Boundary	59.94	75.09	47.6	61.79	.000 (S)

(S) = Significant, (NS) = Not Significant.

8.5.1.2 Percentage Cover Loss

Percentage cover loss is a common impact indicator (Monz and Twardock 2010), which is calculated by subtracting vegetation cover levels in the campsite areas from those of the boundary areas. Percentage cover loss was calculated between both the boundary and campsite, and boundary and perimeter for shrub, grass and combined shrub and grass vegetation categories.

Vegetation percentage cover loss was calculated for both grasses and shrubs to assess the resilience of each (*Table 8.17* and *Graph 8.6*). As with vegetation cover, significant differences existed between the clusters for all of these categories with the exception of vegetation percentage loss between perimeter and boundary for shrub species.

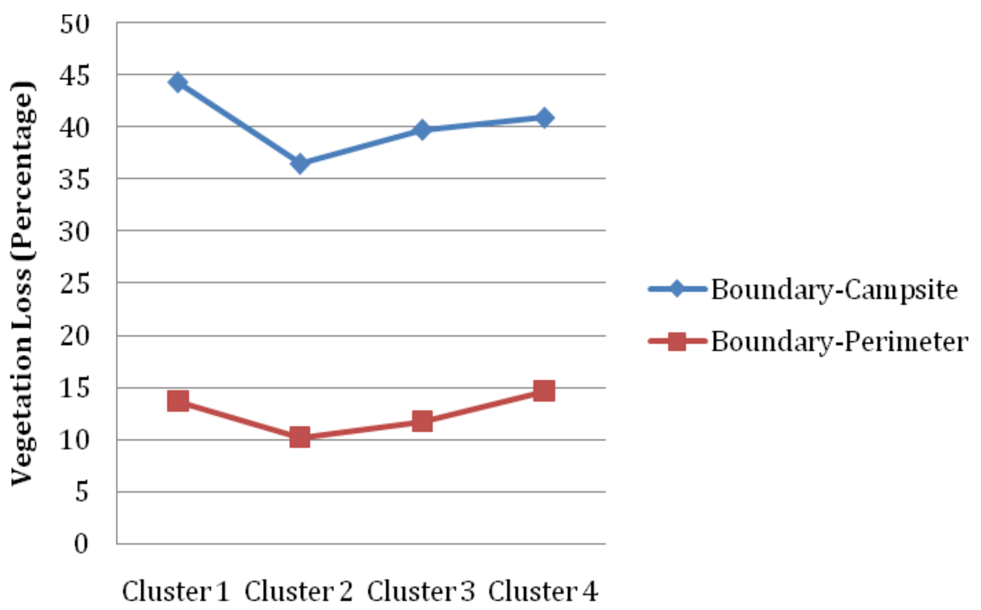
The presence of a high level of vegetation cover difference between a campsite's perimeter and its boundary suggests that campsite expansion may be occurring. For all clusters vegetation on the perimeter comprises between half and three quarters of that in the boundary, despite campsite borders being put in place in Clusters 3 and 4. However, these clusters also experience a higher number of year-round visitors. When the clusters were combined into one data set (N = 225), the data suggest that there is greater vegetation loss for bushes than for grasses between both campsite and boundary (27.97 % for grasses; 52.66 % for shrubs) and perimeter and boundary calculations (9.33 % for grasses; 15.91 % for shrubs). This is likely to occur because, as campsite areas are disturbed, shrubs and native vegetation are replaced by grass species.

Table 8.17

Percentage of Vegetation Cover Loss between Boundary Areas and both Campsite Areas and Campsite Perimeters.

Cluster		**1**	**2**	**3**	**4**	**Average loss**	**Significance for Pearson Chi-square ($p \leq .01$)**
Boundary-Campsite							
	Grasses	39.1	8.99	39.59	24.48	27.97	.000 (S)
	Shrubs	49.48	64.0	39.9	57.29	52.66	.000 (S)
Boundary-Perimeter							
	Grasses	10.84	1.62	15.12	9.77	9.33	.000 (S)
	Shrubs	16.69	18.9	8.46	19.6	15.91	.120 (NS)

(S) = Significant, (NS) = Not Significant.



Graph 8.6. Percentage Vegetation Loss between Campsite Area and Boundary, and Perimeter and Boundary.

8.5.2 Coastal Vegetation Loss and Area of Coastal Vegetation Loss

Coastal Vegetation Loss (CVL) was between 44.60 % (Cluster 3) and 53.93 % (Cluster 1), while Area of Coastal Vegetation Loss (ACVL) was between 41.38 m^2, (Cluster 4) and 179.19 m^2 (Cluster 1) (*Table 8.18*). This indicates that not only are campsite areas larger in the lesser regulated clusters; they also have higher absolute and relative vegetation loss per campsite when compared with the more regulated areas.

Table 8.18:

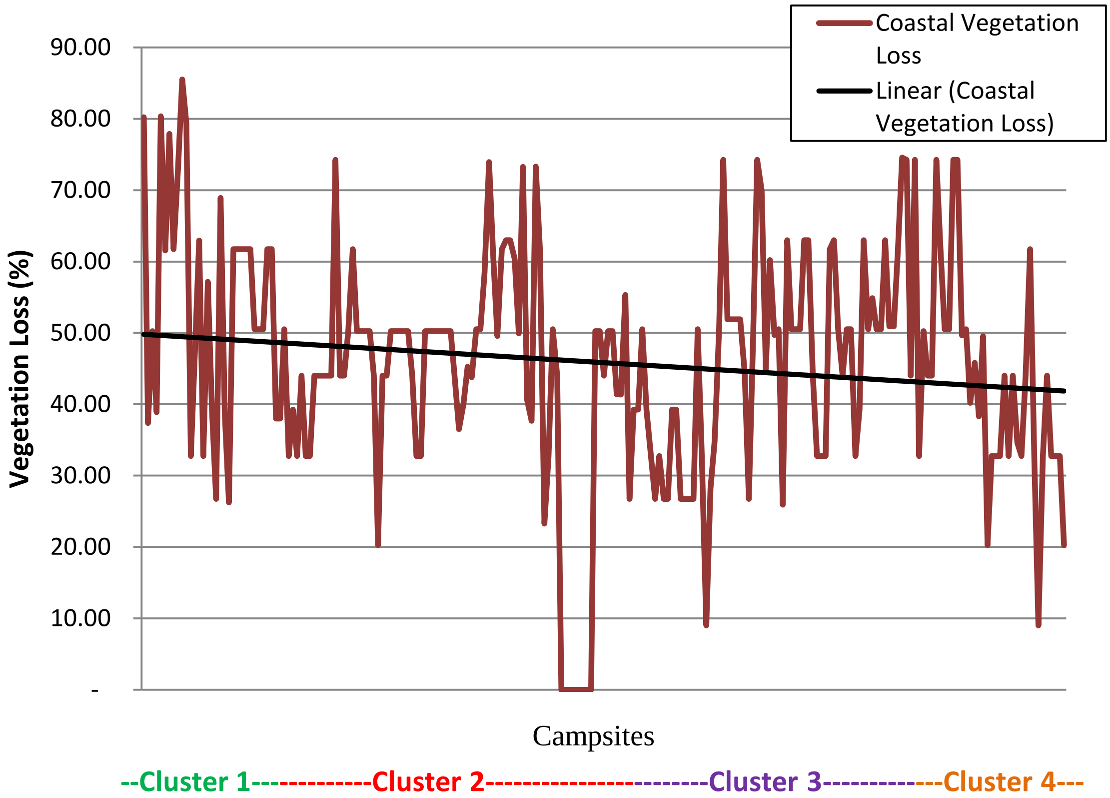
Coastal Vegetation Loss and Area of Coastal Vegetation Loss for all Clusters.

Cluster	**1**	**2**	**3**	**4**	**Mean**	**Significance for one-way ANOVA ($p \leq .01$)**	**Correlation (r) ($p \leq .05$)**
Coastal Vegetation Loss (%)	53.93 ± 16.4	46.96 ± 10.1	44.60 ± 13.7	45.48 ± 16.0	47.13 ± 13.7	.008 (S)	-.180 (S)
Area of Coastal Vegetation Loss (m)	176.19 ± 179.2	84.21 ± 63.3	74.27 ± 71.9	41.38 ± 18.8)	88.1 ± 98.6	.000 (S)	-.371(S)

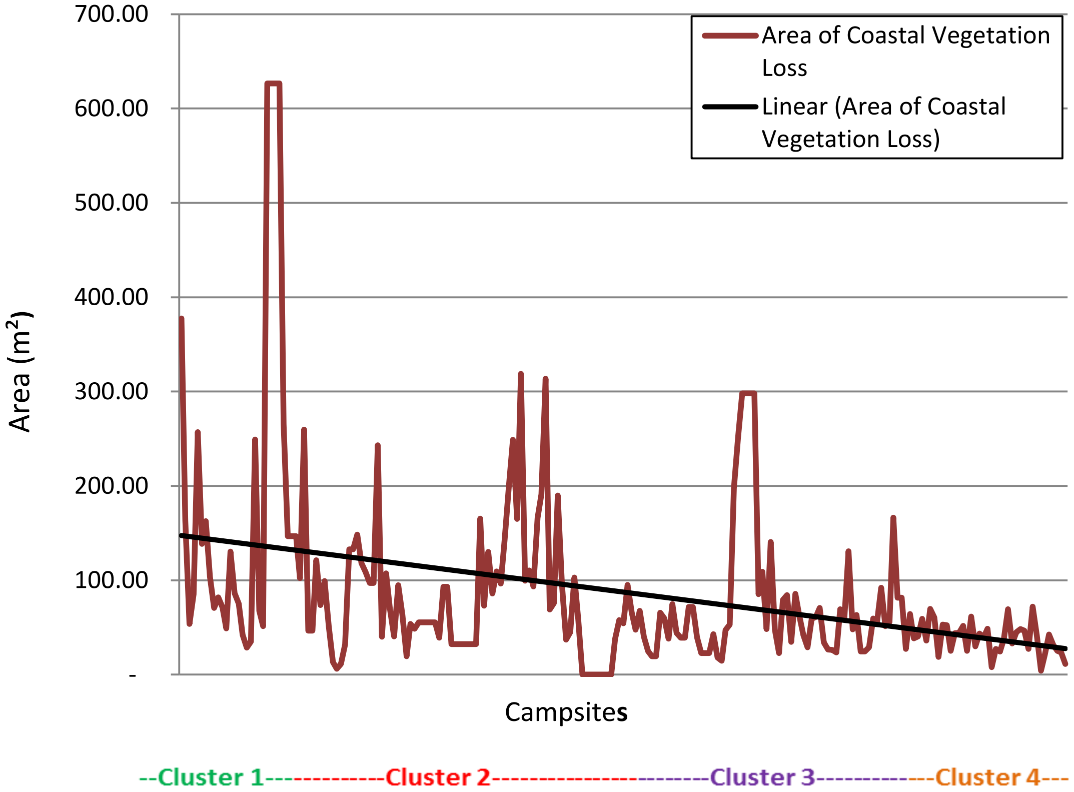
(S) = Significant (NS) = Not Significant

A significant negative correlation exists for both CVL and ACVL when these are compared across the clusters (*Graph 8.7* and *Graph 8.8*). This indicates that damage decreases as cluster number (and therefore regulation) increases. These findings align with those from other literature comparing designated with undesignated campsite areas (Smith 2003) and this is an important finding for management purposes along the Ningaloo coast given the contentious issues surrounding regulation and camping rights. Additionally, these findings reject the null hypothesis that no difference exist between the clusters/management regimes with regard to adverse environmental impacts.

CVL was between 44.60 % (Cluster 3) and 53.93 % (Cluster 1), while ACVL was between 41.38 m^2 (Cluster 4) and 179.19 m^2 (Cluster 1). Camp area size is therefore a strong predictor of absolute damaged area and is therefore an important factor for managers to consider.



Graph 8.7. Relationship between Coastal Vegetation Loss (CVL) and Increasing Regulation (r = - .180).



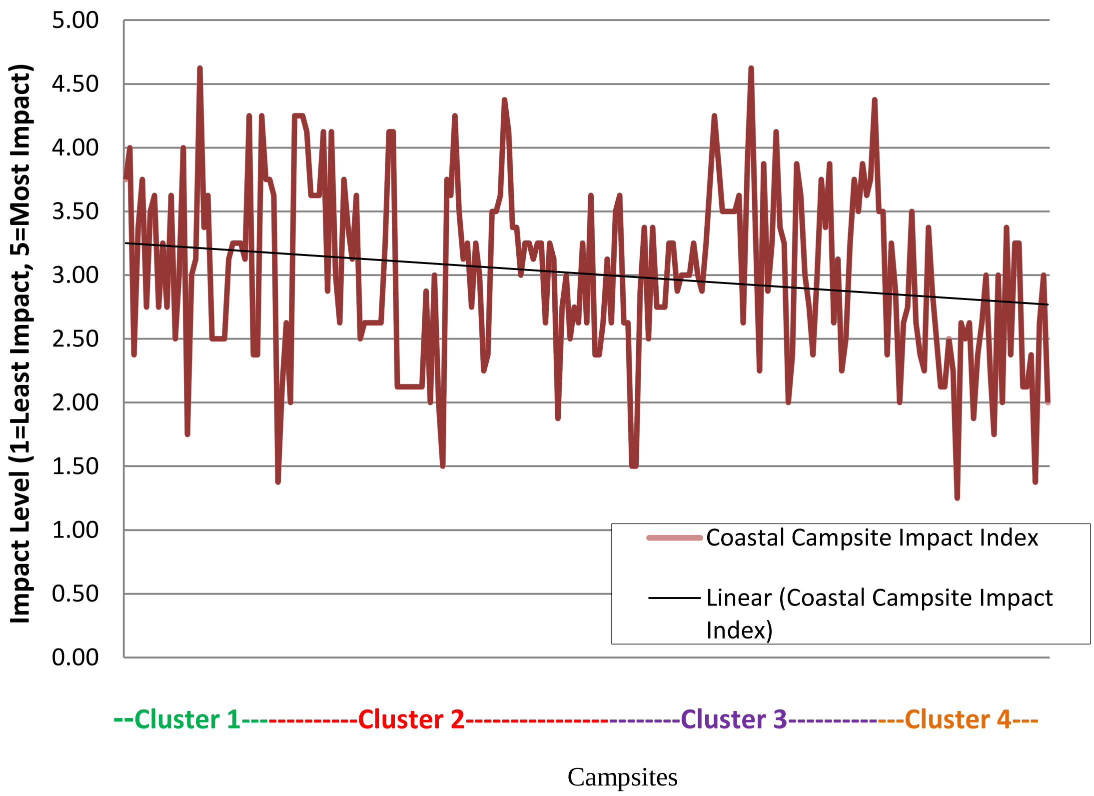
Graph 8.8. Relationship between Area of Coastal Vegetation Loss (ACVL) and Increasing Regulation (r = - .371).

8.5.3 Coastal Campsite Impact Index

The Coastal Campsite Impact Index (CCII) sums the impact results per campsite. These were then calculated for each cluster (the methods used for this are contained in section 4.4.7.3). Each campsite was rated between 1 and 5, with 5 reflecting the highest impacts. The environmental impacts across clusters, like those for the campsite preferences, produced two levels of findings; the overall findings when clusters are compared against each other and the findings on what could be improved for each cluster.

When the clusters were compared against each other, a highly significant (p = .01) negative correlation (r = -.227) was found (Graph 8.9) when the impact values for each campsite were correlated against the clusters This suggests that, as was found for the indices of CVL and ACVL (section 8.5.2), the overall environmental impact also decreases as management intervention increases. As with the findings from section 8.5.2, these findings are important for the Ningaloo coast from both political and policy perspectives. In addition they add to our knowledge of the environmental impacts of camping in coastal areas from an international perspective.

Cluster 4 experienced the least impact (2.55 out of 5 on impact index scale). This was followed by Cluster 2 (3.02), Cluster 3 (3.18) and Cluster 1 (3.20). While Cluster 4 experienced the least overall impact at its campsites, the scores for Clusters 1, 2 and 3 were similar. In fact, a Bonferroni post hoc test revealed that only Cluster 4 was significantly different (p = .000) from the other clusters (*Table 8.19*), and that Clusters 1, 2 and 3 were not significantly different from each other.



Graph 8.9. Relationship between Coastal Campsite Impact Index and Increasing Regulation (r = - .227).

Table 8.19

Mean CCII Impact Values ± SE for each Cluster.

	Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**	**Significance for one-way ANOVA (p≤.05)**	**Correlation (r)**
Camp Area (m^2)	3.88± .202	3.14± .161	2.89± .169	1.97± .142	.000 (S)	-.368 (S)
Barren Core Area (m^2)	3.13± .287	2.95± .167	3.31± .155	2.50± .149	.031(S)	-.129 (NS)
Coastal Vegetation Loss (I)	3.61± 262	2.65± .122	2.85± .190	2.64± .242	.005 (S)	-.181 (S)
Vegetation Damage (Perimeter)	3.44± .208	2.71± .172	3.37± .156	3.76± 1.461	.000 (S)	.150 (S)
Fire Pits (count)	3.77± .195	2.89 .136	3.34± .097	1.00± .000	.000 (S)	-.496 (S)
Social Trail Number (Count)	2.88± .251	3.55± .127	3.35± .182	3.11± .248	.860 (NS)	.015 (NS)
Sum Social Trail Widths (cm)	2.69± .263	3.22± .141	3.10± .191	2.57± .202	.047 (S)	-.053 (NS)
Litter, small and large (weighted)(count)	2.16± .259	3.03± .171	3.26± .156	2.83± .235	.004 (S)	-.013 (NS)

Although a significant correlation was found between the clusters indicating that those clusters with more regulation experienced lessened environmental impacts, both campsites which displayed high impact index ratings (over 4.0) and low impact ratings (less than 2.0) existed in all clusters (*Graph 8.9*). The impact values for individual campsites ranged from 1.25 to 4.63 (with 1 being less impacted, 5 being more impacted). The majority of sites scored between 2.0 and 2.99 (n = 91) or 3.0 to 3.99 (n = 104). There were no sites which scored 5.0 to 5.99, which was considered to be severely impacted.

Only ten sites scored 1.0 to 1.99, reflecting a very low impact. All clusters were represented in this category including one from Cluster 1, three from Cluster 2, two from Cluster 3 and four from Cluster 4 (*Figure 8.12*). Twenty sites scored 4.0 and over. The most impacted ten sites ranged from 4.25 to 4.65 and were found in Clusters 1, 2 and 3 only (*Figure 8.13*).

Plate 8.21 Low-impacted site, Cluster 2

Plate 8.22 Low-impacted site, Cluster 3

Plate 8.23 Low-impacted site, Cluster 4

Plate 8.24 Low-impacted site, Cluster 1

Figure 8.12. Examples of Campsites with Low Impact Indices for each Cluster.

Plate 8.25 High-impacted site, Cluster 3

Plate 8.26 High-impacted site, Cluster 4

Plate 8.27 High-impacted site, Cluster 1

Plate 8.28 High-impacted site, Cluster 2

Figure 8.13. Examples of Campsites with High CCII, for each Cluster.

8.6 SUMMARY OF RESULTS

This chapter has explored the differences between management regimes/clusters with regard to inventory variables, impact variables and impact indices in order to test the null hypothesis that there is no significant difference between the clusters with regard to campsite impacts. Significant differences were found across the clusters for all three impact categories (*Table 8.20*), thereby disproving the null hypothesis.

Significant differences existed for four of the eight individual impact variables which had no correlation between clusters. This means that an increase in regulation does not correspond with an increase in impact for these variables. These variables were barren core area, social trail number, social trail width, and litter. This suggests that even clusters which have higher regulation have greater impacts for some variables than do the lesser regulated clusters, possibly because of increased patronage.

The findings from the three indices (CVL, ACVL and CCII) supported the null hypothesis through strong correlations between regulation level and campsite impact. For these indices, the adverse environmental impacts decreased as regulation increased. Additionally, half the impact variables which comprised the impact indices (campsite area, vegetation loss, vegetation damage and number of fire pits) also correlated with regulation level, with the former three increasing with increased regulation and number of fire pits decreasing with increased regulation.

Table 8.20

Significant Differences of Impact Assessment Variables between Clusters

(✓ = significantly different)

Inventory				
	Camp area	✓	Distance to closest campsite	✓
	Barren Core Area	✓	Number of campsites in a 50m radius	✓
	Substrate	✓	Number of campsites in one Barren core area	✓
	Distance to the ocean		Access (road quality)	✓
Facilities				
	Permanent fire pit	✓	Garbage Bin	✓
	Drop toilet	✓	Rubbish Tip	✓
	Sewerage disposal	✓		
Vegetation Type present – Campsite				
	Grass	✓	Large Shrub	✓
	Spinifex	✓	Small tree	
	Saltbush	✓	Large Tree	
	Small Shrub			
Vegetation Type present – Campsite damage				
	Grass		Large Shrub	
	Spinifex		Small tree	
	Saltbush		Large Tree	
	Small Shrub			
Vegetation Type present – Perimeter				
	Grass	✓	Large Shrub	
	Spinifex	✓	Small tree	✓
	Saltbush	✓	Large Tree	
	Small Shrub			
Vegetation Damage - Perimeter				
	Grass		Large Shrub	
	Spinifex	✓	Small tree	
	Saltbush		Large Tree	✓
	Small Shrub			
Social Trails and Litter				
	Litter small		Social Trail Number	
	Litter large	✓	Social Trail Width	✓
			Social Trail Depth	
Indices				
	Coastal Vegetation Loss	✓	Coastal Campsite Impact Index	✓
	Area of Coastal Vegetation Loss	✓		

8.7 DISCUSSION AND CONCLUSION

This chapter explored the differences between management regimes/clusters with regard to inventory variables, impact variables and impact indices to test the null hypothesis that no significant differences in environmental impact exist between the clusters. Significant differences were found across the clusters with regard to inventory variables, impact variables (*Table 8.20*, above) and impact indices, thereby rejecting the null hypothesis.

However, as in the preferences chapter, two different levels of results were found. First, these results show that an increase in cluster number/regulation level does coincide with a decrease in adverse environmental impacts. Whether this is due to management actions or other independent variables will be explored in the next chapter (Chapter 9:). It was also identified that the camping regimes in all the clusters have individual strengths and weaknesses when compared against each other, for a number of different impact variables. That is, no one cluster was found to have the lowest value for all impact indices (*Table 8.19*). These strengths and weaknesses are discussed below organised by impact indictors and broken into three components: Area disturbance; vegetation damage and; social impacts (Leung and Marion 1999; Smith 2003) (*Table 8.21*). Both levels of findings identify impacts specific to certain management locales, which support the basis for this chapters' argument that understanding the impacts as site-specific and associated with management regimes places responsibility for impacts with management rather than individual campers.

Table 8.21

Three Components of Impact Variables.

Adapted from Leung and Marion (1999) and later Smith (2003)

Component	Impacts Covering	Description
Area Disturbance	Campsite area	Camp area, potential campsite expansion and proliferation
	Vegetation Loss	
	Social trails	
Vegetation damage By campers	Vegetation vigour	The level of on-site disturbance by trampling and vehicles
Social impacts	Litter	Depreciative visitor behaviour

8.7.1 Area Disturbance and Campsite Expansion

8.7.1.1 Camp Area Size

The area affected by camping is one of the common and obvious measures of impact (Cole 1989). As indicated in sections 8.4.1 and 8.5.2, campsite area, Coastal Vegetation Loss (CVL) and Area of Coastal Vegetation Loss (ACVL) decrease as the cluster number increases. The strongest correlations were those between undesignated sites and vegetation loss, common for larger campsites. Camp area size is therefore a predictor of absolute damaged area and is therefore very important factor for managers to consider. This is likely the result of a combination of four-wheel drive vehicle use, lack of campsite barriers and fragile dune vegetation. This suggests that a higher management presence reduces the chances of campsite expansion through vegetation disturbance.

Accurate measurements of campsites in Clusters 1 and 2 were however limited the lack of campsite boundaries which defined the campsite area in Clusters 3 and 4. Without formal campsite boundaries, approximations had to be made regarding the area taken up by each campsite. This was most difficult on campsites containing buffel grass which had received little use in the summer period prior to the field surveys, and as such a barren core area was no longer present (primarily overflow sites at Bruboodjoo on Cardabia station). Also, as surveys were conducted in March, before the busy winter tourism season, fewer campers mean they camped further apart. Therefore these sites were often measured as larger than those with defined boundaries, or than they may have been measured in peak tourism season when camps may have been closer together at periods.

Cluster 4 does have the largest average number of campers in one barren core area (5.33) when compared to the lowest (Cluster 3, 1.95 per site) and the lowest average distance to the closest campsite (7.5m) Due to this ‘management footprint’, the amount of on-site vegetation is the lowest of all clusters, averaging only 6.8 % of the total campsite area. This suggests that, even with site hardening techniques, campsite expansion can still be limited despite an increase in the number of visitors. However, Cluster 4 also has the highest amount of vegetation loss between the campsite boundary and perimeter areas (See the section on Vegetation Cover Loss

4.4.7.1). That is, the areas extending beyond the campsite barriers are often highly disturbed. So, although the campsite area may be restricted by formal boundaries, damage can still spread into perimeter areas if campers choose to ignore these boundaries. Additionally, the lack of vegetation around the perimeter may be another feature of the site hardening procedures if the campsites are close together and the site hardening spreads beyond the campsite itself. However, disturbance by campers past the boundary is the most likely reason behind vegetation loss in the perimeters of the campsite areas. The perimeter damage overall was worst for Cluster 4 due to the large numbers of visitors to NMP who also camped. Despite restrictions such as wooden campsite barriers, many visitors stepped over their boundaries or stored gear outside the campsite areas. This greater perimeter damage in Cluster 4 is likely to be due to higher visitation levels owing to this area's easier access and greater provision of facilities. Cluster 4 also experiences less respite in the off-seasons due to these reasons. Cape Range has a much greater level of use in summer than do most of the other sites, Gnaraloo being the only significant exception.

Cluster 1, the least managed and regulated cluster, is characterised by having the highest values for campsite area, absolute vegetation area loss and absolute percentage loss. Campsite areas are likely to be large in this cluster due to the prevalence of campsites which have no boundaries, the low management presence and the high use of four-wheel drive vehicles. Within the literature this form of transport is said to be the most destructive of all access options, and to encourage campsite expansion (Newsome, Moore et al. 2002). Tyres come very close to vegetation which makes it expand further, and frequently drivers will just run over vegetation (for example at the Blowholes management area), or remove the whole front section of dunes (for example at the beach on Fourteen Mile). Cluster 2 had the second highest ranking for vegetation loss, absolute area loss and campsite area. As with Cluster 1, this may result from the lack of campsite boundaries, an issue further analysed in Chapter 9.

The campsite area average for Cluster 1 was 309.67 m^2, as compared to the Cluster 4 average of 91.4 m^2. Even this latter measurement is considered very large when compared to data from international studies. For example, in a campsite class system developed by Parsons (1980; Parsons and Stohlgren 1987), the largest campsite Class (5) is greater than 93 m^2. The large sizes of coastal campsites in semi-arid regions have been noted before (Monz 1998), with the average coastal campsite in Prince William Sound (Alaska) recorded at 28.0 $m^{2.}$ At Baja the average was 63.0 m^2, with the largest campsite size being 377 m^2. As at the Ningaloo campsites, the Baja sites contained 'initially sparse vegetation, sandy soils and dispersed campsites' (Monz 1998, p.120). This explains the large area of these campsites in comparison to those in more alpine locations. In semi-arid locations, the borders of campsites are far less distinct and thus 'campers may tend to drift to the borders of these sites or to new areas and, therefore, the potential for increasing the size and number of campsites is high.' (Monz 1998, p. 121).

The large sizes of campsites in less regulated clusters at Ningaloo are largely attributable to the use of four-wheel drive vehicles for campsite access. Bunning (2008) also noted the wide-scale impact of four wheel-drive use in the region. If it is the intention of policy and management in the region that the Ningaloo coast is accessible to visitors then four-wheel drives will be a permanent placement along the Ningaloo coast. Hardening sites around camp areas may encourage larger numbers of additional visitors. Regulation through larger numbers of camp hosts and a campsite numbering system like at Warroora may be a good solution in the interim to reduce impacts caused by four-wheel drive vehicles.

Campsites in coastal environments are therefore more prone to expansion and, as such, campsite boundaries should be defined as part of a site hardening process, as has been shown to be effective within Cape Range National Park (Cluster 4). Indeed, many of the less-impacted campsites identified through the Coastal Campsite Impact Index (CCII) had small campsite areas. Though these campsites did not always possess campsite barriers, they were always identified as an individual campsite though labelling provided by managers. Campsites with a low impact index were also often orientated in a way that facilitated easy access to their destinations, such as bathrooms and the ocean, without the need for additional social trails.

One important consideration within this study is that these lands have already been heavily impacted through pastoral use and their degradation may therefore not be a factor of visitor use at all. As discussed in section 2.4.2, this environment has already been highly influenced by pastoralism, as have many remote regions within Australia which are now receiving increased visitation, such as the Canning Stock Route. For example, many campsites exhibit high environmental impacts because they were vegetated with invasive buffel grass, which is not as hardy as native vegetation. Social trails may be expanded and additional trails created by livestock roaming through the campsites. Pastoralism is a common factor on the Ningaloo coast so some impact differences could be attributed to other variables unless there are significant differences in livestock type and density and length of grazing history. While Cluster 4 now has fewer sheep and goats than do the stations that comprise the other clusters, it was under pastoral use for more than a century. Even so, it may be possible to differentiate between camper impacts and those of livestock. Managers should therefore revegetate using natives and not buffell grass and the removal of goats from camping areas is of paramount importance. It is argued that pastoralism is a common factor to all clusters and, as such, the impact differences between the clusters are more likely to be attributable to factors other than pastoralism

8.7.1.2 Social Trails

For both the social trail number and social trail width, Cluster 4 had the lowest values despite having the highest year-round visitor use. This suggests that a higher management presence reduces the chances of campsite expansion though limiting both the width and the number of social trails. However, as with the challenge presented with assessing campsite area size in arid environments as discussed above (section 8.7.1.1), bias may have resulted when assessing social trails existing within different vegetation types due to changes in vegetation density. As grasses were fairly dense, social trail number and width could be measured accurately whilst for small shrubs with sandy substrates in coastal dunes, social trail widths were less defined as the shrubs were sparser. Hence widths in dunal areas may be wider than if they were measured in campsites predominated by grasses.

The existence of social trails may indicate that pre-existing paths were not located in an optimal location for visitors. Social trails may also be a precursor to campsite expansion. It was outlined in the results that Cluster 4 has on average 1.9 social trails per site, but with a maximum of only 5.0, while Clusters 2 and 3 have only slightly higher average social trail numbers (2.7 and 2.5 respectively) yet they have a maxima number of ten and twelve trails per site respectively. This shows that campsites within Cluster 4 have a small number of social trails while, in the other clusters, a few sites have a high number which skews their means. Those sites in Clusters 2 and 3 which contain large numbers of social trails are often located in dunal areas with low, sparse saltbush and small shrubs. The campsite areas and the previously created social trails are not well defined in this vegetation type and new trails are frequently created. The lack of ground cover and the sandy soil mean that the trails do not revegetate. Social trails are also created across different terrains and through different vegetation types and substrates along the Ningaloo coast. For example, multiple trails run up rocky outcrops at Red Bluff, or through thick dune thistle at Blowholes.

Goats are farmed on some stations and are most apparent in Cluster 3. As mentioned previously (section 2.3), it is common for goats and livestock to walk through campsites, especially during drought situations when goats come to the coast to access freshwater springs. While rocks and rope barriers reduce campsite expansion in Cluster 3, they still allow movement through the campsites for goats. Many small trails winding up Red Bluff are primarily created and utilised by goats. When looking at a control site to the south of Gnaraloo dominated by buffell grass (*Cenchrus ciliaris)* and high shrubs, the presence of goats is evidenced by multiple tracks, vegetation trampling and goat hoof prints. During one drought period kangaroos also frequented the beach areas to access springs across the whole coastline, also altering the vegetation in the control areas, particularly in Cluster 4. It was common to see them lying underneath cars or around drop toilets in Cluster 4 to cool off. This may also lead to vegetation damage surrounding and within campsites, though not to the same extent as the damage caused by human trampling and four-wheel drive vehicles.

The sum of the social trail widths radiating from each campsite was considered to be an important measurement to understand the extent of bare soil surrounding a campsite which can lead to campsite expansion. Cluster 4 has the lowest social trail width average (mean = 117 cm) while the largest was in Cluster 2 (mean = 256.9 cm). Higher management presence and regulation, ideally incorporating campsite barriers and campsite positioning in relation to facilities, are recommended. Prevention of goat and other livestock presence and active rehabilitation are likely to be effective in reducing social trail number and width. It is also suggested that larger, thick shrubs at least waist high be planted on campsite perimeters to reduce visitor use of these areas.

8.7.2 Vegetation Damage

The average campsite vegetation damage rate was 10-30 % while for the perimeters it was 10-20 % for all clusters except cluster 4 which was higher, averaging 10-30 %. The greater perimeter damage in cluster 4 is likely to be due to greater visitation though accessibility and facilities, with less respite in the off-season. As has been previously mentioned, Cape Range (Cluster 4) has a much greater level of use in summer than many of the other sites, Gnaraloo (Cluster 3) being the only significant exception which is popular with windsurfers in the summer months.

A four-level rating system was used to assess vegetation damage for this study. However, a more detailed rating system would have yielded more specific results to compare against clusters. This more detailed rating system was not selected as it was more time consuming, and survey time was one limitation of this study. Bias may have also resulted from the primary researcher not having a botanist background and thus challenges existed when deciphering vegetation damage against a natural dormant life phase. To overcome these subjective assessments, only one researcher was used to provide consistency to the findings.

The vegetation type also varies with respect to its resilience to campers. No significant differences in vegetation health between the clusters existed for grasses, small shrubs or large shrubs within campsite areas. However, significant differences existed for the health of spinifex, saltbush, small trees and large trees (*Table 8.14*). These differences may reflect different behaviours or group sizes of campers which result in different levels of stress on these vegetation types since damage was distributed across different clusters and for different vegetation types. For campsites that contained vegetation, vegetation on the perimeter in general experienced less damage. While the sample aimed to be representative and was the largest possible given the time and resources, other sites may also need to be assessed over time to pinpoint those which should receive the most rehabilitation attention.

Different types of vegetation are present in different geological areas along the coastline. In dunes and on the beaches, spinifex and saltbush are most common, followed by shrubs and trees combined with grasses as the substrate becomes harder further inland. Therefore, campsite vegetation will experience different impacts depending on its location. When comparing clusters, all the clusters contain both buffel grass dominated environments and sensitive coastal dunal vegetation, both of which are vulnerable to camping impacts. Despite there being significant differences between spinifex and salt bush abundance between the clusters for both the campsites and the campsite perimeters, those management areas that do not have campsites directly within the dunes, such as Bruboodjoo and Three Mile, nevertheless have campsites that are immediately backed onto dunes. Consideration of which species are more resilient to human presence in these environments is therefore important.

Vegetation type is a reflection of local substrate and, within coastal environments some dunal profiles areas are far more sensitive than others. In the Netherlands, the dune grass is a very hardy native coastal plant but is highly vulnerable to dune trampling (McHarg 1992). After many studies of these impacts, the public are now denied access to the dunes and only licensed researchers can walk on them (McHarg 1992). It is pointed out that these grasses do indeed stabilise the dunes, which in turn protect the land. Clusters 3 and 4 may have the highest vegetation damage of the clusters, both on the campsite itself and on the perimeter, due to their high level of visitation. These locations are likely to experience a greater level of damage over time irrespective of prohibitive measures. Tamarisk trees experience low damage and, unlike other studies (Smith 2003), this project found that there was no vandalism around the trees. Tamarisk trees were planted as a management initiative to provide shade for campers at Cape Range National Park and Warroora. Tamarisk trees were also planted by campers at Bruboodjoo at Cardabia station to provide shade. Large shrubs were also planted at Three Mile Camp, Gnaraloo station, which was shown to reduce campsite expansion and width of social trails. Therefore, differences in vegetation damage across clusters were in part a reflection of management actions at a camp area, where vegetation most resistant and resilient to anthropogenic impacts was planted. Also, rehabilitation efforts were in place to rehabilitate old campsites (Cluster 2) (Plate 8.29) and control erosion outside the campsite (Cluster 4) (Plate 8.30) was seen to be working effectively. Whilst significant differences did exist for vegetation damage across clusters, disproving the null hypothesis that no significant differences exist, rehabilitation efforts currently undertaken and possible for all clusters can play a large role in reducing these impacts. Further study by a botanist to identify native, hardy plant species that are resistant to human trampling is warranted for rehabilitation purposes.

Plate 8.29 Regenerating Campsite with introduced Buffel Grass, Cluster 2

Plate 8.30 Regenerating Social Trails with Woody Debris, Cluster 4

Figure 8.14: Rehabilitation Techniques, Ningaloo Coast.

8.7.3 Litter and Cleanliness

The presence of minimal litter was found to be of high importance for all campers along the Ningaloo coast (section 6.5) and this is therefore an important management consideration. Cluster 4 had the largest amount of litter overall (large and small litter items combined) (section 4.4.6.2.2), suggesting that regulation does not always reduce impacts. This is further shown by large differences in litter amounts between the different management areas (Blowholes and Warroora's Fourteen Mile) in Cluster 2. The Blowholes camp appeared to have the most litter of all the management areas, while Fourteen Mile had negligible amounts despite the two sites having similar characteristics.

The sample size is a limitation of the litter audit, which was only conducted during the second field trip. It is possible that someone had been through a given area the day before and cleaned the area or conversely made the area dirty, influencing the survey results. For example, one manager had gone around collecting the small rubbish items from camp areas the week before our litter audit. Additionally, the audit was done before site caretakers arrived at Blowholes and Cape Range National Park, when camp areas were relatively quiet. The litter counts are however more accurate as they were counted with each impact assessment.

Between the clusters, large disparities exist between not only the amounts but also the types of litter present. Very large litter (>15cm) was most common in Cluster 1, and the type of litter decreased in size to Cluster 4, which had the largest amount of small (<5cm) litter items. While large miscellaneous items comprising largely plastic and rubber items and offcuts, 5-15cm long were the predominant rubbish types in Clusters 1 and 2 (averaging 20 % of rubbish items), for Cluster 3 it was bottle tops. Cluster 3 had the youngest demographic of all the clusters, with surfing being one of the main attractions. While management do a good job of managing the litter by placing out rubbish bins, bottle tops get left behind. The demographic of Cluster 4 (many European backpackers who were heavy smokers) indicates why cigarette butts were high in number on the campsite floors. Before the caretakers arrived at Cluster 4 for the winter (peak period), there was also a large amount of plastic rubbish and other food wrappers strewn around the campsites, particularly at Lakeside campground. The caretaker of that site later collected a large household wheelie bin full of rubbish from the surrounding area. Often rubbish bins were overflowing with loose litter, and so the lids were hinged open. Cluster 4 also had large amounts of large rubbish on the perimeter of the campsite areas in the coastal vegetation, possibly from overflowing bins or being blown from the campsites.

These differences may well reflect the stewardship of the long-term campers at Fourteen Mile, many whom picked up litter on their daily walks (Remote Research 2002). Additionally, many campers at Cardabia Station (also Cluster 1) stated that, during the summer, a small group of people are responsible for most of the littering and damage when there are no caretakers on site. Most campers at the Blowholes management area did not stay for long periods (more than two weeks). The importance of stewardship was also highlighted in recent reports (Remote Research

2002; Davies, Tonts et al. 2009; Jones, Hughes et al. 2009). Long-term campers at Fourteen Mile would frequently talk about keeping the area clean and picking up litter. At Blowholes, campers were seen collecting very old bottles and cans that were weather beaten, but they left them on the side of the road instead of taking them to the skip bin. Warroora (Fourteen Mile) had an effective closed tip for rubbish disposal and a recycling station (further described in section 7.2) which was later taken to Carnarvon and sold to raise money for charity. Many small items of rubbish were present, especially cigarette butts. This may relate back to camper awareness of the environment, despite signs not to litter being present.

Interestingly, Cluster 3 excelled at having the best 'Clean Coast Category' (CCI) score. This measures the number of rubbish items over a given area. The 'acceptable' amount of litter found within a public space is very subjective. For this reason, the amount of litter found within the different clusters was compared against the CCI (Alkalay, Pasternak et al. 2007). The CCI is a suggested evaluation tool of actual coast cleanliness, which has been applied to coastal campsite cleanliness measurement elsewhere. At all the clusters the measurements fell between 1.11 and 1.67 and all areas were therefore rated 'very clean' by this international standard, which is represented by 0-2 on the CCI. Cluster 4 had the highest CCI rating, presumably because small and large litter items were combined for the analysis, and Cluster 4 contained many small litter items such as cigarette butts. Interestingly a highly significant correlation ($p \leq .01$) existed between small and large campsite litter for the whole Ningaloo coast, indicating that overall litter as was comprised of both small and larger litter items.

8.7.4 Indices

The findings from the three indices, Coastal Vegetation Loss (CVL), Area of Coastal Vegetation Loss (ACVL) and Coastal Campsite Impact Index (CCII) rejected the null hypothesis that no significant differences in environmental impact exist between the clusters through strong correlations between regulation level and campsite impact. All three indices were found to decrease with an increase in regulation. This supports Smith's (2003) findings from a study in the Eucalypt forests of Western Australia's south-west which found that designated campsites experienced significantly fewer adverse impacts than did the informal ones.

As outlined in the methods section (4.4.7), CVL and ACVL were adapted from indices developed by Monz (2010) and Cole (1989) respectively. To derive the CVL and ACVL for this study, vegetation percentage cover data was derived from photographs taken for each sampled campsite, from the campsite area, campsite perimeter and campsite boundary and placed into one of six cover classes (Monz and Twardock 2010) (*Table 4.13*). Photographs were used to save time assessing vegetation within the campsite area, perimeter and boundary area whilst in the field to place them into one of six vegetation density categories. Instead, vegetation damage was assessed on-site as one of only four categories, which was quicker yet not as detailed. Assessing photographs to determine the CVL and ACVL was an effective method to reduce field work time, yet collect data that was of the desired accuracy for analysis purposes. Photographs were beneficial as they focused down onto the ground to determine vegetation density. One challenge with collecting accurate data at the study area was that individual campsite boundary areas (or 'control' areas) may also have been be disturbed in the past, by livestock or anthropogenic impacts. This method of using photographs would be transferrable to other environmental locals for research studies which have a limited survey period.

To determine CVL and ACVL, challenges arose when applying methods from Monz (2010) and Cole (1989) directly and so an adapted calculation was instead utilised. Calculations by Monz (2010) and Cole (1989) were considered accurate only if estimates of cover are representative of the entire campsite and are not biased toward either the more de-vegetated campsite core, or the more vegetated periphery. Campsites along the Ningaloo coast more often than not comprise both a vegetative area and a barren core area within the campsite area, creating a challenge in applying the Area of Vegetation Loss index. With the original calculations, estimates of vegetation cover within a campsite needed to be representative of the entire campsite and are not biased toward either the more de-vegetated campsite core, or the more vegetated periphery. Campsites along the Ningaloo coast more often than not comprise both a vegetative area and a barren core area within the campsite area, particularly in dunal areas. The amended calculation therefore took into consideration the ratio of campsite that was barren against the vegetated areas. The campsite areas for all samples within this study, calculated through geometric figure method, were found to significantly correlate (r = .960) to the ACVL (results presented below, section 9.2.1). Therefore, the ACVL may be considered a slightly more accurate version of campsite area. If creating methodologies for other surveys whereby a high level of accuracy is not required and available time for analysis is limited, the original campsite area impact variable may in itself be suitable.

Variables relating to vegetation loss, including campsite area, barren core area and CVL had the largest influence on CCII impact scores. For example, only camp areas which had a relatively small campsite area also had a low CCII score. This is because a larger camp area size, particularly barren core area, had significant positive correlations with other impact variables, further outlined in Chapter 9. Low impact campsites were also orientated in a way that facilitated easy access to their desired destinations, such as bathrooms and the ocean, which reduced the need for multiple social trails and associated larger social trail width variables.

Impact intensity is largely determined by campsite durability (for example through vegetation type) as well as amount and type of use (Cole 1994). While this study lack of site-specific data on use levels at all clusters, it can be said that Clusters 1 and 2 receive less visitors (though potentially a similar number of visitor nights during the winter period) than Clusters 3 and 4. That Clusters 3 and 4 have a lower CCII, this must reflect site durability which is in turn a reflection of management actions. Whether fewer impacts are created by having fewer visitors for longer period of time, or more visitors for shorter periods of time warrants further investigation.

While this chapter has examined the impacts across the clusters, the focus of the next chapter is to determine which (if any) independent or management affect these impacts across the whole of the Ningaloo coast. The next chapter therefore examines those factors which may affect the magnitude of the environmental impact overall in more detail.

Chapter 9: Factors which Affect Magnitude of Impact

Figure 9.1. Southern Boundary, Warroora Station.

9.1 INTRODUCTION

The previous three chapters have explored differences between the clusters with regard to preferences, resource use and environmental impacts of Ningaloo coastal campers. In Chapter 8, the results from the impact assessments found that significant differences existed for many environmental impact variables across the clusters. This chapter therefore aims to identify more generally applicable factors which strongly influence the amount of impact and in turn may also be controlled to minimise impacts. As findings from Chapter 5: highlighted, the basis for the argument of this chapter is that independent variables are elements that management should take into account, not caveats that disprove the importance of site-specific impacts associated with management regimes.

The purpose of this chapter is to test the null hypothesis that impact variables are influenced by management variables alone. These include ‘campsite distribution and location’, ‘site hardening’, ‘management presence’, ‘vehicle access’ and, ‘facilities’. Other variables against which these impacts will be correlated include other impact variables and independent variables (substrate and vegetation). Understanding which variables have a strong relationship with impacts can help management to ameliorate these impacts.

In the magnitude of impact section in the literature review (section 3.4.4), Hammitt (1998) stated that a number of variables affect environmental impacts. An understanding of each of these influential variables may suggest strategies for managing the impacts of hiking and camping on soils and vegetation (Leung and Marion 2000; Leung and Marion 2004). However, most of these studies were from the United States in forested areas as already highlighted throughout the thesis. Those variables of most interest to this study have been manipulated to render them measurable within the scope of this research. The following variables of will be examined in this Chapter: ‘vegetation density’, ‘vegetation resistance’, ‘soil characteristics’, ‘use distribution’, and ‘mode of travel’. The influences of frequency of use, season of use and visitor behaviours could be studied due to the time constraints of this project and as such are outside the scope of this research.

In order to assess how the impact variables were related to other impact variables, independent variables and management variables, regression analyses were undertaken as outlined in section 4.5. Due to size limitations of the tables within this section, table headings (comprising impact variables to be tested) for Tables 9.2 through 9.6 were abbreviated (*Table 9.1*) for this section.

Table 9.1

Abbreviations for Table Headings within Chapter 9.

Full Details	Abbreviation
Area of Coastal Vegetation Loss (Index)	ACVL
Camp Area (m^2)	CA
Coastal Vegetation Loss (Index)	CVL
Barren Core Area (m^2)	BC
Vegetation Damage (Perimeter)	VD
Fire Pits (count)	FP
Social Trail Number (Count)	ST (N)
Sum Social Trail Widths (cm)	ST (W)
Litter, small and large (weighted)(count)	L

Section 9.2.1 will explore the relationship between impact variables while section 9.2.2 will explore the relationship between the independent variables of vegetation type and substrate on impact indicators. Section 9.2.3 focuses on relationship between management variables and impact indicators. A summary of results is then presented (section 0), followed by a combined discussion and Conclusion (section 9.4).

9.2 RESULTS

9.2.1 Relationships between Impact Variables

The relationships between the impact variables were tested to better understand whether the presence of one impact indicator may also determine the presence of other impact indicators. Since like indicators would naturally correlate to 1 (such as campsite area correlated to campsite area), these results were removed from the table. The results (*Table 9.2*) suggest that all campsite area and vegetation loss measurements (vegetation area, vegetation loss, barren core area and campsite area) were significantly ($p = \leq .01$) correlated to one another. Vegetation loss on a campsite is considered one of the key impact measurements (Cole 1989).

A second finding was that the index ACVL was significantly correlated to campsite area, CVL, barren core area and number of fire pits.

Barren core area correlates significantly to ACVL, campsite area, number of fire pits, number of social trails number, sum of social trail widths and litter. The results (*Table 9.2*) suggest vegetation perimeter damage did not correlate with any other impact variables, which suggests that impacts which influence this indicator may be independent of, or different from impacts that influence the other variables. Management strategies to reduce vegetation damage may therefore need to be different, such as planting resilient plant species around the campsite perimeters.

Barren core area correlates significantly to ACVL, campsite area, fire pits, number of social trails, sum of social trail widths, and litter. This suggests that there may be a link whereby, if the barren core area is reduced, the other factors associated with it may also decrease. Also, the index ACVL was significantly correlated to campsite area, CVL, barren core area and number of fire pits. Therefore, monitoring ACVL and barren core area may be considered the most important indicators for any monitoring programs, especially because vegetation loss on a campsite is considered one of the key impact measurements (Cole 1989).

Table 9.2

Significant (p=≤.05) Correlations between Impact Variables.

	ACVL	**CA**	**CVL**	**BC**	**VD**	**FP**	**ST (N)**	**ST (W)**	**L**
Area of Coastal Vegetation Loss (Index)		.960	.406	.274		.147			
Coastal Vegetation Loss (Index)	.406	.200							
Campsite Area (m^2)	.960		.200	.385		.185			
Barren Core Area (m^2)	.274					.245	.181	.258	.202
Vegetation Damage (Perimeter)									
Fire Pits (count)	.147			.245			.155	.181	
Social Trail Number (Count)				.181		.155		.856	.149
Sum Social Trail Widths (cm)				.258		.181	.856		.206
Litter, small and large (weighted)(count)				.202			.149	.149	

Note: Blank cells represent no significant correlation

9.2.2 Independent Variables

It is necessary to sample independent variables to remove noise from the data (Cole 1992). Substrate was a challenging variable to assess because there were many combinations at each campsite, comprising a mixture of sand, limestone, clay and rock and, as such, many combinations had a small sample size. Therefore, to create a larger sample size, substrates were classified on whether they were compact or not, thereby indicating whether or not the substrate was in a dunal location.

'Area of Coastal Vegetation Loss (ACVL)' was significantly correlated with 'soft sand' (*Table 9.3*). 'Soft sand' was more common dunal areas close to the high water line with shrub-like vegetation, while 'compact sand' often contained 'grasses', which were more prone to trampling and more vulnerable to campsite spread. 'Social trail numbers' and social trail widths' increased on 'soft sand', but decreased on 'compact substrates'.

Another consideration for management is which species are more resilient to human presence. Grasses and small shrubs, less than one metre in height, were significantly and positively correlated with higher levels of 'Coastal Vegetation Loss (CVL)'. The lower to the ground the vegetation was physically, the stronger was this correlation. However, 'small tree' and 'large tree' produced a significant negative correlation, indicating that vegetation loss decreases when large trees are present.

The type and size of vegetation can also affect the number and width of social trails, with small shrubs such as 'spinifex', 'salt bushes', and 'small shrubs' having significant negative correlations with the impact variables of both 'social trail number' and 'total social trail width'. This suggests that the physically smaller the vegetation, the greater the damage that occurs (*Figure 9.2*).

Table 9.3

Significant *(p* = ≤.05) Correlations between Impact Variables and Independent Variables of Substrate and Perimeter Plant Types.

	ACVL	**CA**	**CVL**	**BC**	**VD**	**FP**	**ST (N)**	**ST (W)**	**L**
Soft sand	.200			.156			.231		.200
Compact sand				-.164			-.193		
Grasses	.178		.144			.410			.178
Spinifex		-.200	.172	-.167		.359	-.277		
Saltbush			.187	-.152		.342	-.233		
Small shrub				-.156		.251	-.19		
Large shrub									
Small tree			-.361						
Large Tree			-.241		.153				

Note: Blank cells represent no significant correlation

Plate 9.1 Dense coastal scrub keeps trails defined, Cluster 1

Plate 9.2 Multiple wide social trails exist within Dispersed Spinifex, Cluster 1

Figure 9.2. Relationship between Vegetation Density and Social Trail Width.

9.2.3 Management Variables

9.2.3.1 Campsite Distribution and Location

Distribution of campsites is one component of management regimes which is known to influence environmental impacts (Hammitt and Cole 1998; Leung and Marion 2004). The spatial distribution of campsites has an effect on the area of impact, which, together with the intensity of use, influences the total impact of campers on a site (section 3.5.3.3). Since this was a snapshot study rather than a longitudinal study, the intensity of use at each site was not calculated quantitatively. The three variables of campsite distribution are 'distance to closest campsite', 'number of campsites on one barren core area', and 'number of campsites within a 50m radius'.

The regression analysis, results shown in *Table 9.4* suggest that containment seems to be a better approach than dispersion. The campsites which were more contained as measured by the variables 'distance to closest campsite' and 'campsites within 50 m' through the variables 'distance to closest campsite' and 'campsites within 50 m' were shown to have reduced vegetation area loss, lower percentage loss, a smaller barren core area, fewer fire pits and less vegetation damage. This research therefore indicates that, within a coastal camping area, containment strategies can be an effective method of both avoiding disturbed area increases and preventing several other adverse environmental impacts.

An increase in the number of campsites on one location such as a 'car park'-style camp area was shown to reduce the number of social trails and social trail total width. This is likely to be due to the fact that campsites of this type have only one or two sides of the campsite exposed to vegetation and other areas which are vulnerable to the creation of social trails. The rest of the campsite leads into a space comprising only barren core area where social trails are not applicable.

The correlations also suggest that the farther the campsite is from the ocean (distance to ocean), the more likely it is that there will be large areal disturbance ('ACVL', 'CVL' and 'campsite area'). The campsites farther from the ocean often contain 'grasses', which positively correlated with 'ACVL' (section 9.2.2). Grasses are less resilient to disturbance than larger shrub species and, as such, the campsites may be more susceptible to expansion.

Table 9.4

Significant *(p* = ≤.05) Correlations between Impact Variables and Campsite Distribution.

	ACVL	CA	CVL	BC	VD	FP	ST (N)	ST (W)	L
Distance to closest campsite		.338	.307	.276	-.233	.263		-.146	-.133
Number of shelters on campsite area						-.383	-.302	-.320	
Number campsites in 50m		-.378	-.325	-.250	.227	-.036			
Beach Profile			.228			.134			
Distance to ocean	.141	.135	.139			.169			
Distance to nearest town.	-.244								

Note: Blank cells represent no significant correlation

9.2.3.2 Site Hardening, Management Presence and Access

Management interventions through site hardening, management presence and campsite site access (which also determines mode of transport) are explored in this section. The rating system developed for these three management variables (*Table 9.5*) are the same as those selected when developing the clustering method (section 4.2.2).

Table 9.5

Ratings for Management Presence, Site Hardening and Access.

Regulation Characteristics, Ningaloo coast	**Method**	**Measurement Scale**
Management presence	Rating	(1) No management presence, (2) Seasonal caretaker on-site, (3) Year-round caretaker on-site, (4) Year-round ranger on site
Site hardening	Rating	(1) No site hardening, (2) Limited campsite definition, (3) Campsite boundaries, (4) Campsite pads and boundaries
Access	Rating	(1) Only accessible by four-wheel drive, (2) Not sealed but accessible by two-wheel drive, (3) Sealed road

Access and site hardening exhibited the same results for each impact variable. This was because those sites which had no site hardening were also only accessible by four-wheel drive. The findings suggest that an increase in site hardening and management presence resulted in a decrease in campsite area and vegetation loss, vegetation damage and fire pits (*Table 9.6*).

Table 9.6

Significant *(p* = ≤.05) Correlations between Impact Variables and Management Presence.

	ACVL	**CA**	**CVL**	**BC**	**VD**	**FP**	**ST (N)**	**ST (W)**	**L**
Site Hardening	-.371	-.368	-.181		-.150	-.495			
Management presence	-.371	-.368	-.181		-.150	-.495			
Access	-.255	-.273			-.616	-.616			

Note: Blank cells represent no significant correlation

Problems created by a lack of site hardening include campsite expansion; although campsite expansion was found to also occur on hardened sites in Cluster 4 (Plate 9.6). However, as previously discussed in section 8.7, Cluster 4 also received the largest number of year-round visitors. To reduce the size of campsite area boundaries, site hardening must involve a combination of clear campsite boundaries which are not easy to breach either by foot or by vehicle in addition to a strong management presence, perhaps through the presence of camp hosts, to maintain these boundaries and deter visitors from creating new sites.

Social trail number and width were not significantly correlated with any management function. This is probably because each management area, regulated or unregulated, had a combination of small, restricted social trails and non-restricted larger social trails. Although there was no significant difference in the number of social trails across clusters, there is evidence that waist-high wire fencing (Plate 9.3) deters movement beyond the campsite more than any 'suggestive' boundaries that can be walked over or under, such as rocks, low rope or single low or high logs (Plate 9.4 through Plate 9.7). Goats as well as humans also establish and/or expand social trails (Plate 9.8)

Plate 9.3 Social trail confined by markers Cluster 3

Plate 9.4 Cluster 2: Ineffective barrier

Plate 9.5 Hardened site with evidence of social trails.

Plate 9.6 Extension of damage past site markers into Perimeter, Cluster 4.

Plate 9.7 Erosion resulting from missing boundary, Cluster 3

Plate 9.8 Trails formed by goats, Cluster 3

Figure 9.3: Site Hardening Techniques.

Access varies along the Ningaloo coast, from sealed roads requiring only a two-wheel drive vehicle, to sandy tracks which require a four-wheel drive vehicle. Discussions along the Ningaloo coast often surround whether or not to pave coastal roads, particularly the Blowholes to Gnaraloo road, to provide easier access, (Western Australian Planning Commission 2004). The results (*Table 9.6*) of the regression analysis suggest that adverse environmental impacts are reduced through an increase in accessibility. However, the areas which are most accessible also have increased site hardening and management presence which may well affect this result. Accessibility however also reflects ‘mode of transport’, one variable within the literature known to influence magnitude of impact (Hammitt and Cole 1998). The use of four-wheel drive vehicles to access campsites along the Ningaloo coast has led to campsite expansion through poorly–defined campsite boundaries (Plate 9.10), user behaviour, perhaps because there were low levels of management presence (Plate 9.11) and repetitive wear from the tyres of four-wheel drive vehicles (Plate 9.12). Sites that were hardened also face challenges with high levels of visitors using four-wheel drive vehicles, and thereby making the ground soft (Plate 9.9).

Plate 9.9 Damage resulting from a bogging incident, Cluster 4

Plate 9.10 Driving repeatedly over vegetation reduces vegetated areas, Cluster 1

Plate 9.11 User behaviour on-site can influence vegetation degradation, Cluster 2

Plate 9.12 User behaviour on-site can influence campsite spread, Cluster 3

Figure 9.4. Impacts to Campsites resulting from Four-wheel Drive Vehicle use.

9.2.3.3 Facilities

Only two significant correlations existed between the distance to facilities and environmental impacts (*Table 9.7*). These were between ‘number of social trails’ and ‘tip’, and ‘dump point’ and ‘barren core area. These do not have much importance for management purposes. Interestingly, the presence of litter did not have a significant correlation with distance to a garbage bin or tip. This may be because litter was found in all clusters, in particular in Cluster 4, the most regulated cluster.

As previously discussed in section 8.7.3, stewardship and an awareness of environmental impacts are more likely to affect what enters and leaves the Ningaloo coastal system than does the provision of facilities alone. That said, in remote areas the provision of basic facilities such as a garbage tip and sewerage dump point would ensure that most waste would be deposited in the correct places. In a location with a high number of short stay (up to a week) or day trippers, on-site toilets should also be provided.

Table 9.7

Significant *(p* = ≤.05) Correlations between Impact Variables and Facilities.

	ACVL	CA	CVL	BC	VD	FP	ST (N)	ST (W)	L
Garbage bin									
Toilet									
Tip							.132		
Dump point				.138					

Note: Blank cells represent no significant correlation

9.3 SUMMARY OF RESULTS

To test Hypothesis 3, the environmental impacts were correlated against the independent variables of substrate and vegetation types, other impact variables, and management variables incorporating ‘campsite distribution’, ‘site hardening’, ‘access’, and ‘facilities’. The null hypothesis was rejected because, although management variables played a large factor. Several Independent variables also correlated significantly ($p \leq .05$) with a number of impact variables (Table 9.8)

The relationships between the impacts indicated that the impact variable, barren core area, correlated significantly with ‘vegetation loss’, ‘fire pits’, ‘social trail number’, ‘social trail width’, ‘litter’, and ‘campsite area’. Also, the ‘Area of Vegetation Coastal Loss (ACVL)’ was significantly correlated with ‘Coastal

Vegetation Loss (CVL)', 'campsite area', 'barren core area', and 'number of fire pits'.

The independent factors of substrate and vegetation type were tested against the eight impact variables. The presence of 'soft sand', common in beach and dune locations was positively correlated with 'vegetation area loss', however 'compact sand' was correlated with the presence of 'grasses' which were highly susceptible to damage.

The correlations of the management variables of 'campsite distribution' and 'location' with impact variables suggest that containment strategies reduce 'CVL', 'vegetation percentage loss', 'barren core area, 'fire pits', and 'vegetation damage'. The management variables of 'site hardening', 'management presence' and 'access' have a significant positive correlation with the following impact variables: 'ACVL', 'CVL', 'fire pits', 'vegetation damage', and 'campsite area size'. While the least regulated sites have the greatest campsite spread, leading to larger campsite areas, the more regulated sites have site containment strategies in place, such as wooden barriers. The correlation of the management variable of facilities with impact variables was shown to have very little influence. While it might have been expected that there would be a correlation between the presence of litter and the distance to a garbage bin or tip, negligible correlations existed in this regard.

Table 9.8

Significant Correlations (*r*) between Impact, Independent and Management Variables and Impact Variables identified within the Coastal Campsite Impact Index.

	ACVL	**CA**	**CVL**	**BC**	**VD**	**FP**	**ST (N)**	**ST (W)**	**L**
Impact Variables									
Area of Coastal Vegetation Loss (Index)		✓	✓	✓		✓			
Camp Area (m^2)	✓		✓	✓		✓			
Coastal Vegetation Loss (Index)	✓	✓							
Barren Core Area	✓					✓	✓	✓	✓
Vegetation Damage (Perimeter)									
Fire Pits	✓			✓			✓	✓	
Social Trail Number				✓		✓		✓	✓
Sum Social Trail Widths				✓		✓	✓		✓
Litter				✓			✓	✓	
Independent Variables									
Soft sand	✓			✓			✓		✓
Compact sand				☑			☑		
Grasses	✓		✓			✓			✓
Spinifex (Perimeter)		☑	✓	☑		✓	☑		
Saltbush (Perimeter)			✓	☑		✓	☑		
Small Shrub (Perimeter)				☑		✓	☑		
Large Shrub (Perimeter)									
Small Tree (Perimeter)			☑						
Large Tree (Perimeter)			☑		✓				
Management Variables									
Campsite Distribution and Location									
Distance to closest campsite		✓	✓	✓	☑	✓		☑	☑
Number of shelters on campsite area total						☑	☑	☑	
Number campsites in 50m		☑	☑	☑	✓	☑			
Beach Profile			✓			✓			
Distance to ocean	✓	✓	✓			✓			
Distance to nearest town.	☑								
Site Hardening and Management Presence									
Site Hardening	☑	☑	☑		☑	☑			
Management presence	☑	✓		✓	☑	☑			
Facilities									
Garbage bin									
Toilet									
Tip							✓		
Dump point				✓					

✓ = significant ($p \leq .05$) positive correlation; ☑ = Significant ($p \leq .05$) negative correlation

9.4 DISCUSSION AND CONCLUSION

The null hypothesis tested in this chapter was that only management variables influence impact variables along the Ningaloo coast. This null hypothesis was disproven with the findings that several independent variables including vegetation and substrate may also influence the level of environmental impacts experienced.

The factors considered within this chapter with regard to visitor impacts in coastal environments that have been previously discussed within the literature were: soil characteristics, vegetation density, vegetation resistance and resilience, wildlife impacts, and use, distribution and mode of travel. What was also tested in this research were the relationships between impact variables in addition to those of management variables including management presence, site hardening, access and the presence of facilities. An understanding of each of these variables has suggested various strategies for managing the impacts of hiking and camping on soils and vegetation (Cole, Petersen et al. 1987). Different factors were identified, which may be broken down into 'environmental durability' and 'visitor use' (Hammitt and Cole 1998).

Research from this study at Ningaloo has produced an amended set of findings to those presented in the literature review in section 3.4.4. This is presented below in *Table 9.9*. The sections in green represent previous literature findings supported by this research which have been discussed in previous chapters of this thesis. The sections in red which represent findings from this chapter which support the literature highlighted and are discussed in this chapter in two sections; Independent Variables (section 9.2.2) and Management Variables (section 9.2.3). The sections in black were not tested within this study. The sections in blue represent new findings reported in this chapter.

Table 9.9

Variables which affect Magnitude of Environmental Impact by Campers.

Environmental Durability	Visitor Use	Management Strategies
Vegetation density	Amount of use	**Design and orientation of campsite**
Vegetation resistance and resilience	**Use distribution**	**Management presence**
Soil characteristics	Type of user group	**Campsite designation and labelling**
Environmental Durability	Party size	**Trail barriers and campsite boundaries**
Topographic characteristics	**User Behaviour (minimum impact knowledge, experience level, user motivation, social group and structure)**	**Facilities which allow people who want to do the right thing, do the right thing***
Ecosystem characteristics	**Mode of Travel and Access**	**Using impact variables which have high correlations with other impact variables as key indicators for monitoring**
Wildlife impacts	Severity of direct impacts associated with specific activities	
Water impacts	Severity of indirect impacts	
Season of use	Social dimensions of timing	
The conservation value of the site	Ecological dimensions of timing	
Susceptibility to erosion		
Total area affected		

Sourced from: (Cole 1992; Hammitt and Cole 1998; Cole 2004; Pickering 2010)
*The location of Litter bins in remote areas will need more research since these were shown not to be an effective way to reduce littering and to need frequent attention from managers.
Green represents literature findings that are supported by this work and are noted in previous chapters
Red represents literature findings chapter that are supported by this work and are noted in this chapter
Blue represents new findings reported in this chapter

9.4.1 Independent Variables

The independent variables of vegetation type and substrate were tested against the impact variables (section 9.2.2) to better understand whether management factors were indeed responsible for any differences in environmental impact levels. For substrate, overall the presence of soft sand, common in beach and dune locations, was positively correlated with impacts associated with vegetation loss such as ‘barren core area’ and ‘number of social trails’. Conversely, the presence of compact sand decreased the likelihood of impacts, including ‘barren core area’ and ‘social trail number’. Beach and dune locations, as highlighted from the camper preference findings within this study, favour campsites close to the beach. As such it is likely that these sites will have higher use, especially in Clusters 3 and 4. Vegetation at the coastal sites characterised by soft sand area is also fragile and sparse which does not limit the number of social trails. Indeed, larger and denser shrubs were found to reduce campsite expansion resulting from social trail impacts, while grasses were far less resilient and do not discourage impact. Within the literature, coastal grasses are also considered more sensitive than larger bushes (McHarg 1992). However, vegetation losses within the dunal areas were also substantial, and it is likely that these plant communities are not resistant or resilient to trampling disturbance as was found within Monz’s (1998, p. 120) study. It may therefore be argued that denser bushes medium to waist high may help to reduce campsite expansion. Four-wheel drive vehicles with larger tyres also frequent these sites and, as noted by Newsome (2002), four-wheel drive vehicles inflict greater vegetation damage than does trampling.

Substrate, vegetation and topography along the Ningaloo coast have been found to have different suitability for recreation and development (McHarg 1992). Geomorphological mapping of the coastal zone with a focus on land classification scheme based on substrate capability has been undertaken for Bruboodjoo (*Figure 9.5*), Steve’s at Warroora and Red Bluff (Blackwell 2002), Three Mile (Leeden 2003) and CRNP (Hahesy 2004). These studies provide important considerations for campsite location when the considering impacts and interrelationships determined by this study. Current camping grounds and day use sites often comprise poorly vegetated, unconsolidated mobile dunes (Hahesy 2004) and have been classified in the high to extreme risk zones, depending on the type of land use. From Campsite ‘beach profile’ inventories at Ningaloo, between 20.4 % (Cluster 3) and 35 % (Cluster 2) of campsites are within the ‘at risk’ primary dune area (Leeden 2003). It is recommended that land managers avoid placing camp sites on areas with low substrate capacity in order to reduce environmental degradation. Camp area size is therefore a predictor of absolute damaged area and is therefore very important factor for managers to consider.

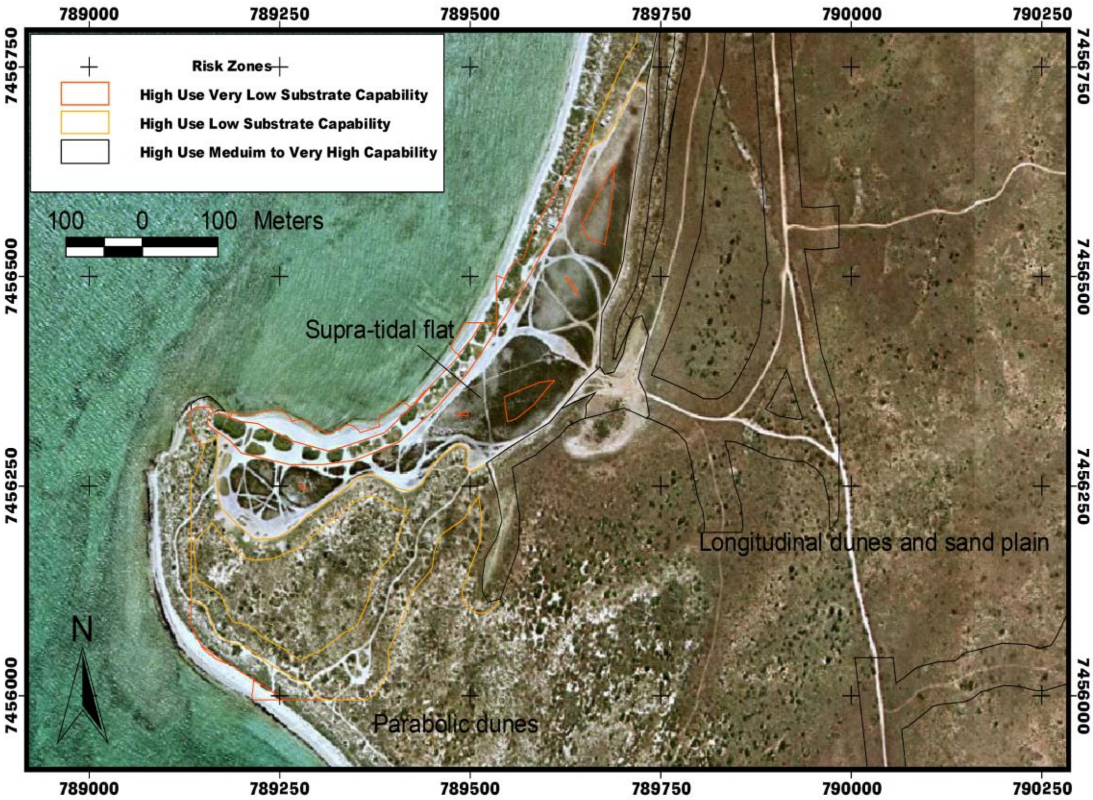


Figure 9.5. Coastal Risk Zones for Bruboodjoo Point.
Derived from Blackwell (2002, p. 84).

9.4.2 Management Variables

While it is very important to maintain visitor satisfaction levels in natural areas as discussed in section 3.2.1, challenges arise when the preferences of visitors, such as four-wheel driving as an activity or staying an unhardened campsite, start to cause physical environmental impact. The balance between satisfying the needs of visitors and maintaining environmental integrity (through management) ultimately comes down to politics, policies and laws in place to protect the natural area. Camp areas within this study area are located within both a marine park and a World Heritage area. The purpose of protected areas is to ‘contribute to the long-term ecological viability of marine systems, to maintain ecological processes and to protect Australia’s biological diversity at all levels’ (Commonwealth of Australia 2002). Additional key values of the Ningaloo Coast include the striking natural landscapes and diversity of flora and fauna of Cape Range and Ningaloo Reef (Department of Environment and Conservation 2011). Whilst development and commercial activities can and do occur in World Heritage places around the world, whether environmental standards and expectations of these accolades are being upheld through current camping and recreation practices warrants examination.

When it comes to management, park managers in the United States subscribe to the term "intensive use must be managed intensively" (Park 2013). Whether visitors can be excluded from nondurable surfaces or durable surface pads for campers should be put into place, and how this fits with the wilderness experience along the Ningaloo coast requires further examination. A containment strategy (indicators were distance to closest campsite and campsites within 50 m) were shown to be a more effective approach than dispersion in reducing key environmental impacts. Containment was also found to be the best campsite management approach in the World Heritage listed Wet Tropics region (Turton 2005). Utilising a containment strategy would appear to reduce: ‘ACVL’, ‘CVL’, ‘and barren core area ’,‘ fire pit number ’and‘ vegetation damage’. Whether to utilise campsite dispersion or containment is a common focus of discussion within the literature. While dispersal can be an effective strategy (Williams and Marion 1995; Marion and Leung 1997) where use levels tend to be low and resistant soil and plant communities exist (Hammitt and Cole 1998), this is clearly not the case along the Ningaloo coast, particularly when campsites are accessed by four-wheel drives. A containment approach for overnight use, either through more rigorous education or campsite designation has been suggested as a future management strategy (Monz 1998) for coastal camping areas in both Prince William Sound and Baja California Sur. Containment is already pursued at Ningaloo in the clusters with increased levels of management intervention such as Gnaraloo and Cape Range National Park.

To limit future camping impacts along the coastline, it is recommended visitors be directed to highly resistant campsites, away from fragile areas where small amounts of use can have lasting effects. These containment strategies could be integrated with spatial configuration strategies when new campsites are designed, since campsite movement patterns are influenced by the site layouts (Leung and Marion 2004) (*Figure 3.5*). Understanding campers’ needs, preferences and activity patterns is necessary for the success of this integrated system. Smallwood (2011) studied visitor activity movements throughout the Ningaloo coast, but studies on a finer scale may be warranted to understand local activity patterns in relation to campsites.

Site hardening and management presence were both shown to have a relationship with overall campsite area. The presence of campsite boundaries and thus campsite designation was shown to be especially effective in preventing campsite area expansion and the number of fire pits. Despite the larger numbers of visitors and year-round pressure on the sites that had a greater management presence (Clusters 3 and 4), the overall impact was still smaller for these clusters than for those that were less managed. However, because visitors were confined to a smaller space which may have been provided with an artificial surface to make the site more durable, the barren core area was larger for those sites with a higher management presence. The presence of a large number of campers through the years in a confined area would also cause the health of the vegetation on the edge of the site to decrease. In the Kimberly region of Western Australia, Hercock (1999) questioned the sustainability of promoting an increasing number of four-wheel drive visitors when old camp fire sites, litter, tracks comprising compacted soil and a lack of toilet facilities were observed. Their level of impact also varied due to the presence of different management regimes. It was argued that eco-tourists taking part in pre-sold packages were the easiest to control, as opposed to the majority of four-wheel drivers in the Kimberly which were difficult to confine and manage. Promoting eco-tourism along the Ningaloo coast is an option, considered in detail with the Regional Strategy (2004).

In all, seven factors identified as affecting the magnitude of impact within the literature were supported by this research as also being applicable to coastal areas. Additionally, six management strategies were added to the list as applicable to coastal areas. As outlined within the introduction of this Chapter (section 9.1), these independent variables are elements that management should take into account, not caveats that disprove the importance of site-specific impacts associated with management regimes. Whether these factors are also applicable in different coastal environments warrants further research.

Chapter 10: Conclusion

Figure 10.1. Maggies Camp Area, Warroora.

This study set out to answer whether relationships exist between level of regulation and the variables of visitor preferences, resource use and environmental impacts at remote coastal campsites on the Ningaloo coast. Five null hypotheses and their associated objectives guided this study. The null hypotheses were disproved in all five instances, indicating that statistically significant differences do exist between management regime areas with regard to camper preferences, resource use and environmental impacts, but that these environmental impacts are also influenced by variables other than management.

A combined approach, incorporating both biophysical monitoring and social surveys, to provide detailed information about both environmental impacts and visitor preferences are rare. Smith and Newsome (2002) is one example. However, this combined approach added scope and breadth to the study even though extra time was required to research different disciplines for literature reviews, and to develop two different research methods, to conduct separate field trips (because the seasonal requirements for the two research methods were not compatible), and to enter and analyse two different data sets. The information generated from this holistic approach is particularly valuable in providing initial snapshot information on the related topics of who the campers are, what they do, and the environmental impacts that therefore ensue.

Concern in this multidisciplinary case study was primarily for the fragility of the Ningaloo coastal environment, which was why most detailed consideration was given to the analysis and discussion of the impact assessment results. The resources drawn from the surrounding regional centres and the waste deposited along the Ningaloo coast also impact on the health of the environment; hence resource use by campers was also investigated. It is also acknowledged that it is desirable for campers to enjoy the Ningaloo coast, ideally in the manner that they desire. However, the environment and its management was the primary focus of this research. Understanding of the implication of different management regimes to arid coastal environment was the leading contribution from this thesis, which is why the environmental focus was of highest priority.

Major research questions and themes of research surrounding recreation impacts and management in wilderness areas have been examined by Leung and Marion (2000), of which this study addressed three for vehicle accessed remote campsites within a coastal, semi-arid environment: What factors contribute to the problem? How effective are visitor and site management actions? And; how can research and impact assessment methods be improved? These themes are explored within outcomes of objectives presented below. This thesis concludes with study contributions of this research.

10.1 RESEARCH OBJECTIVES

Findings surrounding the five research questions and their associated objectives are summarised below.

Do similarities exist between the nine management areas within the study area with regard to regulation, access, cost and facilities?

The associated objectives were to:

- *Develop a technique to group management areas for analytical purposes, in order to better understand the relationships between the management strategies and user preferences, resource use and visitor impacts*.

A clustering method was developed to assist in answering the null hypothesis that similarities do not exist between the seven management areas within the study area with regard to regulation, access, cost and facilities. The clustering method built on the concepts utilised by Shafer (1969) and later Choi and Dawson (2002.). Shafer (1969) stated that survey locations should be grouped by campgrounds which contain comparable characteristics. To achieve large sample sizes for analytical purposes, \the potential for the development of (a) a (statistically verifiable) continuum of management regimes in Ningaloo and (b) the possibility of then comparing data obtained from these internally similar management groups to assess whether they differ in terms of camper preferences, resource use or environmental impact was explored.

For this study, nine management variables which reflect levels of regulation along the Ningaloo coast were selected. Six of the nine variables were derived directly from the campsite impact assessment inventory pro forma. The remaining three management variables ‘management presence’, ‘site hardening’ and ‘access’ were adapted from the literature to suit the camping contexts at Ningaloo. The variable, ‘number of campsites in one camp area’, as used by Shafer (1969) was not directly suitable. Within one management area at Ningaloo, there were up to eight different camp areas. Therefore the variable ‘number of campsites within a 50 m radius’ was utilised instead.

Generating similar clusters of management groups was undertaken both to allow for stronger statistical analysis (four clusters rather than nine management areas) and to provide anonymity for the management areas concerned. The clustering method was effective in this instance as all management areas included in the study had similar histories (pastoral) in a similar climate with similar vegetation species present. The main difference was that differences existed regard to management and facilities.

When applying the clustering method to other locations, challenges may be found when management areas in locations with different areas topography, climate, vegetation or land-use history. In addition to grouping similar campgrounds for analysis, Shafer (1969) also recommends stratifying the survey temporally into monthly intervals. However, due to time limitations of this study, the additional temporal analysis by was not feasible.

- *Identify four similar management clusters to use as a basis for data analysis throughout the research*

The nine management areas were initially placed, from prior knowledge of the area, into one of four management clusters. The clusters increased in regulation numerically, with Cluster 1 being the least regulated and Cluster 4 the most regulated. Results from the one-way ANOVA revealed that significant differences existed between the clusters for each management variable, thereby rejecting the null hypothesis. Additionally, correlations comparing each management variable across the clusters were statistically significant; suggesting that all management variable values increase as cluster numbers, and therefore regulation levels, increase. These correlations thus supported a (statistically verifiable) continuum of management regimes in Ningaloo in the form of four campsite clusters. This research therefore argues that it is more important to understand the preferences and behaviours at sites as associated with management regimes than those of individual campers in recreational ecology. The basis for this argument is that understanding the impacts as site-specific and associated with management regimes is accurate and provable.

This research therefore focused on the four clusters of camp sites, which were compared to assess differences between the environmental impacts of the campsites, the environmental load (water, waste and energy) generated by the campers and camper preferences with regard to a range of campsite attributes. This research will aid in the understanding of the relationships between regulation, facilities, and campsite environmental impacts, as well as what campers regard as being important to their campsite choice and overall experience.

Do differences exist between the different management areas with regard to camper demographics, their activities and campsite preferences along the Ningaloo coast?

The associated objectives were to:

- *Develop a questionnaire to better understand camper demographics, their activities and their campsite preferences along the Ningaloo coast*

This research argued that it is more important to understand the preferences at sites as associated with management regimes than those of individual campers in recreational ecology. As such, questionnaires were compared across management clusters rather than individual campers. The questionnaire format and content were based on the approach taken by Moore and Polley (2007) and Smith and Newsome (2002) then adapted to suit the objectives of this study. The visitor survey was organised into four parts. These questions were designed to gauge perceptions and opinions relating to current and future management of camping in the region, and current resource use. The questions in Part 1 addressed preferences concerning campsite site selection, distance to ocean, management preference and activities. Visitor demographics, such as age, gender and origin were recorded in Part 3 to compare these between clusters.

Whilst the questionnaire was effective in answering null hypotheses two and three, campers surveyed, Question 1a and 1b was not as clear and effective as it could have been. Confusion was created when ‘why did you choose this campsite’ was mistaken for ‘camp area’, resulting from questionnaire miswording. Structuring the questionnaire in a manner analogous to others used along the Ningaloo coast was therefore useful for comparative purposes. However, issues arose when comparing these results to other Ningaloo coast findings due to different study areas and, as a result of differing timing of surveys, different demographics. Bias may therefore exist due to the limited time frame for data collection.

- *Describe and compare the demographics, activities and campsite attribute preferences of campers across management regimes*

Significant differences were found between campers at the different clusters regarding their site preferences and activities, thereby proving the null hypothesis that significant differences exist between the clusters with regard to the respondents' campsite preferences. However, several activity and preference similarities between clusters also exist. Therefore, two different levels of preferences were found for the Ningaloo region for both campsite preferences and activities. These findings support the argument of this chapter that it is more important to understand the preferences at sites as associated with management regimes than those of individual campers in recreational ecology.

The first are preferences common to all clusters that reflect the regions' amenities as a remote coastal camping destination. The 'average' Ningaloo remote camper values the natural environment, solitude and beach access highly. A second level of preferences was identified through campsite cluster comparison whereby significant differences between preferences were found at different clusters for a variety of campsite attributes and activities. The different clusters contained distinctive camper subgroups differentiated through their demographics, repeat visitation patterns and preferred activities as indicated by previous research on campers at different campsites along the Ningaloo coast (Davies, Tonts et al. 2009; Jones, Hughes et al. 2009). For this reason, as suggested by Shafer (1969), grouping camper research findings across the whole of the Ningaloo coast would have resulted in the fabrication of a non-existent 'average' camper, and could provide findings which could be misleading for management. Thus, keeping results grouped into clusters provides more specific information about campers on the Ningaloo coast.

Additionally, positive and negative linear relationships for the importance of a number of campsite attributes relate to the level of campsite management being imposed were found. That is, some individual attributes were considered least important for Cluster 1 and most for Cluster 4 and vice versa. These findings support the argument of this chapter that it is more important to understand the preferences at sites as associated with management regimes than those of individual campers in recreational ecology.

Using camper preferences for management purposes would require consideration of:

4. The region as a whole in terms of its remote, wilderness-experience camping style preferred by all clusters
5. Area-specific considerations based on the cluster type categories identified within this study.

A uniform management approach for remote campsites across the entire Ningaloo region is therefore not recommended.

Within the literature, it is argued that camper preference studies cannot be compared or applied across different environments. Additionally, the preferences found to be important in this study (litter, price, seclusion, distance from water) were consistent with those in the international literature. Despite these similarities however, relying on the international preference literature to aid management at Ningaloo is likely to result in inaccuracies due to several characteristics of Ningaloo's unique remote camping situation, specifically length of stay, remoteness and car-based accessibility. It is therefore recommended that, since the different clusters exhibit different camper preferences, demographics and activities, the redevelopment and / or removal of remote camping areas to be undertaken on a case-by case basis.

Do differences exist between the different management areas with regard to resource use?

The associated objective was to:

- *Describe and compare resource use across the different management regimes*

Many significant differences exist between the clusters for a variety of the resource-use criteria, thereby disproving the null hypothesis that differences in management regimes produce no significant differences in this regard. Based on these results, there was no significant difference between the clusters for the amounts of rubbish produced per campsite, but there were significant differences for amount of water and energy used per campsite. While remote campers use far less water than all other accommodation types, and produce a similar amount of rubbish to visitors in regional centres, some clusters consume more energy than full amenity caravan parks or hotels. This is presumably due to long periods of stay which cause them to bring numerous appliances, combined with their use of power generators which are less efficient than the power sources available in regional centres.

Despite the differing levels of management oversight, environmental concerns existed in all clusters. The occurrence of dumping sewerage in the dunes did not vary significantly across the clusters, nor did the large amounts of rubbish deposited within the coastal areas by campers. However, bias may have resulted from questionnaire responses surrounding waste management due to the stigma of the 'right' thing to do. Therefore, the dumping of sewerage in locations such as 'in the dunes' may be more prevalent than what was presented in the results.

Other findings included:

1. Remote campers supply their own water and consume less than 10 L per person per day, derived mainly from public taps, shops, home or Caravan Parks.
2. Rubbish is principally disposed of on-site into campsite bins or station tips.
3. Sewerage from portable toilets is primarily disposed of in shire and station dump points, though the responses to this question also included ‘in dunes’, ‘side of road’ and ‘pit next to tip’.
4. In camp areas that do not provide toilets, it was found approximately one in six campers did not carry portable toilets.
5. Renewable energy is popular among the campers; with primary sources of power being, equally, generators, solar and dual battery.

Despite the differing levels of management oversight, environmental concerns exist in all the clusters. The occurrence of dumping sewerage into dunes was not significantly different across the clusters, or was the amount of rubbish deposited by campers within coastal areas. The lack of toilets being provided by campers in those management areas that do not supply them was also of concern. Since sewerage presents the greatest health and environmental risks at the campsites, it is recommended that the provision of greater numbers of dump points or toilets be considered. The drop toilets at Red Bluff, which are supplied with sawdust and hand sanitiser are the most aesthetic and efficient waterless toilet system in the region.

Do differences exist between the different management areas with regard to the environmental impacts of camping?

The associated objectives were to:

- *Develop a new quantitative measurement system, involving inventory indicators, impact indicators and summary indices for assessing the biophysical impacts of camping within a semi-arid coastal environment*

As highlighted in the methods section, Monz (1998) found that, although the modification of existing campsite monitoring protocols to apply them to non-forested ecosystems was challenging, overall the original methods were applicable to coastal ecosystems. Because recreational impacts differ between ecosystems (Buckley, Pickering et al. 2006, p.84), the methods for this study were further adapted to suit the Ningaloo environment. This study supports the argument that, overall, the methods within the recreation ecology literature can be adapted and applied to coastal environments. For this study, a multi-indicator approach using quantitative counts and ratings was utilised rather than a condition class approach utilised by Monz (1998), due to both the increased accuracy of this method and diversity of the individual campsites along the Ningaloo coast. Impact indicators omitted from this study were ‘condition class’, ‘stumps/cut shrubs’, ‘root exposure’, ‘tree damage’, and ‘mineral soil loss’ since they were not applicable to the local environmental conditions. However, the impact indicators ‘social trail width’ and ‘social trail depth’ were added to test whether they were a precursor to campsite expansion. This study also added a number of inventory indicators, including ‘distance to the nearest campsite’, ‘number of campsites within a 50m radius’ and ‘vegetation type’ in order to test both independent and management parameters. The addition of these indicators was very useful for this study because it was an exploratory census, where understanding what affected the magnitude of the environmental impacts was the topic of primary interest.

A four-level rating system was used to assess vegetation damage for this study. However, a more detailed rating system would have yielded more specific results to compare against clusters. This more detailed rating system was not selected as it was more time consuming, and survey time was one limitation of this study. Bias may have also resulted from the primary researcher not having a botanist background and thus challenges existed when deciphering vegetation damage against a natural dormant life phase. To overcome these subjective assessments, only one researcher was used to provide consistency to the findings.

Challenges arose when using the geometric shape method to measure campsite area. One campsite in Cluster 2 had fifteen different geometric shapes and took over one hour to measure, while the smaller campsites with one geometric shape would take only 15 minutes. If another land-based study is required, consideration could be given to using remote sensing instead (Bunning 2008; Kobryn, Pinnel et al. 2008). However, initial collection of camp area data by the geometric method is essential for ground-truthing to assist in the interpretation of any subsequent data obtained from satellite images.

Two of the three indices, Coastal Vegetation Loss (CVL) and Area of Coastal Vegetation Loss (ACVL) were adapted from indices developed by Monz (2010) and Cole (1989) respectively. Vegetation percentage cover data was derived from photographs taken for each sampled campsite, from the campsite area, campsite perimeter and campsite boundary and placed into one of six cover classes. Assessing photographs to determine the CVL and ACVL was an effective method to reduce field work time, yet collect data that was of the desired accuracy for analysis purposes. Photographs were beneficial as they focused down onto the ground to determine vegetation density. One challenge with collecting accurate data at the study area was that individual campsite boundary areas (or ‘control’ areas) may also have been be disturbed in the past, by livestock or anthropogenic impacts. This method of using photographs would be transferrable to other environmental locals for research studies which have a limited survey period.

Campsites along the Ningaloo coast more often than not comprise both a vegetative area and a barren core area within the campsite area, creating a challenge in applying the ACVL index. Calculations by Monz (2010) and Cole (1989) were considered accurate only if estimates of cover are representative of the entire campsite and are not biased toward either the more de-vegetated campsite core, or the more vegetated periphery. The amended calculation therefore took into consideration the ratio of campsite that was barren against the vegetated areas and the he ACVL was found to be a slightly more accurate version of campsite area. If creating methodologies for other surveys whereby a high level of accuracy is not required and available time for analysis is limited, the original campsite area impact variable may in itself be suitable.

- *Characterise the extent and intensity of environmental impacts, and assess variations in the intensity of the impact indicators at campsites with different management regimes along the Ningaloo coast*

The differences between management clusters with regard to inventory variables, impact variables and impact indices were measured in order to test the null hypothesis that there is no significant difference between the clusters with regard to campsite impacts. Significant differences were found across the clusters for all three variable types, thereby disproving the null hypothesis. In fact, only a few inventory and impact variables exhibited no significant differences between the clusters. These included distance of campsites from the ocean, damage to vegetation types at campsites for those sites which have vegetation within their campsite areas, vegetation damage to most vegetation types at the campsite perimeter and social trail numbers.

As with camper preferences along the Ningaloo coast the results pertained to two different scales. Both levels of findings identify impacts specific to certain management locales, which support the basis for this chapters' argument that understanding the impacts as site-specific and associated with management regimes places responsibility for impacts with management rather than individual campers.

Significant negative correlations were found for the three impact indices to indicate that, as cluster number, or management presence, increases, overall environmental impact decreases. However, that despite these general correlations, all clusters contained variables on which they scored well and on which they scored poorly. There were no clusters which exhibited no adverse environmental impacts. Additional impacts viewed offsite which may affect campsite impacts include prevalent use of four-wheel drive vehicles which damages surrounding vegetation and the presence of goats and other livestock.

By understanding each cluster's specific characteristics and vulnerabilities, adverse environmental impacts may be ameliorated through equally specific management initiatives. Individual campsite impacts should also be considered. Variables relating to vegetation loss, including campsite area, barren core area and CVL had the largest influence on CCII scores. Campsites with low CCII scores were also orientated in a way that facilitated easy access to their desired destinations, such as bathrooms and the ocean, which reduced the need for multiple social trails and associated larger social trail width variables. A uniform management approach for remote campsites across the entire Ningaloo region is therefore not recommended.

However, it should be borne in mind that the adverse environmental impacts may not have been solely produced by camping given that the study area has also been impacted and influenced by livestock and invasive plant species due to past and current pastoral use. Further study by a botanist to identify native, hardy plant species that are resistant to human trampling is warranted for rehabilitation purposes across all clusters. Whether fewer impacts are created by having fewer visitors for longer period of time, or more visitors for shorter periods of time warrants further investigation.

Does management level alone influence the environmental impacts which result from coastal camping?

The associated objective was to:

- *Describe and compare the relationships between the environmental impact indicators and both management and independent variables*

This question sought to test the null hypothesis that differences in the environmental impacts of camping along the Ningaloo coast are due to regulation and management factors alone. The null hypothesis was rejected because significant correlations also existed with factors other than management variables, including other impact variables and the independent variables of substrate and vegetation.

Relationships between impacts found that the impact variable ‘barren core area’ correlates significantly to ‘vegetation loss’, ‘fire pits’, ‘social trail number’, ‘social trail widths’, ‘litter’ and ‘campsite area’. This suggests that if ‘barren core area’ is reduced, the other factors associated with it may also decrease. With regard to management, ‘barren core area’ is primarily affected by density of campsites – a small number of campsites in a 50m radius and increased distance between campsites contributes to a larger barren core area. Also, ‘barren core area’ is has significantly negative correlations with larger shrubs such as spinifex, salt bush and small shrubs (as opposed to grass). Therefore, by adapting a confined rather than dispersed campsite layout and encouraging the regeneration of larger native plant species, the size of the barren core area and its related impact variables may also be reduced along the Ningaloo coast.

With regard to monitoring indicators, in addition to ‘barren core area’, ‘ACVL’ was also significantly correlated with a large number of other impact variables (‘CVL’, ‘campsite area’, ‘barren core area’ and ‘fire pits’). ‘Campsite area’ and ‘barren core area’ are therefore a strong predictor of absolute damaged area and is therefore an important factor for managers to consider. These two factors may therefore be useful indicators for the purpose of future monitoring along the Ningaloo coast.

Independent factors substrate and vegetation type were correlated against eight impact variables. The presence of ‘soft sand’, common in beach and dune locations, was positively correlated with ‘ACVL’. However, ‘compact sand’ was common in the presence of ‘grasses’, which are highly susceptible to damage. Additionally, large shrubs such as ‘spinifex’, ‘salt bushes’ and ‘small shrubs’ had significant negative correlations with impact variables of both ‘social trail number’, ‘total social trail width’ and ‘barren core area’. Therefore it is advisable to rehabilitate areas with larger, rather than smaller, shrubs and grasses to reduce future visitor impacts on vegetation.

Correlations between the management variable of ‘campsite distribution’ with impact variables suggest containment strategies aid in reducing: ‘ACVL’, ‘CVL’, ‘barren core area’, ‘fire pits’ and ‘vegetation damage’. Therefore within a coastal camping area, containment strategies can be an effective method of both avoiding disturbed area increases and preventing several other adverse impact variables.

Correlations between the management variables of ‘site hardening’, ‘management presence’ and ‘access’ with impact variables suggests that an increase in these management variables results in a decrease of: ‘ACVL’, ‘CVL’, ‘fire pits’, ‘vegetation damage’ and ‘campsite area’. While the least regulated sites have the greatest campsite spread, leading to larger campsite areas, the more regulated sites have site hardening strategies in place such as wooden barriers. Due to the high accessibility of Cluster 4, this cluster sees the largest number and turnover of visitors of all study areas. Therefore it has a high amount of perimeter vegetation damage around the hardened sites. However, the site hardening and caretaker presence saw that site impacts through vegetation loss were still lower than the lesser-used undesignated areas. Correlations between the management variable of 'facilities' with impact variables suggest facilities have very little influence on impact variables.

While it may be expected that there would be a correlation between litter and the distance to a garbage bin or tip, negligible correlations existed. This is likely because of environmental stewardship at undesignated sites of long-stay campers and better waste management strategies.

10.2 MANAGEMENT CONSIDERATIONS

This section highlights additional management considerations further to discussion on those management variables which affect magnitude of impact discussed in section 9.4.2.

As previously mentioned, park managers in the United States subscribe to the term "intensive use must be managed intensively" (Park 2013). Clearly this term reflects Cluster 4's and to a certain degree also Cluster 3's level of use and resultant management strategy. Whether visitors can be excluded from nondurable surfaces (Blackwell 2002; Leeden 2003; Hahesy 2004) or durable surface pads for campers should be put into place, and how this fits with the wilderness experience along the Ningaloo coast requires further examination with regard to carrying capacity.

For Clusters 1 and 2, aesthetically pleasing, well-maintained toilets and sewerage dump points are currently of the highest necessity. Basic campsite boundaries, campsite numbering (as had been put in place at Fourteen Mile) and education to use existing paths are also necessary. As suggested by Jones (2009), any form of regulations in Clusters 1 and 2 would be best received by campers if coming from the station management themselves and not from Government regulators. This has proven successful at Warroora station when 'prime' waterfront campsite areas were changed given a two-week stay limit. Livestock, especially goats, in the coastal zone were found to place additional stress on coastal vegetation and should be removed from within coastal area.

Seven factors identified as affecting the magnitude of impact within the literature were supported by this research as also being applicable to Ningaloo coast and likely coastal areas in other locations: vegetation density, vegetation resistance and resilience, soil characteristics, wildlife impacts, use distribution, and user behaviour. Additionally, six management strategies were found to affect the magnitude of environmental impact along the Ningaloo coast: design and orientation of campsite, management presence, campsite designation and labelling, trail barriers and campsite boundaries, toilets and sewerage dump points, and using impact variables which have high correlations with other impact variables such as barren core area and ACVL as key indicators for monitoring campsite impacts. As outlined within the introduction of this Chapter (section 9.1), these independent variables are elements that management should take into account, not caveats that disprove the importance of site-specific impacts associated with management regimes. Whether these factors are also applicable in different environments requires further research.

While it is very important to maintain visitor satisfaction levels in natural areas as discussed in section 3.2.1, challenges arise when the preferences of visitors cause physical environmental impact. The balance between satisfying the needs of visitors and maintaining environmental integrity (through management) ultimately comes down to politics, policies and laws in place to protect the natural area. Camp areas within this study area are located within both a marine park and a World Heritage area. Whilst development and commercial activities can and do occur in World Heritage places around the world, whether environmental standards and expectations of these accolades are being upheld through current camping and recreation practices warrants examination.

10.3 CONTRIBUTIONS AND FUTURE RESEARCH

Research on vehicle-accessible camping sites and their visitors in coastal protected areas is limited while empirical evaluation of management influence is scarce. The lack of baseline and current conditions data has limited management effectiveness, such as setting management priorities and selecting impact management strategies. The thesis addresses this significant research gap by focusing on the influence of management regimes and oversight on visitor preferences, resource use and environmental impacts using an integrated biophysical-social science methodology. The identified relationships between management variables and impact and use variables contribute significantly to conceptual understanding in recreation ecology and recreation sciences.

One key contribution of this thesis lies in the integrated methodology that was informed by past research in recreation ecology and social science and adapted for the coastal environments. The resource use and impact assessment procedures as well as the construction of the three summary impact indices (CVL, ACVL, CCII) may be evaluated and/or applied by other researchers and managers interested in this topic. The four campsite ‘management’ clusters identified in the thesis provide an effective framework in which comparisons on visitor, resource use and impact variables are made. This classification distinguishes some common styles of management in Australia’s protected areas. Such an analytical approach may be valuable to researchers in recreation ecology or protected area management, even though the exact clusters would vary in different study areas.

Whilst the Ningaloo coast has many features which make it unique to other locations studies within the recreation ecology literature (section 1.1), theories generated and methods developed to suit coastal, semi aid environments may be transferrable to other such locations. As such, a number of findings pertaining to coastal camping and the impact of different management regimes in arid coastal environments emanate from this study.

One theory contributed by this research was that it is more important to understand the preferences and behaviours at sites as associated with management regimes than those of individual campers in recreational ecology, building on work by Shafer (1969) and the ‘average camper who doesn’t exist’. The basis for this argument is that understanding the impacts as site-specific and associated with management regimes (1) is accurate and provable, (2) emphasises the importance of tenure and management to the social-ecological systems that produce and are produced by recreation, and (3) places responsibility for impacts with management rather than individual campers (or rather, specific management regimes are attractive to campers who desire or have a connection with a location that involves stewardship). The independent variables are elements that management should take into account, not caveats that disprove the importance of this division. These topics were examined through the five results chapters.

This thesis therefore expands knowledge by (a) disaggregating the myth of the 'average camper' (b) contributing to three common research themes for coastal and semi-arid environments from within the recreation ecology literature (c) applying analytical techniques from elsewhere in a completely different ecological and camping context ('arid coastal' and 'drive in') and (d) applied value by virtue of baseline data and management recommendations for the Ningaloo region.

Future Research

- Additional key values of the Ningaloo Coast include the striking natural landscapes and diversity of flora and fauna of Cape Range and Ningaloo Reef (Department of Environment and Conservation 2011). Whilst development and commercial activities can and do occur in World Heritage places around the world, whether environmental standards and expectations of these accolades are being upheld through current camping and recreation practices warrants examination.

- To limit future camping impacts along the coastline, it is recommended visitors be directed to highly resistant campsites, away from fragile areas where small amounts of use can have lasting effects. These containment strategies could be integrated with spatial configuration strategies when new campsites are designed, since campsite movement patterns are influenced by the site layouts (Leung and Marion 2004) (Figure 3.5). Understanding campers' needs, preferences and activity patterns is necessary for the success of this integrated system. Smallwood (2011) studied visitor activity movements throughout the Ningaloo coast, but studies on a finer scale may be warranted to understand local activity patterns in relation to campsites.

- In all, seven factors identified as affecting the magnitude of impact within the literature were supported by this research as also being applicable to coastal areas. Additionally, six management strategies were added to the list as applicable to coastal areas. As outlined within the introduction of this Chapter (section 9.1), these independent variables are elements that management should take into account, not caveats that disprove the importance of site-specific impacts associated with management regimes. Whether these factors are also applicable in different coastal environments warrants further research.

- Further study by a botanist to identify native, hardy plant species that are resistant to human trampling is warranted for rehabilitation purposes across all clusters.

- That Clusters 3 and 4 have a lower CCII, may reflect site durability which is in turn a reflection of management actions. Whether fewer impacts are created by having fewer visitors for longer period of time, or more visitors for shorter periods of time warrants further investigation.

- Park managers in the United States subscribe to the term "intensive use must be managed intensively" (Park 2013). This term reflects Cluster 4's level of use and resultant management approach and to a certain degree also Cluster 3's. Whether visitors can be excluded from nondurable surfaces (Blackwell 2002; Leeden 2003; Hahesy 2004) or durable surface pads for campers should be put into place, and how this fits with the wilderness experience along the Ningaloo coast requires further examination.

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Appendices

Appendix A
Campsite Area Maps

Maps within Appendix A are presented north to south for ease of geographical orientation. Campsites present in each camp area are shaded green. Campsites sampled as part of the impact assessment method (N = 225) are also numbered. Numbering of the campsites are in increasing order from the least regulated to most regulated management areas, from north to south within each management area. Therefore, campsites with a higher number (up to 225) are more regulated. Each Map has a figure number, presented below in Table 1.

Table 1: Figure Number of each Map presented within Appendix A.

Management Area	**Camp Area**	**Figure Number**
Cape Range National Park		
	Neds Camp	1
	Mesa	2
	T bone	3
	Lakeside	4
	Tulki	5
	Pilgramunna	6
	Osprey Bay	7
Learmonth Air Weapons ‘Bombing’ Range		
	Doddies Camp and Sandy Point	8
Cardabia Station		
	Bruboodjoo (9 Mile) Camp	9
Warroora Station		
	Fourteen Mile Camp	10
	Sandy Point	11
	Elles Camp	12
	Steves Camp	13
	Lagoon	14
	Southern Boundary	15
Gnaraloo Station		
	Three Mile	16
Quobba Station		
	Red Bluff (Whole Camp Area)	17
	Red Bluff (South of the Office)	18
Blowholes		
	Blowholes Camp	19

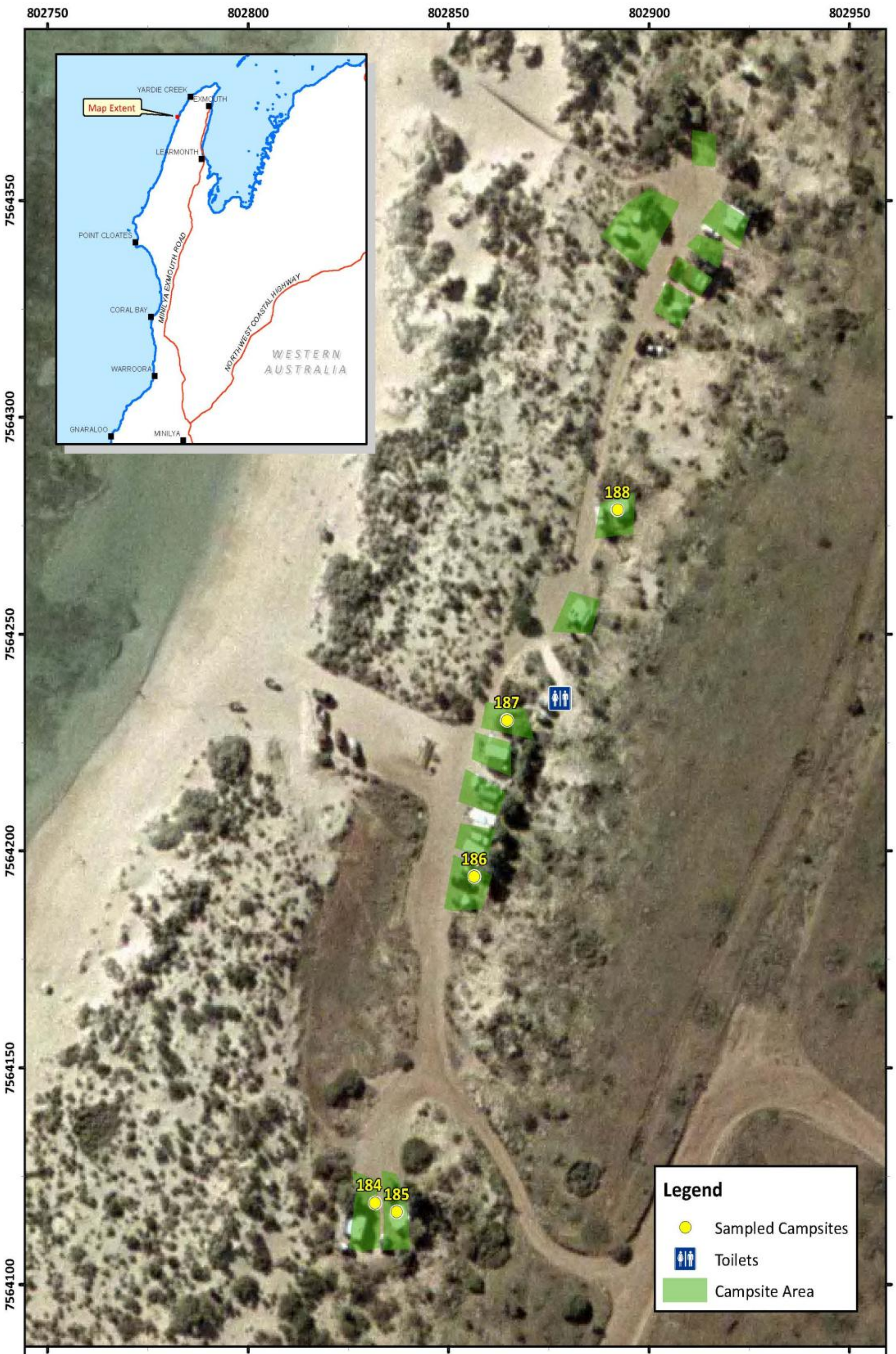

Figure 1: Ned's Camp - Cape Range National Park

Author: A. Lewis	Date: 21-06-2012	Datum: GDA 1994 Projection: MGA Zone 49 0 10 20 30 40 50 Metres N
Drawn: C. Dyde		

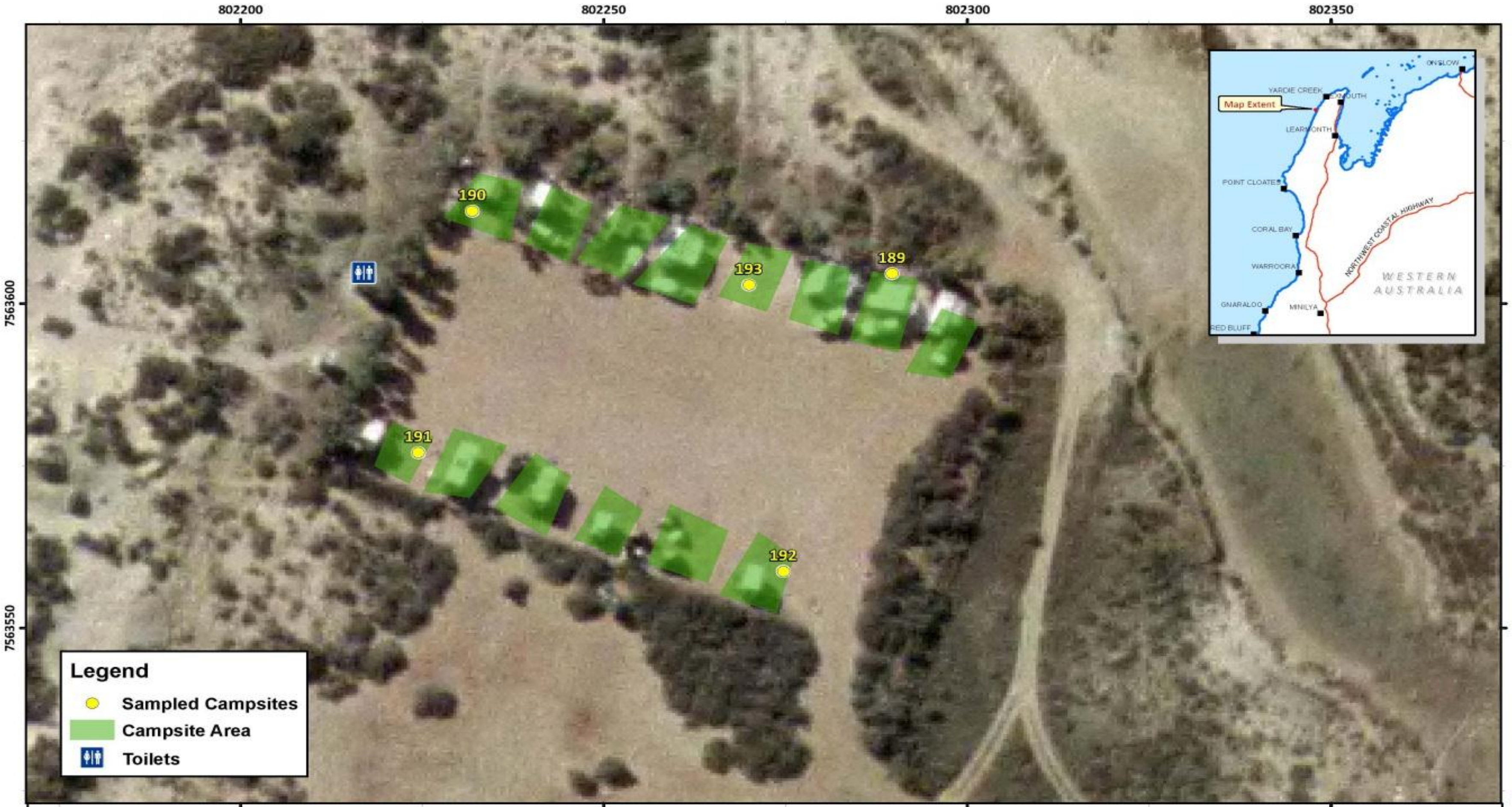

Figure 2: Mesa - Cape Range National Park

Author: A. Lewis | Drawn: C. Dyde | Date: 21-06-2012

Figure 3: T- Bone - Cape Range National Park

Datum: GDA 1994 - Projection: MGA Zone 49

0 10 20 30 Metres

N

Author: A. Lewis | Drawn: C. Dyde | Date: 21-06-2012

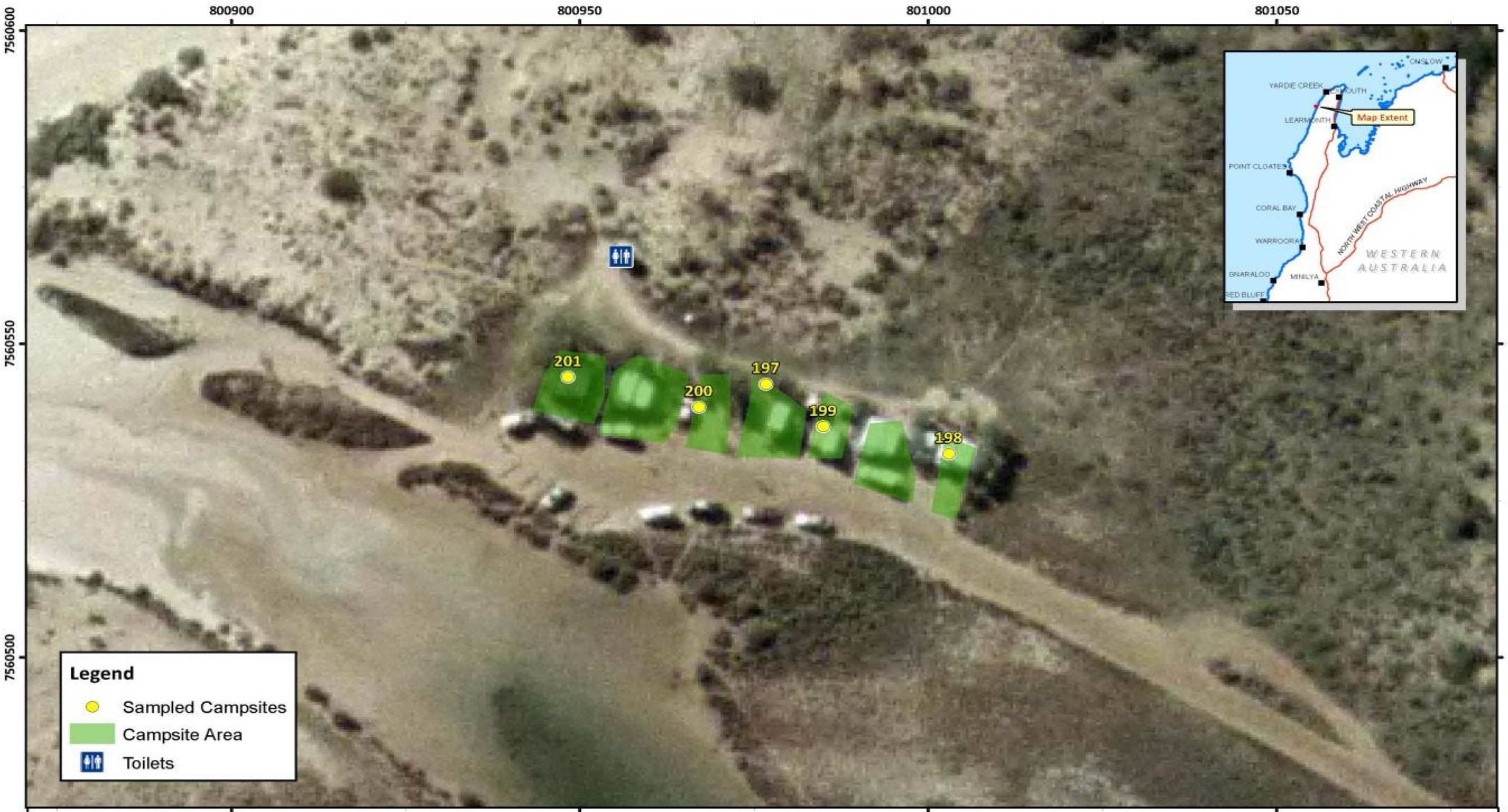

Figure 4: Lakeside - Cape Range National Park

Datum: GDA 1994 - Projection: MGA Zone 49

Metres 0 10 20 30

N

Author: A. Lewis | Drawn: C. Dyde | Date: 21-06-2012

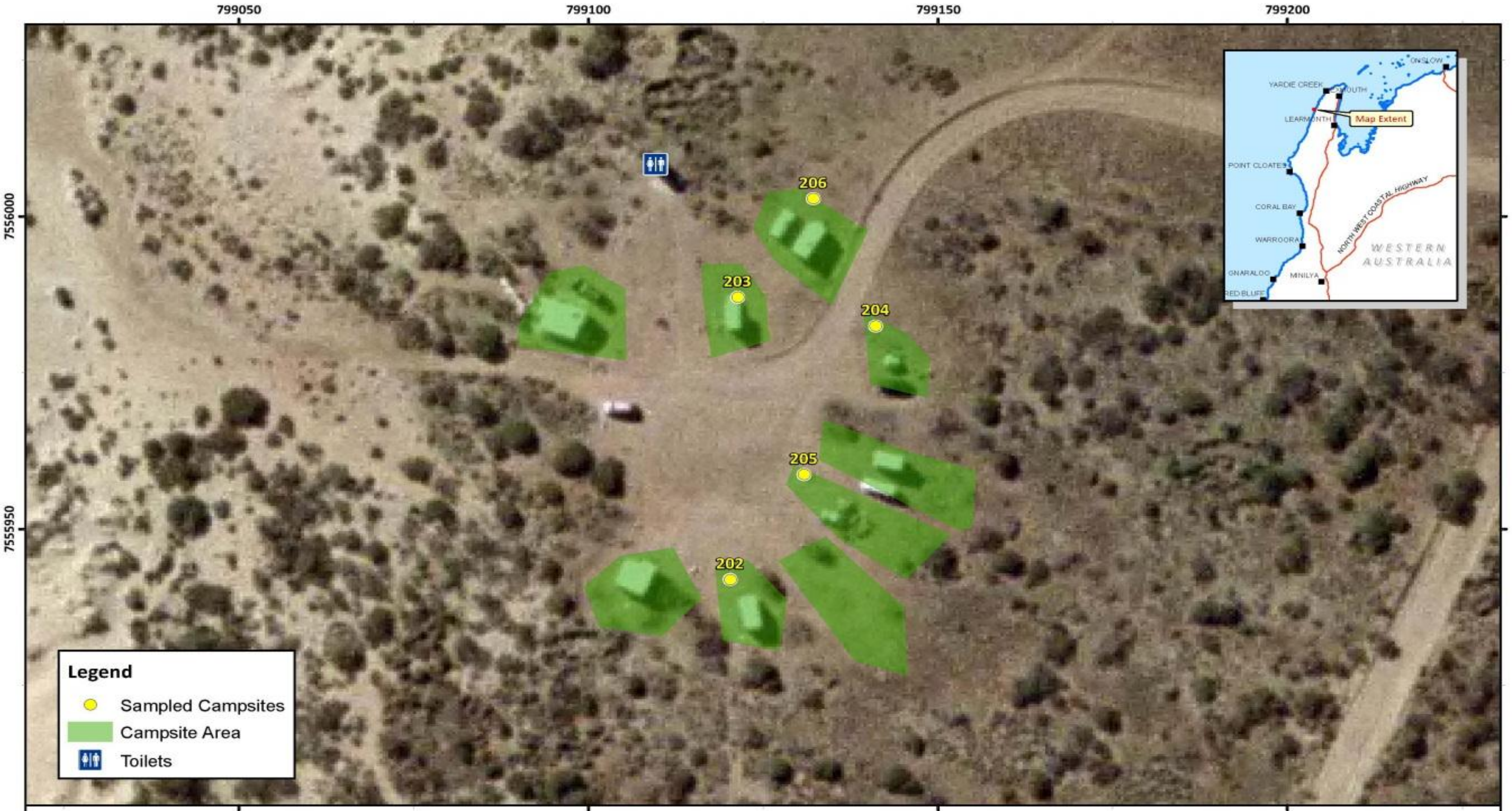

Figure 5: Tulki - Cape Range National Park

Datum: GDA 1994 - Projection: MGA Zone 49

0 10 20 30 Metres

N

Author: A. Lewis | Drawn: C. Dyde | Date: 21-06-2012

Figure 6: Pilgramunna - Cape Range National Park

Datum: GDA 1994 - Projection: MGA Zone 49

0 10 20 30 40 50 Metres

N

Author: A. Lewis | Drawn: C. Dyde | Date: 21-06-2012

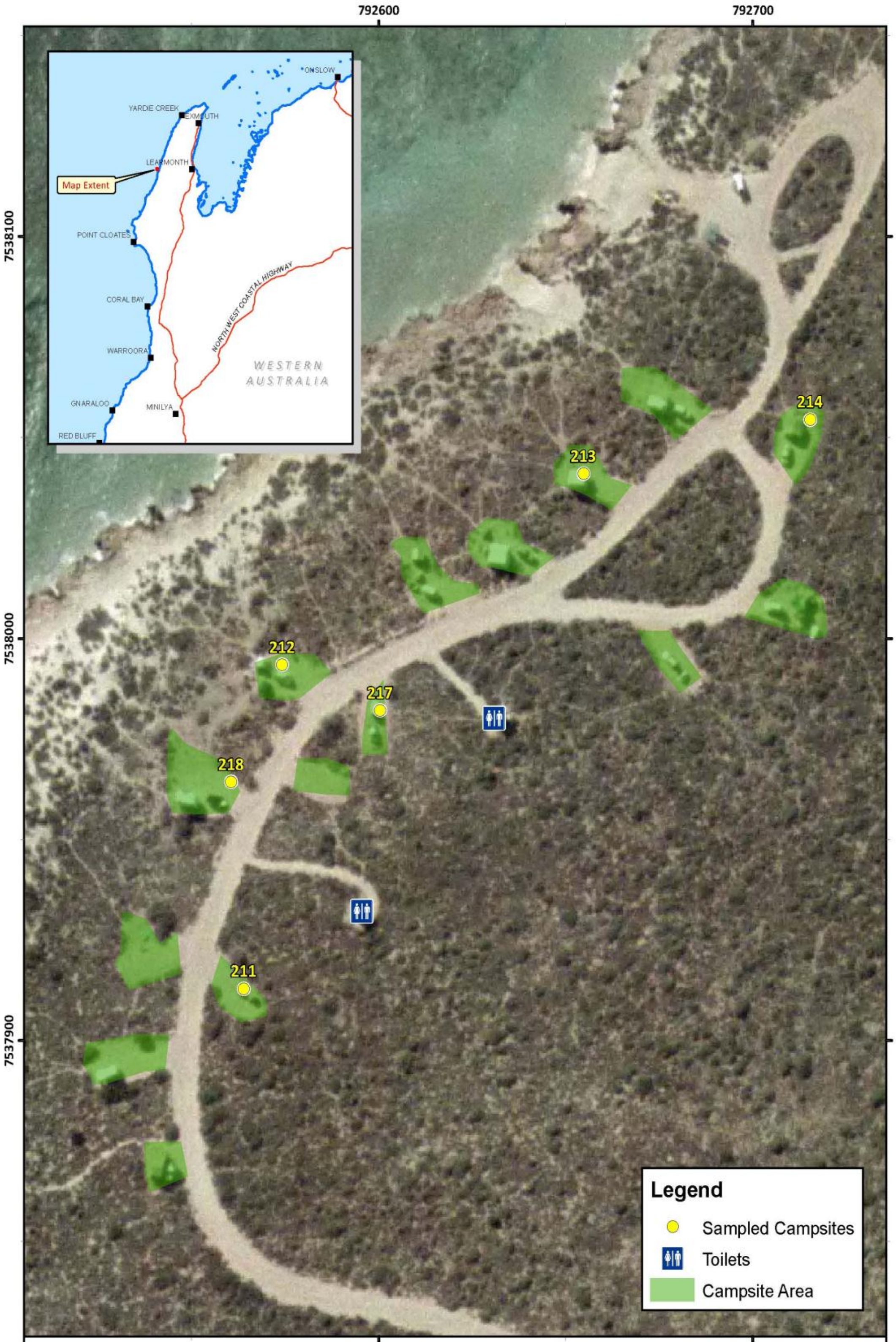

Figure 7: Osprey Bay - Cape Range National Park

Author: A. Lewis	Date: 21-06-2012	Datum: GDA 1994 - Projection: MGA Zone 49
Drawn: C. Dyde		0 10 20 30 40 50 Metres N

Figure 8: Doddies and Sandy Point - Learmonth Bombing Range

Datum: GDA 1994 - Projection: MGA Zone 49

Metres

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160

N

Author: A. Lewis | Drawn: C. Dyde | Date: 21-06-2012

Figure 9: 9 mile Camp - Cardabia

Datum: GDA 1994 - Projection: MGA Zone 49

0 50 100 150 200 Metres

N

Author: A. Lewis

Drawn: C. Dyde

Date: 21-06-2012

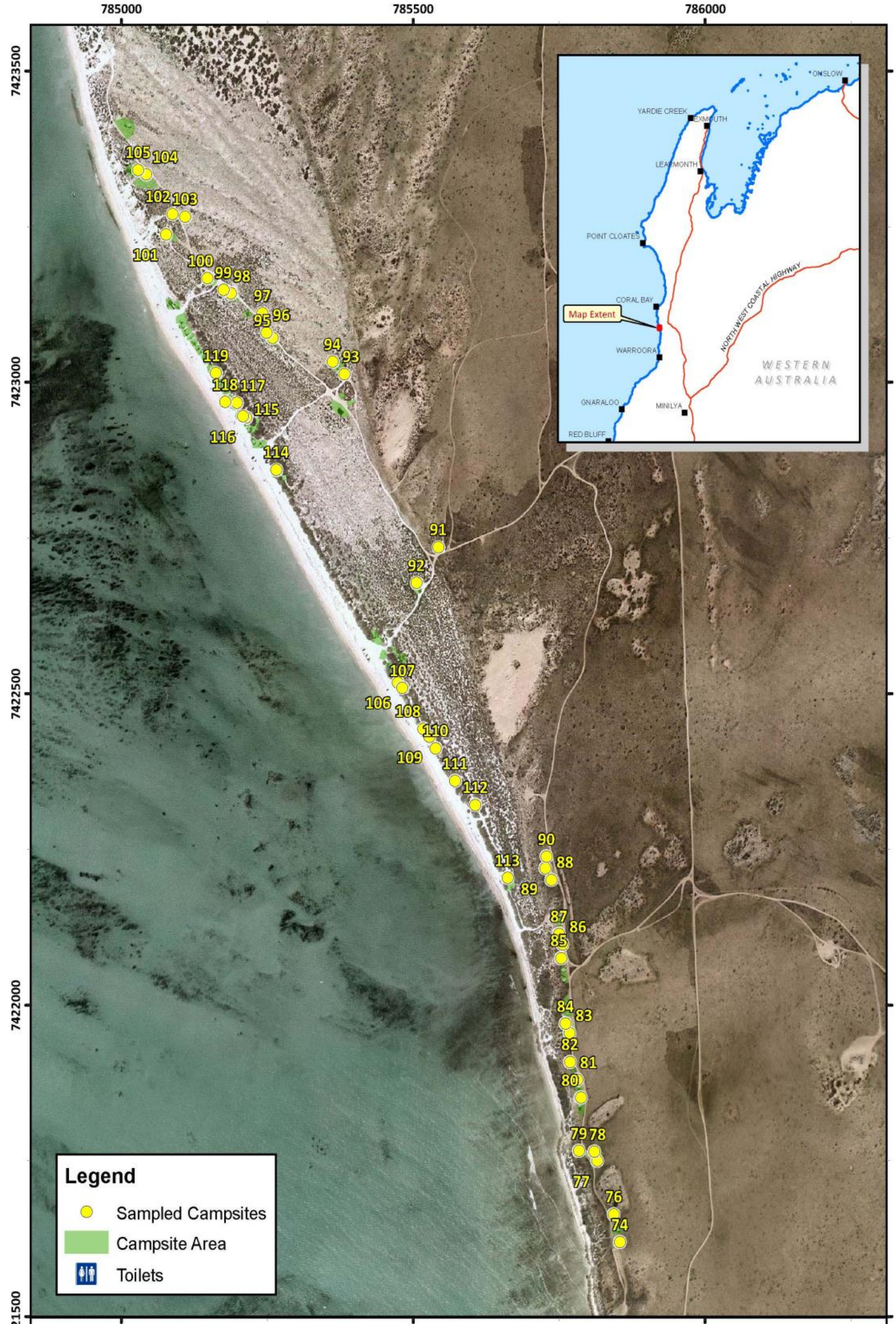

Figure 10: 14 Mile Camp - Warroora Station

Author: A. Lewis	Date: 21-06-2012	Datum: GDA 1994 - Projection: MGA Zone 49
Drawn: C. Dyde		0 100 200 300 Metres N

Figure 11: Sandy Point - Warroora Station

Author: A. Lewis	Date: 21-06-2012	Datum: GDA 1994 - Projection: MGA Zone 49
Drawn: C. Dyde		0 50 100 150 200 Metres N

Figure 12: Elles Camp - Warroora Station

Author: A. Lewis	Date: 21-06-2012	Datum: GDA 1994 - Projection: MGA Zone 49
Drawn: C. Dyde		0 50 100 150 200 250 300 Metres N

Figure 13: Steves Camp - Warroora Station

Author: A. Lewis	Date: 21-06-2012	Datum: GDA 1994 - Projection: MGA Zone 49
Drawn: C. Dyde		Metres 0 50 100 150 N

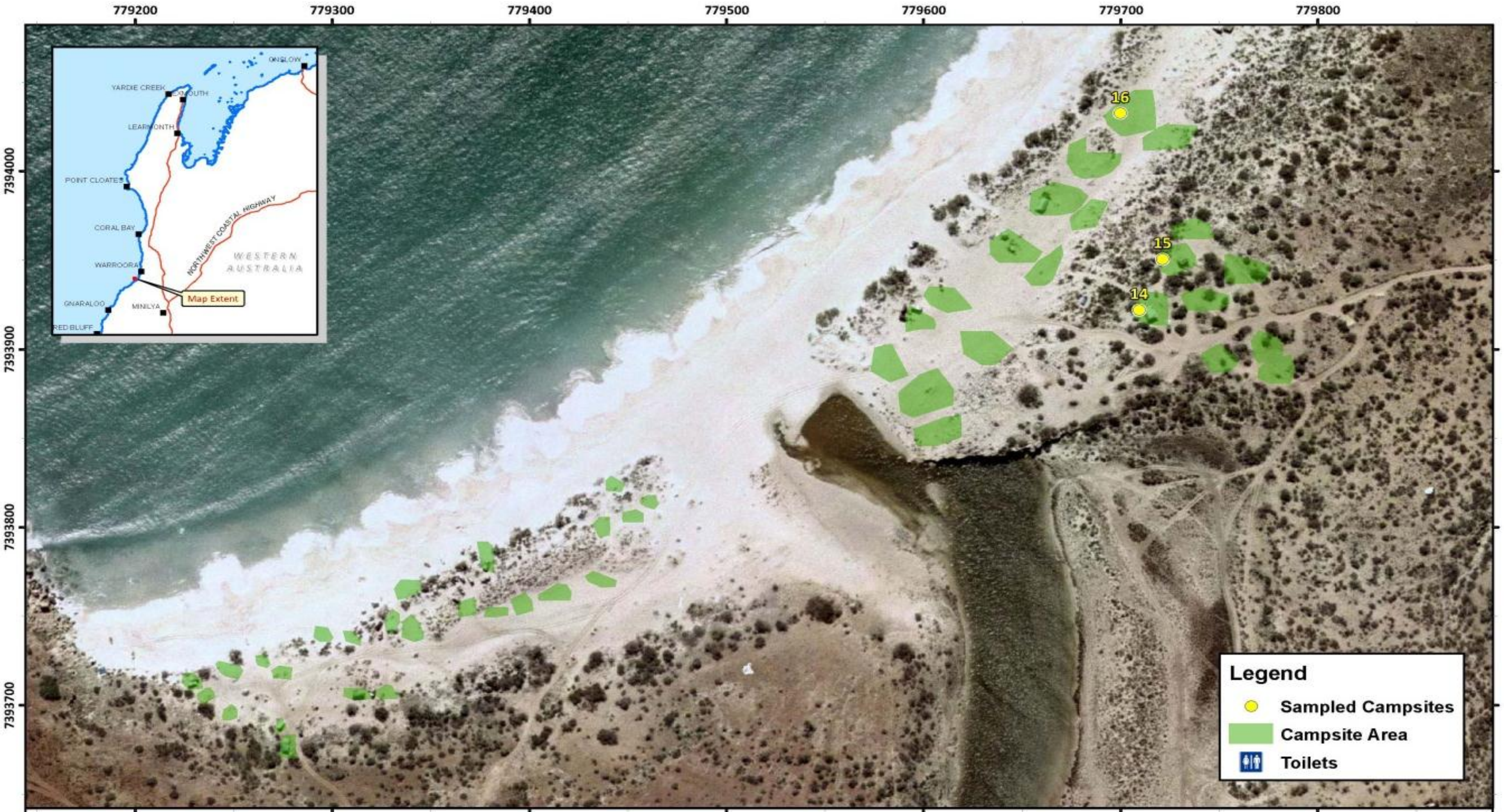

Figure 14: Lagoon - Warroora Station

Datum: GDA 1994 - Projection: MGA Zone 49

Metres 0 20 40 60 80 100

N

Author: A. Lewis

Drawn: C. Dyde

Date: 21-06-2012

Figure 15: Southern Boundary Camp - Warroora Station

Datum: GDA 1994 - Projection: MGA Zone 49

Metres: 0 10 20 30 40 50

N

Author: A. Lewis | Drawn: C. Dyde | Date: 21-06-2012

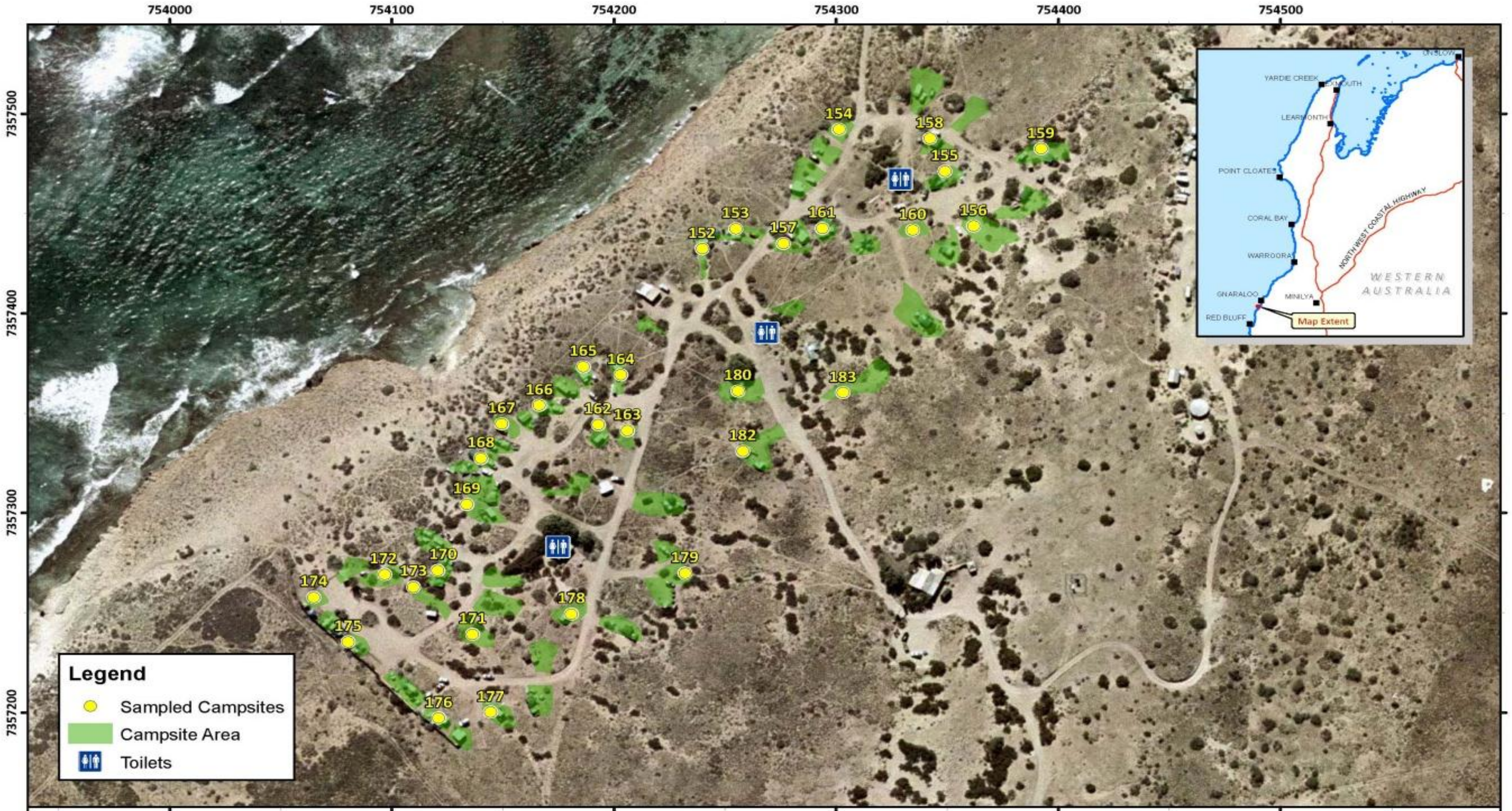

Figure 16: 3 Mile Camp - Gnaraloo Station

Datum: GDA 1994 - Projection: MGA Zone 49

0 20 40 60 80 100 Metres

N

Author: A. Lewis

Drawn: C. Dyde

Date: 21-06-2012

Figure 17: Red Bluff Camp - Quobba Station

Datum: GDA 1994 - Projection: MGA Zone 49

0 50 100 150 200 250 Metres

N

Author: A. Lewis

Drawn: C. Dyde

Date: 21-06-2012

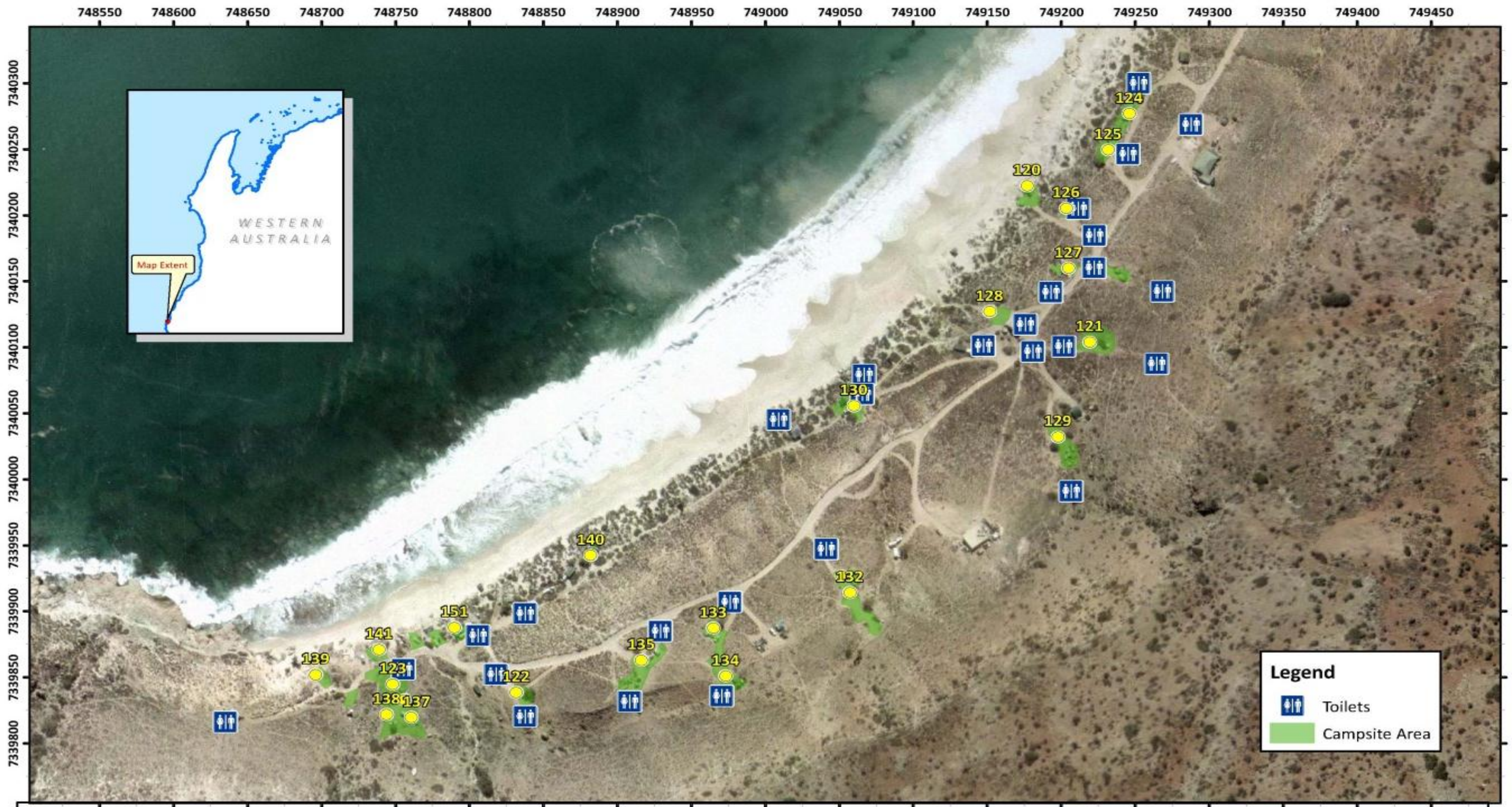

Figure 18: Red Bluff Camp - Quobba Station, South of the Office

Datum: GDA 1994 - Projection: MGA Zone 49

Metres
0 20 40 60 80 100 120 140

N

Author: A. Lewis   Drawn: C. Dyde   Date: 21-06-2012

Figure 19: Blowholes Camp - Shire of Carnarvon

Author: A. Lewis	Date: 21-06-2012	Datum: GDA 1994 Projection: MGA Zone 49 0 100 200 300 400 Metres N
Drawn: C. Dyde		

Figure 20: Blowholes Camp - Established Shack Area

Author: A. Lewis | Drawn: C. Dyde | Date: 21-06-2012

Appendix B
Management and Governance Documents pertaining to the Ningaloo Coast

Management Context						
The Ningaloo Coast	**Ningaloo Marine Park (Commonwealth waters)**	**Ningaloo Marine Park (State Waters)**	**Cape Range National Park**	**Proposed conservation and recreation areas ***	**Leasehold & freehold land incl. pastoral leases**	**Learmonth Air Weapons Range**
National planning	Ningaloo Coast World Heritage Strategic Management Framework (2009)					
WA regional planning	Ningaloo Coast regional strategy Carnarvon to Exmouth (2004)					
Commonwealth planning	Ningaloo Marine Park (Commonwealth Waters) interim management arrangements					Learmonth Air Weapons Range Management Plan (in preparation 2010)
WA State Government (provincial) planning		Management plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005–2015 (2005)	Cape Range National Park Draft Management Plan (final in preparation)	Management consistent with the objectives and underlying principles of the Cape Range National Park Management Plan conducted by the Department of Environment and Conservation	Management by pastoral lessees under the Pastoral Lands Board, other lessees and freehold owners, consistent with the Ningaloo Coast Regional Strategy Carnarvon to Exmouth.	

Governance Context						
The Ningaloo Coast	**Ningaloo Marine Park (Commonwealth waters)**	**Ningaloo Marine Park (State Waters)**	**Cape Range National Park**	**Proposed conservation and recreation areas ***	**Leasehold & freehold land incl. pastoral leases**	**Learmonth Air Weapons Range**
National governance	Environment Protection and Heritage Council & Australian World Heritage Advisory Committee					
	Ningaloo Coast World Heritage Advisory Committee					
Australian Government agencies	Department of the Environment, Water, Heritage and the Arts					Department of Defence
Western Australia (provincial) agencies	Department of Environment and Conservation & Department of Fisheries	Department of Environment and Conservation & Department of Fisheries	Department of Environment and Conservation	Department of Environment and Conservation	Department of Regional Development and Lands & Department of Environment and Conservation	
Local agencies		Shire of Exmouth	Shire of Exmouth	Shire of Exmouth & Shire of Carnarvon	Shire of Exmouth	

Management System						
The Ningaloo Coast	**Ningaloo Marine Park and (Commonwealth Waters)**	**Ningaloo Marine Park (State Waters**	**Cape Range National Park**	**Proposed conservation and recreation areas**	**Freehold owners and leaseholders**	**Learmonth Air Weapons Range Facility**
National planning	Ningaloo Coast World Heritage Strategic Management Framework (2009)					
WA regional planning	Ningaloo Coast regional strategy Carnarvon to Exmouth (2004)					
Common-wealth planning	Ningaloo Marine Park (Commonwealth Waters) interim management arrangements					Learmonth Air Weapons Range Management Plan (in preparation 2010)
WA State Government (provincial) planning		Management plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005–2015 (2005)	Cape Range National Park Draft Management Plan (final in preparation)	Management consistent with the objectives and underlying principles of the Cape Range National Park Management Plan conducted by the Department of Environment and Conservation	Management by pastoral lessees under the Pastoral Lands Board, other lessees and freehold owners, consistent with the Ningaloo Coast Regional Strategy Carnarvon to Exmouth.	

Appendix C
Demographics of Ningaloo Campers: Results from Previous Research

Preference findings from previous research at Ningaloo

Author	What testing	Preferences	CRNP (%)	Station (%)
Polley, Northcote and Moore (2008)	Reasons cited as extremely important for visit			
		To view scenery	38	N/A
		To be in and enjoy the natural environment	61.3	
		To learn about nature	17.7	N/A
		To enjoy outdoor activities	47.4	N/A
		To spend time with companions	36.9	N/A
		For solitude	21.4	N/A
		For a sense of adventure	19.3	N/A
Jones *et al* (2010)	Trip elements rated as important or very important			
		Importance of natural environment	96.5	90.9
		Importance of getting away from it all	68.2	81.2
		Importance of region's warm weather	71.2	77.5
		Importance of access to Ningaloo Reef	85.9	63.0
		Importance of fishing	28.2	57.2
		Importance of camping facilities	71.2	56.9
		Importance of going to viewpoints	51.	33.7
		Importance of toilet facilities	54.1	33.3
Galloway and Northcote (2008)	Natural features viewed as important			
		beaches	N/A	97.6 +93
		reef	N/A	94.6
		wilderness	N/A	69.3
		Landscape	N/A	67.5

		Ranges etc.	N/A	64.5
		wide open paddocks	N/A	51.8
		biodiversity	N/A	51.2
	Of high importance, other			
		being able to stay for long periods	N/A	84.6
		secluded campsites	N/A	83.4
		self-reliant camping	N/A	82.2
		solitude	N/A	71.6
Remote Research (2002)				
	what attracted campers to set up camp at their current location			
		Good fishing	N/A	69.9
		Scenic location	N/A	66.9
		Good boat mooring	N/A	55.6
		Sheltered site	N/A	45.9
		Meet friends	N/A	42.9
		Isolation	N/A	25.6

Appendix D
Preferences of Ningaloo Campers from Previous Studies

Author (s)	**Variable**	**Moore and Polley**	**Jones etal CRNP**	**Jones etal**	**Remote Research (2002)**	**Remote Research (2002)**	**Remote Research (2002)**	**Galloway and Northcote**	**Wood and Carlsen**	**Jones etal**
Study Area										
Demographics										
Sex										
	% Male		50.3	58.8				42		58.8
	% Female		49.7	41.2				55 (females seemed more likely to complete this survey)		41.2
Origin	Perth metro	39%			50%	55%		50%		
	Northwest	3%						6%		
	Southwest				25%	19%		17.3%		
	Goldfields							2.4%		
	Central/Murchison							2.4%		
	Great Southern							11.9		
	Regional WA							39.9		

	Other WA areas	16%			7%	22%				
	Western Australia	58	26.5	71.9	82	96		89.9	79%	71.9
	Interstate	27	42.4	18.6	8	3		5.4%	17%	18.6
	International	15	31.2	9.5	1	1		1.8%	4%	9.5
	Unknown				8					
	No fixed address							3%		
Repeat visitors	Repeat visitor? yes	33%			87%(no significant difference regarding origin of campers)	77%		80.6%		
	Stay longer than 22 days				45%			59.5%		
	How often visit including current visit?							1.1 times/year (SD 0.25)		
	Intend to visit again in future?							91.7% yes		
	Times visited in last 10 years including current visit?							5.5 (SD = 3.7)		
	Average no. repeats				47day (1-245 day range)			45.7		
	Family							42.82 (SD57.3)		

	Couple							50.97 (Sd 40.65)		
	Friends							28.35 (Sd 26.2)		
	Individual							69.57 (Sd76.755)		
	Other							60.00 (n=1)		
	Total							45.72 (Sd46.4)		
Income										
	$0–$19,999		11.5	14.4						14.4
	$20,000–$29,999		15.3	14						14
	$30,000–$39,999		5.7	10.5						10.5
	$40,000–$49,999		10.8	7.4						7.4
	$50,000–$99,000		33.1	32.7						32.7
	$100,000+		23.6	21						21
								(		
Age	0 to 15				18 (9.7%)	84 (32.6%)				

	<15							0.6%		
	15-24							1.8%		
	15 to 54				77 (41.62%)	134 (52%)				
	18-29		20.6	15.4						15.4
	25-39	26						18.3%		
	30-44		28.8	31.3						31.3
	40-59	40								
	45-59		25.9	29.4						29.4
	55+				90 (48.6%)	39 (15%)				
	60+	12	24.7	23.9						23.9
	60-69							30.2		
	70-79							9.5%		
	>80							1.2%		
length of stay	Day visitor	36								
	One night or longer	64								
	Longer than 7 days				88%	77%				
	1 to 3		15.4	6.7						6.7
	4 to 7		29.6	20.8						20.8
	8 to 27		40.8	47.8						47.8

	28+		14.2	24.7						24.7
	1 to 3						30			
	4 to 7						57			
	8 to 14						152			
	15 to 21						35			
	22 to 100						93			
	>100						48			
	1									
	2 to 5									
	6 to 10									
	11 to 20									
	20 or more									
	14 or more									
	more than 22									
Mean length of current stay					60	31				
Total time away from home for current trip										
	From Central and North-West							9.1 days		
	Perth							46.3 days		
	South-West, Great							72.9 days		

	Southern and Goldfields									
	Interstate							229.3 days		
Travelling with	Partner		65.1	46.4				44.6%		46.4
	Friends		16.9	23.4				20.8%		23.4
	Family		13.4	20.1				28.6%		20.1
	Alone		4.7	9.4				5.4%		9.4
	With club/tour group		0	0.7						0.7
	2	54								
	3 to 4	28								
	5 to nine	13								
	Alone	5								
Average # in travel group										
	Family							4.8 ppl		
	Friends							5.7ppl		
	Expenditure per day (Ex 142 and CB 96).								$46.10	

Appendix E
Trampling and Four-wheel Drive and Camping Impacts in Coastal and Semi-arid Environments

Impacts of Trampling on Vegetation and the Environment: International Context

International Research			
Ecosystem element	Impacts	Outcomes	Authors
Soil	Soil compaction, reduction in soil organic matter, fluctuations in soil temperature and moisture,	Dune degradation of different stages, Vulnerability to erosion which can destabilise fore dunes, disturbance to the natural sand cycle which can potentially altering the shoreline, both in shape and position, Irreversible damage can occur if threshold is reached. Vegetation removal in particular can lead to localised foredune erosion areas called blowouts. This can lead to sand being transported further inland though loss of the dunes buffering capacity, leading to burial of once-stable coastal vegetation	(Bates 1935; Burden and Randerson 1972; Liddle and Moore 1974; Liddle and Greig-Smith 1975; Boorman and Fuller 1977; Slatter 1978; Hylgaard 1980; McAtee and Drawe 1981; Bowles and Maun 1982; Nickerson and Thibodeau 1983; Carlson and Godfrey 1989; Goldsmith, Rosen et al. 1990; Andersen 1995; Bonanno, Leopold et al. 1998; Kerbiriou, Leviol et al. 2008)
Microclimate	Near-ground wind velocity and reduced sand accretion.		
Vegetation	Decrease of vegetation cover and density, mean height of colonising fore dune vegetation, decrease in biomass production, reduction in number of flowering, disappearance of vulnerable species, interference in the natural succession, loss of biodiversity		
Physical	Creation of paths, erosion.		

Four-wheel Drive Impacts in Coastal Areas: Australian vs. International Literature

International Research		
Ecosystem Element	**Impacts**	**Authors**
Soil	disturbance of beach sediment, erosion, track creation and widening,	(Hosier and Eaton 1980; Hosier, Kochlar et al. 1981; McAtee and Drawe 1981; Steiner and Leatherman 1981; Wolcott and Wolcott 1984; Anders and Leatherman 1987; Anders and Leatherman 1987; Stephenson 1999; Buerger, Hill et al. 2000; Barros 2001)
Vegetation	dune and grassland vegetation, lowered species diversity reduced vegetation cover spread of weeds	
Physical	increased fire risk from cigarette butts, turbid run-off	
Fauna	disturbance to wildlife, impacts to macro invertebrates and turtle hatchlings on beaches and coastal dunes, shorebirds, road kills	
Australian Research		
Ecosystem Element	**Impacts**	**Authors**
Soil	Soil compaction, sand erosion, compacted tracks,	(Hercock 1999; Priskin 2003; Foster-Smith, Birchenough et al. 2007; Schlacher and Thompson 2007; Schlacher, Thompson et al. 2007; Schlacher and Thompson 2008; Sheppard, Pitt et al. 2009; Lucrezi 2010; Schlacher and Lucrezi 2010)
Vegetation	Vegetation damage, vegetation loss, increases in 4x4 tracks, loss of local flora species, reduced vegetation cover, No dune vegetation remains in the tracks	
Physical	Litter, erosion of salt flats, accelerated erosion and shoreline retreat centred around vehicle tracks, destruction of algal mats, restricted movement of tidal waste	
Fauna	Loss of local fauna species, Ghost crabs and three bi-valve species were absent in areas of high vehicular use, abundance of ghost crabs (Ocypode spp.) is significantly reduced compared with control dunes.	

Impacts of Camping in Coastal Areas: International context

Ecosystem element	Impact	Country	Author
Vegetation Disturbance			
	promote the invasion and spread of exotic species		(Allen, Forys et al. 2001)
	Substantial vegetation losses	Baja, Mexico	(Monz 1998)
	Existing shrubs and trees cut down for firewood	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
	Dune Disturbance	Queensland (Fraser Island)	(Tully, Carter et al. 2009)
	Vegetation clearance to clear and level site for drainage	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
	Social trails	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
	the potential for increased size and number of campsites due to visitors drifting because of the unclear campsite border	Baja, Mexico	(Monz 1998)
Litter and Human Waste			
	Litter and lack of toilet facilities	Western Australia	(Hercock 1999)
	Disposal of food scraps could modify the trophic dynamics of animal consumers	Cypres	(Strachan, Smith et al. 1999)
	Human waste and trash were also found at 41 to 59 percent of the sites	Baja, Mexico	(Monz 1998)
	microbial pollution and increased nutrient loading to the dune sands and underlying aquifer from human waste	Queensland (Fraser Island)	(Tully, Carter et al. 2009)
	human faeces and toilet paper was observed within 10m of the campsite	Baja, Mexico	(Monz 1998)
	There are no rules and no conventions covering the disposal of faecal material in any of the free-range camps. There are no regulation depths and no rules for marking sites used where such pit toilets have been so that someone may subsequently establish their food preparation areas on this very site.	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
	Introduced pathogens	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
Dogs and Fire Pits			
	Old camp fire-rings,	Western	(Hercock 1999),

	Resulting in ground sterilisation and public safety challenges	Australia/ Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
	There is the direct impact on the ground itself where the ground is sterilised as a result of the heat. All the hyphae in the soil are not only killed but appear to take decades before they can recolonise areas subjected to open fires.	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
	There is a major issue of public safety. Environmental Protection Agency officers have estimated that almost one medical evacuations call per month is to deal with people who have suffered severe burns and most if not all of these occur from the campfires of beach campers.	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
	The cost of supplying firewood is a major drain on the budget for managing Fraser Island and is diverting resources from other more critical aspects of recreation management on Fraser Island. It has been estimated that most of the $600,000 spent supplying firewood for campers is consumed at beach campsites.	Queensland (Fraser Island)	(Fraser Island Defenders Organisation nd)
	Dogs - same issues as human waste contamination and wildlife disturbance	Alberta, Canada and others	(Macarthur, Geist et al. 1982; Newsome, Moore et al. 2002; Cole 2004).

Appendix F
Environmental Impact Assessment Data Proforma used for this Study

Curtin University of Technology CSIRO

Initial Campsite Assessment Proforma

Anna Lewis ph. 0403926967

AREA/SUB AREA:

	CAMPSITE INVENTORY	ANSWERS	KEY
(1)	CAMP AREA SIZE		
(2)	BARREN CORE SIZE		
(4)	Date		
(5)	GPS Coordinates		
(6)	Campsite control GPS coordinates		
(8)	Substrate		**(1)** compacted **(2)** loose sand **(3)** red clay **(4)** gravel **(5)** other______
(9)	Beach Geomorphology/landscape setting		**(1)** f secondary berm **(2)** primary dune **(3)** secondary dune **(4)** Field **(5)** Ridge
(10)	Distance to Ocean		**(1)** 5-10 **(2)** 10-20 **(3)** 20-50 **(4)** 50-100 **(5)** 100-200 **(6)** 200-500 **(7)** more than 500
(11)	Distance to closest campsite		**(1)** 5-10 **(2)** 10-20 **(3)** 20-50 **(4)** 50-100 **(5)** 100-200 **(6)** 200-500 **(7)** more than 500
(12)	Number of campsites in a 0m radius		**(1)** None **(2)** 1-3 **(3)** 3-5 **(4)** 5-8 **(5)** more than 8
(13)	Site defined by:		**(1)** Management (2) Bare ground (3) Environmental
FACILITIES			
(15)	Fire Ring/fire pit		Blank=no, number =yes
(18)	Drop toilet		Blank=no, **(1)** <than 5 m **(2)** 5-10 **(3)** 10-20 **(4)** 20-50 **(5)** more than 50m
(19)	Sewerage disposal		**(1)** less than1km **(2)** 5-10km **(3)**10-20 **(4)** 20-50 **(5)** more than 50km
(20)	Garbage Bin		**(1)** less than 10 m **(2)** 10-50 **(3)** 50-200**(4)** 200-1km**(5)** more than 1km
(21)	Tip	Open / Closed	**(1)** less than less than 1km **(2)** 1km-5km **(3)** 5km-10 km **(4)** 10-15 km **(5)** more than 15 km
(22)	Evidence = Erosion soil		Blank=no, number =yes
(23)	Evidence = Erosion vegetation		Blank=no, number =yes

CAMPSITE LOCATION WITHIN SUB-AREA

Location of individual campsite within camp area and major features. Included: Distances to other campsites, water form/ocean, waste management/toilet areas

CAMPSITE FEATURES

Perimeter boundary and/barren core, social trails (where lead), fire, trees, rocks, direction of ocean, location large shrubs, main access track etc

Time Taken (mins): ______________

IMPACT ASSESSMENT	ANSWERS		KEY
	Campsite	*Perimeter*	
VEGETATION			
Vegetation dispersion	1 2 3 4 5	1 2 3 4 5	**(1)** Uniform dense **(2)** Uniform medium **(3)** Uniform sparse **(4)** Clumped in one area **(5)** Clumped in > one area
Vegetation distribution across whole campsite	1 2 3 4	1 2 3 4	**(1)** Evenly distributed **(2)** Vegetation increasing from core **(3)** Vegetation increasing from area nearest to road **(4)** Vegetation patchy
Vegetation type	1 2 3 4 5 6 7	1 2 3 4 5 6 7	**(1)** Grasses **(2)** Spinifex **(3)** Salt bushes **(4)** Small shrub **(5)** Large Shrub **(6)** Small tree **(7)** Large tree
% damage/ reduced vigour for vegetation type present. # = *vegetation type 1-6 present*	#___ 1 2 3 4 #___ 1 2 3 4 #___ 1 2 3 4	#___ 1 2 3 4 #___ 1 2 3 4 #___ 1 2 3 4	**(1)** None show any damage **(2)** 10-30% of shrubs show damage (such as broken limbs, crushed, generally unhealthy) **(3)** 30-60% of shrubs show damage: 1-2 show reduced vigour as a result of damage **(4)** >60% of shrubs show damage; 2 show reduced vigour, dead or dying shrubs present.
Root exposure	#____	#____	
HUMAN WASTE			NOTES
Litter : Small (<5cm diameter) Large (>5cm diameter)	 #____ #____	 #____ #____	
Toilet Paper	#____	#____	
Fecal matter	#____	#____	
SOCIAL TRAILS			
a. Number #___			
b. Width 1#____ 2#____ 3#____ 4#____ 5#____ 6#____ 7#____ 8#_____ 9# _____ 10 #____			
c. Depth 1#____ 2#____ 3#____ 4#____ 5#____ 6#____ 7#____ 8#_____ 9# _____ 10 #____			

Appendix G
Camper Questionnaire (Preferences and Resource Use) utilised for this Study

16. a. Your age_______ b. Gender ☐ M ☐ F c. Are your retired? ☐ Y ☐ N

17. a. Who are you travelling with? ☐Alone ☐Partner ☐Friends ☐ Family ☐Tour group
b. Number in travel group __________ Number at your campsite___________

18. Your stay at Ningaloo

a Have you camped in the **Ningaloo Region** (Blowholes to the northern point Cape Range National Park) before this trip? ☐ YES ☐ NO If *Yes*, how many times? ________

b How many nights will you stay at your **current campsite**? ____________

c How many nights will you be **camping total** in the Ningaloo Region? ____________

19. What shelter do you use at your campsite?
☐ Campervan/ Motorhome ☐Caravan ☐ Camper Trailer ☐ Tent ☐ Other ______

20. Please detail below your travel itinerary (within Australia) to and from the Ningaloo region

Transport taken TO Ningaloo *(please fill in all that apply)*

Flight (s)	From:	To:	***Bus***	From:	To:
Driving	From:	To:	***Train***	From:	To

Transport taken FROM Ningaloo

Flight (s)	From:	To:	***Bus***	From:	To:
Driving	From:	To:	***Train***	From:	To

Additional transport comments/notes: ____

21. What type of vehicle are you driving? ☐Car ☐Wagon/AWD ☐ 4WD ☐ Camper
Number of Cylinders: ☐*4* ☐*6* ☐*8*

PART 4
Comments

22. Is there anything you would like to see done to minimise environmental impacts of camping at Ningaloo?

23. Is there anything you do not want to see changed in the future concerning camping at Ningaloo?

Thank you for your time, your participation is greatly appreciated

Curtin University of Technology
CSIRO

NINGALOO FUTURES COASTAL CAMPING & RESOURCE USE SURVEY

PART I
Camping Preferences and Activities

1. What are the two main reasons you chose to camp at:

____________________: 1.___________________ 2.________________

This exact campsite: 1.___________________ 2.________________

2. When selecting a campsite in Ningaloo, how important are the following? *(please circle)*

Importance	**Very low**				**Very high**	
Toilets provided	1	2	3	4	5	N/A
Fresh water showers provided	1	2	3	4	5	N/A
Dogs allowed	1	2	3	4	5	N/A
Minimal litter at campsite/surrounding areas	1	2	3	4	5	N/A
Value for money	1	2	3	4	5	N/A
Campsite close to beach	1	2	3	4	5	N/A
Close to daily activities	1	2	3	4	5	N/A
Boat launch facilities/access	1	2	3	4	5	N/A
Well defined paths and campsite areas	1	2	3	4	5	N/A
Generators allowed	1	2	3	4	5	N/A
Dump point for sewerage (from porta-loo)	1	2	3	4	5	N/A
Campsite not exposed to wind/sun	1	2	3	4	5	N/A
Distance to neighbour campsite	1	2	3	4	5	N/A
Other__________	1	2	3	4	5	N/A

3. What makes you NOT want to camp at a given area? (*Tick all that apply*)

☐ Exposed to wind and sun	☐ Campsites close together
☐ Price too high	☐ Many campsites in one area
☐ No fire allowed	☐ No rubbish collection
☐ No dogs allowed	☐ Stay limited to 4 weeks
☐ No toilet	☐ No power provided
☐ No shower provided	☐ Litter present at campsite
☐ Fishing not allowed	☐ Other___________

4. How satisfied would you be with the following campsite locations?

	Highly satisfied	*Satisfied*	*Not Satisfied*
25 m from the shore	☐	☐	☐
50 m from shore	☐	☐	☐
100 m from shore	☐	☐	☐
On a ridge overlooking the ocean 200 m from shore	☐	☐	☐
On a ridge overlooking the ocean 400 m from shore	☐	☐	☐

5. What is your campsite-style preference? ***(please number (1-4)*** *1 being first preference)*
☐ Dept. Environment & Conservation sites ☐ Side-of-road/free sites
☐ Caravan parks with full amenities ☐ Station-run sites

6. What are your most common daily activities from this campsite, and how far do you travel? (*please enter distance number from key below*)
(1) = <500m, **(2)** = 500m-5km, **(3)** = 5-10km, **(4)** = 10-50 km **(5)** = >50km

Activity	How far do you travel? **(1-5)**	Activity	How far do you travel? **(1-5)**
☐ Lying on beach/swim		☐ Sightseeing/4WD	
☐ Beach walking		☐ Fishing from shore	
☐ Snorkelling		☐ Fishing from boat	
☐ Scuba diving		☐ Commercial tours	
☐ Surfing		☐ Other__________	

PART 2
Resource Use

RUBBISH

7. About how many 'plastic shopping bags' of rubbish does your campsite fill daily?
☐ less than 1/2 ☐ 1 ☐ 2-3 ☐ 4-5 ☐ 5-7 ☐ more than 7

8. How much of the following is typically in your rubbish?

	None	Some	A Lot
Packaging (plastic, cardboard etc)	☐	☐	☐
Aluminium cans and glass	☐	☐	☐
Fruit, vegetable and organic matter	☐	☐	☐
Fish offal	☐	☐	☐
Household items and metal	☐	☐	☐
Other_________	☐	☐	☐

9. How is the rubbish disposed of at this campsite? (tick all that apply)
☐ Bin provided by campsite ☐ Dumping area or 'tip' provided by campsite
☐ On dunes/at sea/on beach ☐ Nearest large town
☐ Take Home ☐ Other_____________

{ Do you have a portable toilet? ☐ Yes ☐ No
If YES, where it is emptied? (tick all that apply)
☐ In a septic system in a caravan park ☐ In dunes/on the beach
☐ In a septic system provided by a station ☐ At home
☐ Shire Dump points ☐ Other_____________

POWER

10. What is your campsites' power source (if applicable)
☐ Solar ☐ Wind ☐ Dual battery ☐ Other_____________
☐ Petrol/Diesel (L/day on average_________)

WATER

11. About how much fresh water (L) does your campsite use each day ?
☐ 1-5 ☐ 6-10 ☐ 11-20 ☐ 20-50 ☐ Over 50
Where is this water from? ☐ Caravan Park ☐ Shop (bought) ☐ Public tap ☐ Other_____

SUPPLIES

12. During your stay at this campsite, do you travel to restock on food or other supplies?
☐ YES ☐ NO
If YES,
Where do you go? ☐ Carnarvon ☐ Coral Bay ☐ Exmouth ☐ Other_____
How often (days)? Every: ☐ 1 -7 ☐ 8-14 ☐ 15-30 ☐ more than 30

13. Are there any supplies you have had a hard time finding in local areas?
☐ YES ☐ NO If YES, what? _____________________________

14. Here in the Ningaloo Region:
a. About what % of your food intake is food that is caught (ie fish) or grown by you?
☐ 0-10 ☐ 11-30 ☐ 30-50 ☐ >50
b. About what % of your food intake is vegetarian? ☐ 0-20 ☐ 21-50 ☐ 51-75 ☐ 76-100

PART 3
Information About You

15. What is your usual place of residence?
Country ___________ State/Province _______________ Postcode ___________ ☐ Permanent Traveler

Appendix H
Why respondents select a given Camp Area and Campsite (Question 1 from Questionnaire)

Answers regarding why respondents select a given camp area and campsite are provided for each management area. Comments within Appendix H are presented by management area, north to south for ease of geographical orientation (Table 1). Each questionniare allowed space for two reasons per question. Thus each row has two columns, for ‘Reason 1’ and ‘Reason 2’. If only one space was filled with an anser, the second space is left blank. Answers are short-answer, qualitative responses. Answers were not analysed in-depth due to time restraints of the study.

Table 1: Order number of comments presented within Appendix H.

Management Area
Cape Range National Park
Learmonth Air Weapons ‘Bombing’ Range
Cardabia Station
Warroora Station Fourteen Mile
Warroora Station Southern Camp Areas
Gnaraloo Station
Quobba Station
Blowholes

CAPE RANGE NATIONAL PARK

Why respondents select a given camp area

Reason 1	***Reason 2***
Indiv campsites	Close to beach
Quiet spot	Minimal environment impact
Been here before	Friends here
Sheltered	Close to water
Boat access	Fishing
Boat launch	Camp Host
Boat mooring	
Knew people	
Knew people	
Flyer-diving	Recommendation from gate keeper
Allocated by DEC	
Close to beach	
Remoteness	Availability
Location	Snorkel off beach
Close to other snorkel spots	Can go fishing
Price	Ocean
Beach	
Fishing	Swimming
Very Relaxing	Lovely view
Environment	Lifestyle
National Park	Generator
Told it was nice	Only available
Fishing	Freestyle camp
Availability	On beach
Camp hosts	
very close Beach	Short distance to supplies
Seclusion	
No other site available	
Quiet	Beauty of National Park
Surf	Fishing
Surfing	Fishing
Surfing	Fishing
Surf	Fishing
Quiet	Campsite hosts
Well spaced sites	o generators
Friends here	Beach
It is quiet	lovely beach
Availability	Secluded spots/sites
Seclusion	Access to coast
Seclusion	Close to beach
Beach access	
Beach access	
Snorkelling	Shade
Availability	Tranquility
Location	Price
Isolation from crowds	
Isolation	Nature camping

Snorkelling	
Snorkelling	Camping
Lots of room	
Protection from wind	Solar hours long
Close to Ningaloo Reef	Pristine
Availability	Price
Proximity to Exmouth	Combination of camping & fishing, good beach access
Shade	Access to beach
Proximity to ocean	Beautiful weather
Lots of kids here	shade from trees
Camps 5	Ningaloo access
Shade	
Shade trees	
Perfect area	Nice campers
Like the area	
Availability	
Availability	
The camp hosts	
Location	
Close to surf	Recommended
No generators	Proximity to surf and dunes
The size	Access to the ocean
Location	Camp Host
Proximity to water	Sheltered from wind
Great Location	
Community	Close to town
Fishing	
Came up when waiting to book a C park	Nice host
Beach	Peaceful, weather
Availability	
Availability	
Availability	Had been before
Availability	Had been before
Simplicity	Beauty of reef
Osprey Bay full	Put here
National Park	good toilets
Came to Exmouth for whale sharks.	Friends here
Availability	
Availability	
Not on top of each other	A little protected from weather
Tidy	Well set out
Camp hosts	
Sheltered wind	Close to beach
At the beach	Can snorkel to Reef
Allocated by ranger	
Site given by	
Availability	Fishing & snorkelling access
Availability	Fishing, snorkelling
Availability	
Availability	
Snorkelling	Generator
No other camps available	Quiet area

See Cape Range Park	Enjoy self sustainable camp style
Site allocated	Only one available
Isolation	Natural
National Park	large sites-away from other campers
Location	Price
Location	Price
Very scenic	Very quiet
Not too busy	Wildlife
Wildlife	Fishing
On the beach	Boat launch
View	Ramp
Isolation	Beach access
Hosting	
Hosts	View
Hosts	Location
Availability	Friends
Family	Beach fishing
Been here before	Large bays
Beautiful	Good size separated sites
Nominated by Dec	First time here
Nominated campsite by DEC	First time here
Nice views	Spacious sites
Sand dunes	Marine habitats
Friends as hosts	
Size	Near Yardie Creek
Size (small)	Yardie Creek and Mandu Mandu Gorge
Snorkelling	Price
Snorkelling	Only free camping site
Close to water	Friendly atmosphere
Closeness to water for boating etc	Safe swimming for families
Swimming	Fishing
Fishing	Swimming
Availability	Generator allowed
Availability	Fishing and Snorkelling
View	Beach
Beautiful	Gorge
Surf	
Surf	Weather
Easy boating launching	
Two sites available	
No other choice	Being directly in the nature
Two sites available	
Ballot	
Availability	Close to beach/reef
Ocean view	Close to boat ramp
Trees	
Availability	Only one
Availability	Limited generator use
My b'friends name is Ned	DEC allocated it
The name	DEC allocation
Close to tour	Great hosts
Boat access from beach	Quiet/shady area
Availability	With generator

Availability	Allows generator
Location	Reasonably priced
Location	Price
Location	Ambience
Friends here	Size of site
Size for my setup	Friends here
Friends	View (snorkelling)
Availability	
First site available	Generator allowed
Availability	Trees - shade/wind break
good swimming/snorkelling	Good fishing
Natural	
Isolated and natural	Gorgous
Close to beach	Boat access
Close to beach	
Close to beach	Secluded
Beach access	Shade
Isolated and natural	Friendly atmosphere
Ocean view	Close to beach
Beach access	Close prox to Exmouth
Beach	Not too far from town
Snorkelling	Close to visitor's centre
On the beach	Very simple ie no development
Camp hosts	
Camp hosts	Allocated by DEC
Wildlife	Distance between campsites
Close to beach/swim	Quiet and beautiful location
Remoteness	Larger sites
Camp hosts	Warmer than home

Why respondents select a given campsite

Response 1	***Response 2***
Availability	
Close to beach	
Secluded	Generally quiet, removed
Price	Length of stay
Shade	Wind protection for tent
Availability	
Availability	
Cheaper than town	
Swimming	
Close to the sea	Good swimming
Cost effective	
Proximity to beach	Secluded
Volunteer	
Remoteness	
on the end	More privacy, close to toilet
Surfing	Surf
Well spaced campsite in a natural environment	
Quiet	
Last one left	Referred by Entry Gate person.

Boat launching	
Peaceful	Close to environment
Close to nature/beach	
Holidaying	Fishing
Level siteq	
Could!!!!	Sun (for solar)
Shade	Big size of site
It was available	Trees for shade
Fabulous scenery	
Lots of trees	More private
Sent by DEC	Availability
Close to beach	
Good beach access	
Clean sites etc	
Area unspoilt	
Layout - some privacy	
We love the camp hosts	The position
Shade trees	Quiet cul de sac keyhole site
Large enough for van	Generator use
Prefer this to other areas	
Fishing	
Close to town	
Friendly	
Locality to ocean, beach, snorkelling	Availability
Secluded	
Mandu Mandu Gorge	
Surfing	Fishing
Beach location	Informal
Shelter by dune from wind	Ocean view
No generator	
Soft sand for the tent	Generator free
Soft sand	Generator free
Generator free	
Close to toilets	Easy access to beach
Generators allowed	
View	
Privacy	Good views
Natural	Scenery at beach
Natural	Close to water (beach)
Shady	View of beqch
View of beach	Sheltered
Trees	Closer to town

LEARMONTH AIR WEAPONS RANGE

Why respondents select a given camp area

Response 1	***Response 2***
Isolation	Quiet
More quiet	
No crowds	Space
No crowds	Space
No one about	Fishing
No dogs allowed on National Park	Safe boat anchorage
Free	Friendship of fellow campers (over many years)
Free	Friendship of fellow campers (over many years)

Why respondents select a given campsite

Response 1	***Response 2***
Fishing	
Fishing	Relaxation

CARDABIA STATION

Why respondents select a given camp area

Response 1	***Response 2***
Fishing	Bush Camping
Fishing	No children
Natural	
Not crowded	Price
Price	Fishing
Price	Isolation
Fishing	Warm climate
Natural	No development
Quiet	Price
Fishing	Friends here
Freedom	Not over crowded
Fishing	Environment
Quiet	Friendly
Been here before	Fishing
Quiet	Serene
Quiet	Friends
Coastal campsite	Regulation
Near to beach	Sunny
Fishing	Easy access
Friends	
Cheap lifestyle	Fishing
Freedom	Friendly
Fishing	Bush Camping

Fishing	No children
Natural	
Not crowded	Price
Price	Fishing
Price	Isolation
Fishing	Warm climate
Natural	No development
Quiet	Price
Fishing	Friends here
Freedom	Not over crowded
Fishing	Environment
Quiet	Friendly
Been here before	Fishing
Quiet	Serene

Why respondents select a given campsite

Reason 1	***Reason 2***
Fishing & netting	Do not spoil Aust Life Style
Few people	Location
Fishing	Far from maddening crowd
Fishing and netting	Location
Affordable	Peaceful
Position	Fishing
Views	Private
with friends	Nice and quite

WARROORA FOURTEEN MILE

Why respondents select a given camp area

Response 1	***Response 2***
Recommendation	Fishing
Partner drove here	Like beach
Recommendation	On coast
Friends here	To see what it is like, never been here before
Location	Fishing
Location	Fishing
Freedom	Fishing
Friends	
Warroora	
Beach	Friends
Beach	Fishing
Fishing	
Love it	Fishing
Fishing	Walking
View	
Weather	Ocean
Warroora	
Wilderness camp	mostly older campers - quiet
Isolated camping	great views

Peaceful	
Location	Quietness
Peaceful	Reasonable price
Remoteness	Open Fires
Beach	Peacefulness
Great price	Peaceful
Fishing	Bush Camping
Environment	Space
Untouched	Very clean
Friends here	The Reef
Close to beach	Fishing
Its beautiful	Home from home
Long stay	
Close to ocean	Privacy
Almost pristine	Relative seclusion
Price	Beach camping
Price	Beach camping
Long stay	Fishing community
Fishing	Environment
Long stay	Fishing/friendship
Life style	The people we meet there
On the beach	Fishing
Atmosphere	Community feeling
Station	Price
Fishing	Location
On the beach	Life style
Magnificient location	Fishing and boating
Dogs allowed	Proximity to beach
Dogs allowed	Proximity to beach
Location	Freedom
Location	Ease of water access
Relative isolation	Minimal regulations
Isolation	
Isolation	
Location	
Natural bush camp	Not CALM (DEC) driven
Part isolation	Beach access
Relaxation	Beautiful spot
Beach location	Fishing
Prior experience here	Weather
Good times before	Natural beauty
Access to beach	
Swimming	Weather
Beach location	
The beach	Price
Unspoiled environment	Love wilderness camping
Unspoiled environment	Self sufficient
Life style	
Environment	Pristine
To fish	Lifestyle
Remoteness	Beach
Remoteness	Access to beach
Fishing	Camping

Curiosity	Location
Beautiful	Price
Fishing	Ocean view
Scenic	Not too commercial
Unspoiled environment	Not over crowded
Fishing	
Fishing	Relaxation
Near to beach	Isolation
Isolation	Unknown destination
We were told	
We were told	
Lovely beach	No litter, very clean
Fishing	Clean campsite
Security	Beauty
Favourite	Access to water (bore)
Wanting to go on beach	
Peace and quiet	
Seclusion	Beach access
Beach	Fishing

Why respondents select a given campsite

Reason 1	***Reason 2***
Availability	View
Beach	
ocean	People
Fishing	View
Beach	
Remoteness	Fire
Scenery	Fishing
Love to swim	Can stay awhile
Sheltered	Clean
Near to ocean	Sheltered
Suitabale for fundraising	Beach view
Fund raising	Beach
Camping on beach	
On the beach	Fishing
Company	Price
Boat launching	social interaction
not important	
not important	
Friends	
No choice - the only available	
No others left	Wanted to be with friends
Joy of camping	
Weather	Swimming
Freedom	
Great place to relax and get back to basics	
Natural environment	
Environment	Weather
Coastal walking	
Recommended	
Relaxation	Wanted to be with friends

No Traffic	

WARROORA SOUTHERN CAMP AREAS

Why respondents select a given camp area

Response 1	***Response 2***
The beach	Value for money
Price	Right on the coast
Close to beach	
The beach	Snorkelling
Diving	Surfing
Close to beach	Not over crowded
Close to beach	Beach fishing
Isolation	No facilities
Quiet	
Warroora	
Close to beach	Sheltered water
Close to water	Quiet
Friends/family have camped here before	get away
Serenity	Organized
Close to beach	
Good for kids	By the water
Remoteness	
Seclusion	Ocean
Snorkelling	Privacy
Reef snorkelling	
To get away	Told it would be ok
To get away	Something different
Open area	Familiarity
Open camp sites	Know the coast
Holiday	
Been here before	Fishing and peace
Peace and quiet	Fishing
Price	Warmer winter
Relaxation	
Close to surf breaks	
Unspoiled environment	Fair price
Remoteness	Quietness
Remoteness	Not over crowded
Boat access	
Isolation	Fishing/surfing
Surfing	Fishing
Isolation	Surf
Surf	Fishing
No crew	Ocean
lack of people	Good fishing
lack of people	Good fishing
Close to beach	Good fishing
Quiet and peaceful	
Good mooring place	Scenic
Close to sea	Few other campers

Location for boat	Good campsite
Scenic/waterfront campsite	Boat mooring
Isolation	Unspoiled
Isolation	Natural environment
Beach access	Protected shoreline
Safe for kids	Good snorkelling
Isolation	Fishing
Seclusion	Fishing
Surf without crowd	
Isolation	Ocean
On the beach	No crowds
Remoteness	Ningaloo Reef
Family holiday	
Others full	
Others full	
Others full	
Close to surf	Great beach
Recommendation	
Surf	No crowds
Freedom	Not a lot of people
Not many campsites	Natural environment
Few campsites	Natural environment
Unspoilt environment and coastline	Few people
Isolation	Challenge
Location	Environment
Remoteness	Lack of people
Beautiful	Snorkel
Recommendation	
Location	Ocean activities
Family recommended	Great outdoors
Isolation	Complete self sufficiency
Fishing & privacy	Beach life style and weather
Fishing	Lifestyle
Recommendation	
Recommendation	
Location	Price
Location	Price
Close to beach	Quiet
14 Mile fall	Looked good for fishing
Less populated	Nice spot
Warm temp	Self sufficient
Not as crowded	Close to access to beach
Trees	Protection from the dunes with wind
Location	Availability
have been coming up here for 25 years	Beach closeness
Quiet	Fishing
Isolation	Weather
Close to sea	Quiet space
Near ocean	Space
Space	Rock fishing
Space	Close to beach/fishing
Coastal	Camp fires
Coastal aspect	Camp fires okay

lack of people	Beach access/boat launching
Sea access	
Remoteness	Close to beach
Sea access	Less people
Internet	Local recommendation
Great views	Sandy floor
Space	Next to beach
Surf	Boat access/landing
Fishing / Surfing	Space
Get back to nature	
Good fishing	Beach
Good boat entry	Nice beach
Close to beach	Sheltered
Surf	Fishing
Surfing	Access to boat
Surfing	Access to boat
Serenity	
Beach	No rangers
Unspoilt water	relaxed camping
Beach	Surf
Surfing	
Surfing	Tranquillity
Access to surf	Location
Surfing	Freedom
Friends	Beach
Not crowded	
Surfing	Close to beach
Remoteness	Not over crowded
Swimming	Diving
Freedom	
No old people - 14 Mile camp	Rude

Why respondents select a given campsite

Response 1	***Response 2***
Not many people around	
Cheaper than town	
Availability	
Surfing	Snorkelling
Views	
Large site	
Close to beach	Secluded
Clean	Safe bay for adults and children
Secluded	
Close to beach	
Waves	Camp on beach
Fishing	
Privacy	
	From Caravan Park
Peace and quiet	Fishing
On our own	Family tradition
Availability	Access to ocean

Fishing	
Lagoon	
Surf	
Beach access	Plenty of room
Drink beer	Chill out
Access to water	Not too close to other campers
Uncrowded	Beach launching
No crew	Ocean
Close to beach	Nice swimming
Close to beach	Good swimming
Quiet	Nice beaches
Fishing	
Boat launching	
Close to sea	Few other campers
Get back to basics	
Isolation	Ocean
Surfing	
Availability	Beach access
Close to beach	
Close to beach	
Close to beach	
Fishing	Boating
Great swimming	Great camping
Beauty	Landscape
Surf	Think
Reputation	Friends
No amenities	
We are in an overflow site - so didn't choose here (set out in a paddock with nothing) waiting for c	
Overflow	Waiting for water front site
More room	
Cheap	
Boat access	
Level	Clean
Away from other sites	Level
Quiet	
Vacant on arrival	
Away from other campers	
Shelter from wind	Clean
Sea access	Distance from other campers
Lots of space to set up and camp	Away from most of the noise down below
Remoteness	Unpopulated
Untouched beauty	
Surf	
Fishing	
	Launching
Close to water	Fishing
Location	
No abusive people e.g. 14 Mile	
Surfing	Close to beach
No old people who abuse young people	
Good atmosphere	

GNARALOO STATION

Why respondents select a given camp area

Response 1	***Response 2***
Surfing	
Close to surf	
Swimming	Snorkelling
Relaxation	Weather
Surfing	Beach
Surfing	Lagoon
View	
Surf	
Coastal purity/Ningaloo	
Surf	Environment
Surf	Relaxation
	Surf
Surfing	Relaxation
Friends going	Visiting Aus from UK. It is good to visit Ningaloo.
Location	Partner gets depressed if not near surf!
Surf	Location
Surfing	Fishing
Surfing	Eco study chicks
Surfing	Fishing
Surfing	Fishing
Close to surf/fishing	Price
Freedom	Wildlife (both ocean and land)
Space	Environment
Location	People
Research	School holidays
Research	School holidays
Surfing	Friends
Beach	Surfing
Family recommended	Warm weather
Friends	great for kids
Surfing	Fishing
Surfing	Location
Surf	
Climate	Family
Surfing	
Surfing	Fishing
Close to beach	
Surf	Facilities
Surf	Facilities
Large	
Location	Amenities
Weather	Close to sea
	Holiday with kids

Surf	Fishing
Hygienic	Good swimming
Ablutions	No flies
Ocean access	
Next to Ocean	
Surf	Sunny
Ocean view	Surf
Waves	Dogs allowed
Clean	History
Surf	Peacefulness
Spear fishing	Snorkelling
Isolation	Location
Always wanted to	Fishing
View of ocean	Privacy

Why respondents select a given campsite

Response 1	***Response 2***
Showers	
Warm weather	
Location	Snorkelling
Fish	
Surfing	
Friends	
Remoteness	
Fishing	
Hot chicks with PHD's	
Relaxation	
Facilities	Word of mouth
Allocated not chosen	
Allocated not chosen	
View	Size
Allocated by management	Near beach and toilet
Staff suggested as out of wind	near friends in family area
Quiet	Close to ablutions which is necessary as we have 2 young children
Weather	
Ocean Front	
Surf	
No flies	Good snorkelling
Friends	
View	Nice and big
Lots of things to do	Fishing
Big	Looks out on bush
Location	Fishing
Great View	Family & Friends
Solitude	Ocean & surfing

QUOBBA STATION

Why respondents select a given camp area

Response 1	***Response 2***

Quobba Homestead	
Affordable	Fishing/Relaxing
Space	Close to water
Blowholes full	Stop over on way to Broome
Near ocean	Unspoiled area
Situation	Weather
Blowholes full	Cost
Homely	Wind shelter
Peace and quiet	Lifestyle
The isolation	
The isolation	The fishing
Blowholes full	Interested to see it
Blowholes full	Necessity
Affordable	Fishing/Relaxing
Space	Close to water
Blowholes full	Necessity
Red Bluff	
Surfing	Diving
Surfing	Nature
Isolation	Surf/Beach
Remoteness	Surf
Location	Access to beach
Surf	Weather
Surfing	
Surf	Remoteness
Surfing	Escape city life
Surf	Quiet
Surf	Remoteness
Natural beauty	Isolation
Surfing	Kite Surfing
Surf	Desert lifestyle
Surf	Weather
Peaceful	Surfing
Its beautiful	Surf
Surfing	Fishing
Surf	Weather
Surf	
The Surf break	
Surfing	Price
Friends	Location
Surf	Work
Surf	
Relaxed management	No bookings
Protected from wind	
Surfing	Adventure
Matt King is here	The beauty
Surf	Community lifestyle
Surf	Beautiful location
Surf	Adventure/action
Nature	People
Quiet spot	
Surfing	Winter holiday

Surf	Location
Good waves	Remote location
Beach Location	Kid friendly
Beach Location	Fishing
Remoteness	
Atmosphere	Surfing
Surf	Nature
Surf	Nature
Mellow	Scenery
Beautiful	Thought For family
Fishing	Beauty
Fun	Cheap
Access to the beach	
Closeness to beach	Less crowded
Surf	Camp style
Surf	View lifestyle
Surfing	
Surfing	
Surfing	
Location	Surfing
View	Not as many campers
Surfing	Remote camping
Surfing	Fishing
No people	Surfing
Natural beauty	Isolation
Friends	Atmosphere
Surfing	People
Surfing	Not over crowded
Surfing	
Surfing	Fishing
Looked good on website	Location
Wilderness experience	Coastal
The Ocean	Been to Quobba
Website	Isolation

Why respondents select a given campsite

Response 1	***Response 2***
Quobba Homestead	
	Whale watching
Un-powered	Level
Coastal	Fishing
The cost	
	Whale watching
Red Bluff	
By the beach	Nice spot
View	Away from other campers
Quiet	
Relaxation	Friendly
Natural beauty. Fauna-Flora. Marine environment	
Cheaper	
Cheaper than Gnarloo	

Friends	Location
Work	Surf
Like the place	
Close to point	On beach
Close to point	
Surfing/spear fishing	Lack of people
Close to beach	Close to mates
Close to beach	
It was vacant	Close to water
Location	Shelter
Beautiful scenery	
Stunning location	Amazing view
Surf	unsanitized
Quality surf	
Fishing	Sun/weather
Chill/unwind	
Protected	Beach access
Right on beach	Close to toilets
Beach	Remoteness
Not too many people	
Only available	
Nowhere else	Tree
Not as buy as Gnaraloo	
Remoteness	
View	Access to ocean
Surf	Fishing
Beautiful location	
Fishing	Remoteness
not Govt owned	
No neighbours	View
Privacy	Close to water/ocean, protected too/shade
Not too many people	
Van we borrowed was here	
The heat	
That's where the van is	

BLOWHOLES CAMP

Why respondents select a given camp area

Response 1	***Response 2***
Beach	Price
Position	Not over crowded
Fishing	Nice Place
Close to beach	Not over crowded
Blowholes	Basic camping
We like to get away from towns	Price
Weather	Fishing
Fishing	Peace and quiet
Quiet	Dogs allowed
Beautiful	Reef/Fishing
Close to shore	

Fishing	
Good Road to Carnarvon	Pleasant coastline
Fishing	Location
Quiet	Good fishing
Fishing	Finance
Bush like camping	Beach
A1	Price
Price	Close to beach
Price	
Pension rates	Relayed Attmutherc
Sun	Swimming
Low cost bush camping	Fishing
Good social life	Plenty of friends
Warm	Fishing
Fishing	Beach
Fishing	Relaxation
Fishing	
Location	
Price	Position
Friendship	Relocation
Natural	Price
Fishing	Dogs allowed
Snorkelling	Price
Fishing	Cheaper than C/V parks
View	Price
Fishing	
Work	Recreation
Fishing	Lifestyle
Freedom	Price
Snorkelling	
Beach/water experience	Dogs allowed
Family holiday	Weather
Remoteness	Laid back style
Nice beach	Nice weather
Family	Weather
Only one available	
Only site available	Close to beach
Fishing/beach	Inexpensive for family
Clean, safe beach	Friends recommendation
Nice beach	Cheap camping
Dogs allowed	Cheap camping
Recommendation	Price
Fees	Natural
Natural	Scenic
Semi isolation	Friendship
Beach access	
Friends here	Low cost
Low cost	Friends here
Coast line	Location
Fishing	
Location	Fishing
Good fishing	It is quiet and can get away from too many people

Location	Fishing
Weather	Sandy beach
Beach location	Proximity to Carnarvon
Fishing	
Natural	F/Fishing
Bush camping	Fishing
Cost	Close to beach
Lower fees	Relaxing - low pressure lifestyle
Freedom	Fishing
Beachside	
Nice and quiet	Fishing
Availability	"free" camping

Why respondents select a given campsite

Water view	Away from other campers
Fishing	
Love to get away from towns	We love this type of camping
On the beach	Availability
Scenic	
Fishing	
Good fishing	
Price	Space
Location	
Sheltered by bushes	Close to toilets
Can camp in Privet	
Fishing	
Sheltered Bay	
Affordable	
Toilets	
Peaceful	Friendly
View and level site	Close to water
Friendship	
Diving	
Fishing	Snorkelling
Cheap	Close to beach
Only available	
Sheltered	Level site
Sheltered	Level
Safe swimming	
Quiet	
Quiet	No generators
Fishing	Snorkelling
Snorkelling	
Pristine coastline	Access
Snorkelling	
Friendship	
Quietness - of other travellers	Friendliness
Cost	Camping out is an Australian tradition and we love it
Few people	
Space	

Appendix I
What respondents do not want to see changed in the future concerning camping at Ningaloo (Question 22 from Questionnaire)

Answers regarding what respondents do not want to see changed in the future concerning camping at Ningaloo are provided for each management area. Comments within Appendix I are presented by management area, north to south for ease of geographical orientation (Table 1). Answers are short-answer, qualitative responses. Answers were not analysed in-depth due to time restraints of the study.

Table 1: Order number of comments presented within Appendix I.

Management Area
Cape Range National Park
Learmonth Air Weapons ‘Bombing’ Range
Cardabia Station
Warroora Station Fourteen Mile
Warroora Station Southern Camp Areas
Gnaraloo Station
Quobba Station
Blowholes

CAPE RANGE NATIONAL PARK

Ban generators or provide very few generator sites
More recycling e.g. paper, plastic. Dump Point somewhere in park
Grey water disposal point
No
Keep limits on number of campers allowed. Do more recycling, boxes, paper etc
Reduce dusk. Down speed limit to 50k
Ban generators. Booking system very difficult.
Reef sanctuary zones should be bigger to minimise the impact from snorkelling
Control Coastal Camping access
More dustbins
Mark pathways to beach at Osprey Bay camp ground. No smoking on beaches. More fauna and flora information at camp spots i.e. importance of stabilised dunes.
Minimise pathways to beaches. E.g. Osprey. No smoking on beaches
Boardwalk thru dunes to swimming beaches especially at Pilgrmunna
Shower/toilet use to recycle for vegetarian
Keep doing what you are doing. No increase in numbers
No generators
Education/punishment for littering, not saying to paths, dumping etc.
Keep the Germans out
Maintain current camping capacity
Ban smoking !
Ok as it is.
Make sure nobody stands on the coral. Maybe forbid flippers
More regular checking by rangers of campers, to ensure rules are adhered to
Fix roads; chemical toilet dump point within park
Free camp areas
Sawdust toilet, no generators
Regular rubbish collection. Prevent development, permit 4WD access to vulnerable sites
Restrict 4 WD campers. Ensure rubbish is removed. Keep DEC policing
Better dirt roads and more larger sites. Dump points
Dump point would be great ?? Visitor Centre. Throw people out or fine if found littering. *Recycling bin PLEASE - There are near to none in caravan parks.
More water/toilet dump (minimal travel)
I wish boating was restricted to sightseeing only. Having a limited number of campsites makes this place very special. Less fishing and more protection areas for marine life. It is disappointing to see people fishing and freezing their catch. It should be consumed here!
No - what is currently in place seems to work well
More restrictions on caravans and generators
Fishing quotas / make roads/ access to extra spots
Keep numbers small
More care in use of sand dunes
Reduce to speed limit from 80 to 60
More control of some areas to stop damage to coral etc
Enforce speed limit of 50kph: ban driving at night. More control over numbers of fish taken
Reduce fishing rights - too many fish caught
maintain hosts at camp sites
Plant more shade trees, signs saying No Butts!! Keep people off dunes; reduce speed to 60 in park to reduce road kill.
Speed limit on road should be 60 kph and regulated. Keyhole campsites & shade trees. More active limits on fishing. A couple of longer marked out walk trails.

Continued supervision/restriction of water skiing/jet skiing
Not overcrowding camping areas
Everyone to care
2 to 3 dump points on west side
More sites made available
Camping not to go under 4 wks max stay
Road to campsite improved
Road in could be better (TARMAC)
Do nothing Please leave well enough alone
Roads into campsites graded/otherwise leave as is
No generator
Raise awareness, provide recycling facilities
Reduce fishing
Nat. parks doing great job
No further campsites (numbers to stay the same)
Keep numbers to present restrictions
Educate campers on care of the reef too many snorkels standing/walking on reef !
More education on how to look after the reef itself or you will not have campers.
Perhaps a few more signs re cleaning of fish.
Pilgramunna Day Parking Area
Day Parking should not be at the water. They should park at the top. As you queue up to be at this site for the view. It's a fantastic spot Pilgramunna
Several dump points, travellers who illegally camp
Toilet dump point/long way to town
More information about fishing restriction and guidelines
Keep same
Maintain the current status
Leave stations with stations away from Nat Parks
Reduce road speed to 65k
No looks like great job being done
Continue as it is- see below
Remind people to be clean and to help when entering the NP
Portable toilet dump
Slow the traffic for the kangaroos
There is too much dead wildlife on the road
No
Central dump point within the park for motor homes please
Current campsites to remain
Current campsit4es to remain
Cull Kangaroos
Cull Kangaroos
Not very happy
Keep up the good work
No in my opinion Ningaloo is very well managed.
No a perfect holiday destination. Excellent Management
Monitoring of road access erosion and dune erosion
Chemical toilet dump point and portable in park
Chemical toilet dump point
Good campsite
Make it easier to get a campsite
More available sites and dump point system and alter allocation
Dump stations - not 160km round trip
Improved waste disposal

Improve waste disposal
Dumping point on west side of cape
Closer toilet dump station
Provision of dump points
Yes! Move Ranger Station entrance to park closer to town first in best dressed is a silly system. Yes - installation of dump point
I have been coming to region for 22 years and I see no environmental damage
Build more beach access points across dunes. No generators
No
Maybe a central dump point to empty the portable toilet
No
Sullage points as well as toilets. Some defined paths to beach / no go area
Build "shed tanks" to collect water
Limit length of stay rather than cater for thousands at a time. Dispersed small facilities
Keep things the same as they are - it is perfect - lower speed limit, less road kill
Grit on camp sites so that the soil does not blow
Keep camp hosts, minimise generator usage
Minimise generator usage, keep camp hosts
Have little canisters at each campsite for people's cigarette butts and bottle caps
Cans for bottle tops and cigarette butts at each campsite
Rangers to stop people treading on coral
Showers, composting facilities, more done walkways
Recycling, so much plastic, paper, cardboard, glass etc. wasted
Dump point available within park, more defined walks
Toilet dump points in NP
Toilets provided
Less generator use / more generator free sites
Anything and everything to keep it as natural as possible
Restrictions of amount of new camp areas
Is good
No I think it is a good balance at the moment
Everything is fabulous
It is perfect as is
Rubbish control by campers
More thoughtful campers
More chairs and tables, dividers between camp and vege - signs to reduce speed to 30 kmph after 6pm
Camp kitchens
Don't make campsites too big
Not making campsites too big
Ban all generators. Reduce fish bag limits . Speed limit reduced and enforced
Reduced speed limit. No generators/running cars to charge battery. More fishing limits
More camp sites and toilet dump points

LEARMONTH AIR WEAPONS RANGE

Goats culled
Culling of goats, sullidge pits
Control of vegetation dieback
Control of dieback in vegetation
No
None, leave how it is (maybe more bins)

Leave as is . Reduce sanctuary zones to prevent over fishing
Leave as is - increase boat fishing area to prevent over fishing one area
Leave everything as it is now. We don't want any changes. We look after it better than any Gov/t agency would (or private business)
Do not want any departmental intervention
Leave as is at Doddy Bay (bombing range)

CARDABIA STATION

Fence rubbish tip. Proper dump point.
If DEC involved put toilets in
Get rid DEC and appoint hosts
Ban idiots from Coral Bay
Proper facility for rubbish and dump point
Limit no of campers in small area
Get rid of DEC and appoint hosts
Toilets & decent dump & caretakers
Toilets decent dump caretakers
rape & Pillage/over crowding/uneducated people about sustainability
Stop the dogs, some campers go to Cardabia for 3 or 4 months every year, they shoot goat, cut wood with chainsaws and take up too much space
Absence toilets at Bruboodjoo Scandal indicates lack concern and planning for environment
Maintain good dirt tracks by grading more often.
Maintenance of rubbish dump and toilet dump
Rubbish tip maintained & toilet dump size.
Restricted access by motor vehicles, bikes on beach and dunes
Keep it as it is
supply rain water tanks
Would you like CALM not to come in and make changes
CALM to give us front beach camping back

WARROORA STATION FOURTEEN MILE

No
Station owners seem to be doing good job.
Just to make sure everyone obeys the rules.
Less interference by Government Departments
No
Keep Government out of the square.
No wood fires, limit to 2 pp.
Campsites need to be comparable with 14 Mile which is efficiently run
No
Less short time stays usually less friendly environment
No
No
No
No
No
No! Leave Warroora as it is
No caravan park

No caravan parks
Leave like that (No caravan Park)
Leave as before 2009 to long term patrons who did look after the environment.
More formal rubbish bins along main roads and overnight sites
Tell D.E.C to keep out of it. Station owner doing a good job
Tell D.E.C to leave things alone
Leave it as it is
Leave it as it is
More education of caretakers so they can educate all campers in care of environment
Lower catch limits
Stricter fishing bag limits
Keep DEC out
No
Availability of brack water
Time restriction. Dogs to be allowed
Leave everything the way it is
Access already managed by station
Already managed by station
Keep DEC away
Availability of drinking/washing water
Keep DEC away - leave it to the public of WA
Recycle area - food scraps, aluminium
Recycling at the tip area
No
No
Netting. Large resorts in Coral Bay
Netting ban
Don't advertise in the Eastern States - they spoil the place
Reduce the amount of frozen fish allowed per head
Ban dogs
No dogs. Install drop toilets
No
No
Sealed roads
Stop putting ridiculous restrictions in place
No
Continuation of great work by station owners
Maintain the lifestyle and freedom
Keep it as it is
Nil
Continued checks on campers, firewood, chem toilet off track re travel
It is beautiful just the way it is
Leave as is
Stop Govt. taking it over
No
No Govt. intervening
Leave alone
Limited numbers to visit region
There must be roles and regulating
None
Visual confirmation of presence of Chem toilet

WARROORA STATION SOUTHERN CAMP AREAS

I think everyone here respects it properly.
Nothing after doing minimal impact camping as a subject in yr 11. I'm very impressed with it here
Better signage of sanctuary zones. Greater DEC of fisheries presence.
Its all good.
No transporting fish out of Ningaloo. Only catch what you can eat during your stay
Low fish limit taken out
No keep Australia the same.
No
Maybe allow turning around areas for cars/caravans so as not to affect dunes.Chemi toilets are great. Tip is great.
Education on how to live in harmony with nature.
No development
Leave it as is.
Keep restricted parts for "self contained" campers only
More marine parks
Warroora camping very well controlled (so far)
Ideal at Exmouth
Better waste management, control ocean side of dune access.
Discourage speeding vehicles
More rubbish dumps and speed restrictions
Stop jet skis. Rotate some fishing areas - repair tracks so only main ones are used.
Take out own rubbish. Educate campers how to preserve the environment eg stay on tracks. Smokers to take butts
Take rubbish you bring, back out
Less advertising
Rubbish dumps could be better
Positive Govt. involvement with station staff to educate and communicate good environmental practice to public
Stop DEC from taking it over and turning it into a circus
Don't get too commercialised
Remain a remote wilderness, don't encourage weekend tourists ie leave it to those dedicated!
More fenced off paths, regular rubbish pickups
No driving on beach, no boats or jet skis, no camping on dunes, no dogs
Fox control, no dogs. No driving on beach, no power boats or jet skis, no camping on dunes
No driving on beach or dunes. More chemical toilet dump sites
No jet skis. No driving on beach or dunes. More chemical toilet dump sites. No boats in certain areas
Ban fires. Kill cats
Ban fires
Ban fires
Fires made illegal. Continue fox baiting. Watch for feral cats/dogs
Don't seal roads to keep masses out
Don't seal the roads. A brief list of general rules eg fishing, no hoons etc seen at the entrance
Keep DEC away. Educate campers. Independent audits
Educate campers more
Maintain driving only designated tracks
Nothing
No bitumen roads, no signs
Leave as is. No bitumen roads/infrastructure

Keep as it is
Less retirees camping for long periods of time
Less retirees camping for long periods of time
Clearly outline "protocols" of impact free camping to campers
Re veg projects
Making sure everyone leaves it clean
Whatever you take there you should take it away eg rubbish
Better campsite management
Better policing (funding for campsite etiquette
Limit campsites and fishing
Better policing (funding for campsite etiquette
Camping number limitations but not infrastructure
Ban fires or supply firewood to stop people pulling up dead shrubs
No changes
No changes
Do nothing
I would like to see more rain water tanks. Basically I believe people are protective and caring to environment
Better water (rainwater)
No
No, very well designated roads and signs
More re-cycling
Recycling facilities, leave as is
Regular rubbish removal - toilets - environment
Improved rubbish disposal
A few more camp sites across the station coastline
Access to good water and improved rubbish dump facilities
Camping on the high tide times on the beach.
Practical reservation system
A system for booking into areas
Goats removed from bushland. No increase in number of campsites
Increase of goats destroying vegetation.Cull numbers
Roadside bins on major roads
Signs saying "leave no rubbish"
Fisheries need to assess limits and size restrictions - fish will not survive when caught in 18m and thrown back in and filleting benches
More dump or rubbish points and Eco toilets. VG though
Prevent this area being locked off by National Parks
No commercial developments
Ensure that commercial development is rejected
Not too much crowding on beaches
Minimise stays and day use areas
Limited camping zones. Composting toilets
Composting toilets
Reduce number of campers for parts of the year
No Bogan
Left under station control
Keep Station Management . No main roads.
Don’t think portable toilets are a good thing
Don't do a thing just stay away
Perfect as is no more caravan parks
Kill the goats
More signs - Less introduced animals

Kill goats
Remove permanently from areas goats
Controlled firewood collection, chemical toilets.
No firewood to be taken from Warroora Station. Pay station. All must have chemical toilets
Toilets, porta loos not supervised.
Proper loos / long drops
Maybe drop toilets. Warra is perfect.

GNARALOO STATION

Upgrade roads
No resorts
Its great
Defined trades -better management of waste and environment education
Station management to stop people going where they shouldn't
Define tracks, solar power, grey water re-cycling
No rip curl search event
No rip curl
Composting toilets - especially at surf locations and places you can put food scraps eg 3 mile - or they could have chickens or compost site as a lot of waste is food scraps in the bins
Composting toilets, minimise access to area, leave it as is.
No skills
More education
Keep sponsored riders from staying at Gnaraloo
More rubbish bins
Maintain strict camping regulations and protect from development
No generators and no road development
No road development - minimise traffic to these areas
No
Better interpretation to educate public e.g. water resource
More signs regarding protection of coral reefs
More signage and interpretation re Marine Park
All water vehicles use channel in lagoon to enter & exit (Gnaraloo Station)
Retention of rugged camping for people who want it
Info about reef & creatures and how to look after them e.g. rubbish. Info pre travel recommending people re packaging
Get rid of jet skis !! Driving over coral.
More tracks
Signs advising people not to touch
Stop people, stocking freezer full of fish.
No
Tables
No driving on sand dunes at 3 Mile camp
No 5 star camp grounds
No power
Nil
None
Bitumen Road & Bluff-toilets
Proper ablutions of camping grounds
Solar power panelling only (no generators)
Less rubbish, more bins
Yes rubbish recycling
Keep camp facilities available

More education, more following of rules
Leave campsites at minimum size (capacity)
Better boat ramp facilities to minimise dine damage
Better maps
Leave roads dirt

QUOBBA STATION

Quobba Homestead
More respect for closed and station tracks
More respect i.e. rubbish dumping. People to obey rules of not driving on closed tracks
More dump points. No wood fires. No dogs
Limit length of stay @ sites to 1 week
Rubbish control/compost toilets
Length of stay in the area (Ningaloo) to be one week only.
Beach access over dunes marked
More free camping sites on beach
No "high end" tourism development
No
Minimum stay at Blowholes
Red Bluf
More recycling bins
Bag limits on fish (policed)
People placing heavy fines on people who litter
No
Defined Traces & Signage to keep traffic off sensitive areas
More bins
Yes
Supply Free Fire wood. Stop people grabbing the trees
Restrict no's visiting
Chemical Toilet dumping on station Camping Stays
More marine sanctuary, more fencing of delicate areas
A proper recycling system - WA should adopt SA system of deposits.
Minimise rubbish so kangaroos, goats etc aren't attracted.
Educating dumb campers. No goats
Ensure that the coast is held in public ownership with management. responsibility given to State.
Keep it as is, no developing
Keep development to bare minimum
Cheap firewood
Cheap firewood
Make good toilets
Restrict the number of 4WD tracks that all go to the same place
No boogers
Police littering on site. Limit spear fishing somehow
Goat cull. Fox and cat baiting. Ban on dogs
Pick up broken boards, old travel bags, all else clean.
Solar, wind power
Shower and toilet facilities help greatly
Education of Travellers, where possible advise
Empty the bins @ Gnaraloo more often. fix urine smelling campsites at Bluff & Gnaraloo
No major surf contest - will lead to mass influx of o/s travellers
More government resources to monitor/control human activity

We think this area is very well managed
Appears well managed
Only a certain number of people allowed
Do not increase the number of campsites placed on existing
Do not increase number of campsites on existing areas.
Educate dirty, greedy, littering fisho's. Ban fisho's from filling freezer trailers so I can catch a fish too.
Free firewood, cull goats
Cull the goats and sheep to protect the land and vegetation.
Stick to established tracks
More bin placements more long drop toilets less chemical toilet requirement
Leave roads minimal
No main roads
No caravans & 2W cars.
Limit coastal tracks to 4wd only with no caravans.
Don't bitumise, no govt, more fish sanctuary
More interactive education sigh, protection/to reef/dunes. Recycling
More composting toilet systems
More composting toilets
Containing camping within certain areas to minimise widespread damage
Recycle bins - bottles
Keep it at camping/No resorts etc.
Restrict free camping

BLOWHOLES CAMP

No
No changes
Put permanent fire places so people do not lit fires everywhere
Also make definite campsites and paths
Leave it as it is please. Don't change a thing to Quobba. Thanks !!!
Clean up shacks at blowholes
No caravan parks
Harsher penalties for littering. More bins.
No
No
Recycling bins (many more)
cat Culling Program
No
No 4wd on the beach
No dogs
More stopped humps
Dump points are really good
Left as natural as it can be
Move CAL out
More signage - speed signs, no fishing signs. Leave facilities as they are - No further development
No more c/van parks. No tourist development
Leave it alone for all to enjoy
Keep CALM out
Not too many people
Leave it as is. Do not put in caravan park
Stop development

Better toilet system
Keep the shacks to dissuade people from building mansions, this encouraging greater people numbers
Designated, protected campsites: Environal-Loos: fire rings
Do not develop further
Maintain control of feral animals
Keep coastline natural
Keep coastline natural
Limit people in one area
Dump point (toilet waste)
Toilet dump point
More signs and rubbish bins for day visitors
More signage showing no fishing zone
More free sites
Supply: Wood for fires, more free sites
Needs fresh water facilities (just taps will do)
Provision of fresh water
Designated areas would be useful to prevent further scrub/environment damage. To make the camping areas larger
Yes! More care from campers ie litter, firewood, general care
No
To leave as natural as possible
More toilets, some bins, no littering signs at entry point
Get rid of the "Hitlers" at CALM
Reasonably well managed as is
No. Please leave it alone, keep it as it is and don't spoil it
No
No
More 'low impact' camp sites (ie no facilities). Take it all in and out!!

Appendix J
What respondents would like to see done to minimise the environmental impacts of camping at Ningaloo (Question 23 from Questionnaire)

Answers regarding what respondents would like to see done to minimise the environmental impacts of camping at Ningaloo are provided for each management area. Comments within Appendix J are presented by management area, north to south for ease of geographical orientation (Table 1). Answers are short-answer, qualitative responses. Answers were not analysed in-depth due to time restraints of the study.

Table 1: Order number of comments presented within Appendix J.

Management Area
Cape Range National Park
Learmonth Air Weapons 'Bombing' Range
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Warroora Station Southern Camp Areas
Gnaraloo Station
Quobba Station
Blowholes

CAPE RANGE NATIONAL PARK

Keep it this way, if you want to protect the area
Natural environment
Happy as it is, don't want campsite not too much bigger.
The first-in system seems to work. If it was changed to advance bookings a lot of people would miss out. This way is more flexible and accessible. Limit to small numbers good, the positions of the camps (close to the beach) great. Maximum stay restrictions essential.
No of campsites available
I think it is all good now and no changes should be made
Shade trees removed, beach sites closed
Keep it basic !
Don't overcrowd ! Continue to not take bookings so that people such as myself who can't plan too far ahead can get a site !
Uncontrolled coastal camping
Fresh water (drinking)
Caretakers
Caretakers (they do a good job info, cleaning, collect money
Very well run but longer time would be great
Maybe shower block/toilet
No change at all
No enjoyed the visit
Keep numbers low
Booking in system. Enterprising local
Retaining the free camps available
No more Germans
Keep my infrastructure simple and clean (like Kurrajong Camp site in Cape Range) and well spaced.
Fire risk and toxic pollution
The quiet (low number of people)
Keep current campsite style and basic toilet facilities
No resort style camping
We would like to see more camp sites. Important: Allowed to use more campsites, don't take spots 4 day trippers, too much advertising 9999999
More camping sites
Free camp areas
No more camp grounds
Not increase number of campsites
Better advertising re: access to sites - need to line up at entrance at 7am etc.
No (keep the same. No resorts)
Camping to continual
Nil
I would like to see it the same in hundreds of years
Don't put up Fees especially for kids. Minimise rules, keep it basic/simple. Even Shire run recycling would be ok.. Take recycling to Info office or something. Good drinking water - so don't need to get in car to travel
Increased fees
Ability to camp close to beach. Restrictions on numbers in Cape Range Nat Pk
Minimise number of available campsites: not creating more, unless the park size is increased
Extension of camping areas, method of access ie queuing at Ranger Station
Keep dunes open for public use
Easier access /booking system

Have an advance booking system in place
Yes, do not change camping sites to booking
Leave area as is (no further commercial activity)
Keep staus quo except for No.22. most especially do not change National Park Ethos so as to cater for yuppies!!
Do not change first come first served camping rule. Do not have more sophisticated camp facilities in the part
No bookings policy is fair for all
Removal of trees. We think it would be good if there was a program to plant a tree by donating money and asking long term stayers to care/water tree while camping (like they do at Woodford Folk Festival). School kids can be involved. Indigenous varieties trialled.
The first come first served booking system. Ban on use of fires.
Keep it as simple as it is.
Nothing keep it as it is
Camp hosts time restrictions. Rec fishing only
Large areas openest up and not being fully environmentally cared for.
More than 4 weeks per year
I would not like to see stay shorter than 28 day
Not less than 4 weeks in Parks
No
Any type of commercial development
Any type of commercial development
No private developments
Development west of Cape Range
No commercialisation
Keep campsites as they are - small and peaceful
Not too many people. Not too many tours
Would like to be able to book rather than lining up
On-line booking system
No increased numbers leading to overcrowding at popular spots (Sandy Beach, Oyster Stacks etc etc)
Do not provide anymore amenities. Keep it eco friendly
People stand up on the reef and are destroying it at a rapid pace.
It is great as it is now. Well done.
Access and numbers
ore campsites available
No
No
Leave management with stations
No
Best not to increase campsite numbers but allow only up to 14 days to give more people a chance to stay
Don't enlarge or modernise facilities
Leave it as is minimal impact on environment I like it natural
I do not want it made too comfortable as too many people will stay here who do not care about the environment
Number of camp ground
do not increase number of campgrounds and campsites per campground
Camping sites not close together than at Osprey
Keep it as it is. D not make more camping areas
No booking accepted in Cape Range N it's a very good thing
No hotels/Lodges/shops/cafes
One host-supervised fire pit at each site to provide some warmth ! Also an evening social

focus that would be a big draw without any environment impact. Think about it - cavemen had fires.
Introduction of caravan Park style camping
larger caravan park style accommodation
Reduced camping periods
Reduced Camping periods
Low cost camping
Suggesting Easy dumps avoid fools pulling chemicals in pit toilets. Do not change low-cost camping availabilities to so many people
I don't want to see any developers come into this area ever and no extra campsites.
Respect for the surrounding environment & abundant wildlife
No large camp grounds
No campgrounds with more than 10 sites. Portable water in park
Toilet at Rangers Post. Arrived 8am as directed by T/B - no vacancies. Arrived 3.15am - second in line . Love low impact camping facilities
Clean toilets, rubbish collection at site
So you don't have to camp in line sometimes for days to get preferred camp location
No resorts - keep it natural
No resorts or caravan parks. Keep it natural
Preservation of reef and environment. Note: slower speed limits to preserve wildlife in park
Preservation of reef
Move entrance point closer to town (otherwise nothing) To drive 30 kms to be turned away is annoying
More camp sites
Restricted access, increase in fees, increased zoning (increase in minimise bag size catching instead)
No
No
No further site development
Keep it small and controlled please - to try and protect it
Small National Park facilities best
No permanent accommodation buildings, or lights, no pets, I LOVE Cape Range NP
No reduction in the allowable time to stay of 28 days
Keep no booking system. No large developments, keep them small
No large developments, keep no booking system
A generator free area for people in tents, or somewhere that isn't taken over by caravans and motor-homes
Include tents, keep the generator free areas
Time allowed for length of stay reduced
Small numbers per camp, nice camp hosts, friendly dulled environment!!
Great just the way it is!
No
No full service caravan parks
Development - buildings
With regard to Cape Range NP sites, site availability / booking point to be based in Exmouth
No massive infrastructure - buildings etc
Is great
Prices being raised, more accessible to encourage lots of people
Everything is fabulous
Adding amenities and increasing prices
Keep Ningaloo low impact
Keep it "low impact"
Reduction of flora and fauna via erosion and fishing and damage

I don't want campsite reservation introduced thanks. Love the low campsite fees + camp hosts.
I do not want campsite reservations introduced. Minimal campsite fees great and camp hosts. Cape Range NP and campsites are fantastic!
Price Rises

LEARMONTH AIR WEAPONS RANGE

No change
No change
Sad to say, fences, barriers and police alone will save Ningaloo (for the long term)
This campsite
The campsites
This campsite
We like it as it is. No interference, no "help" We are self sufficient. We look after the land better than other "Govt and private agencies" would
Leave as is at Doddy Bay (bombing range)
Do not want any departmental intervention

CARDABIA STATION

Why alter natural inlet for sapphire etc.
Keep DEC out
Camping on the beach areas. Pensioners cannot afford caravan Park fees
Keep DEC out
Turned camping areas into full on tourist areas
Serenity
dogs being allowed
Camping in beach areas. Definitely no development. No extra rules.
Freedom of choice to stay where my situation ditches
I love the camps, but we did not feel welcome at Cardabia, you have permanent people there every year they think they own the place, should be run by CALM
closure
Self composting/environmentally safe toilets, perhaps - salt water/bore water showers.
To be left in its natural state
Fee structure same and left in its natural state
Restrictions on station campsites
Leave it just as it is
I would like always to be able to camp here.
Leave at it is
My parents came here 30 years ago. We have been coming 12 yrs now my 4 sons are coming here attraction is simple life.
No development, keep natural

WARROORA STATION FOURTEEN MILE

No
No- extend the stations lease beyond 2006- gives more people access
Just to leave it the way it is, so lovely
Limit time stay on beach front campsites
Caravan Park
Restricted time limits because long term campers look after the environment. Short stay

campers that are only going to be here once don't care.
No
Government control
Everything
Long stay at 14 Mile Warroora
Length of time at Ningaloo i.e. 28 days
Accessibility to such beautiful coastline not the same if camps were too far from the ocean
Tip and chemical toilet facilities available. Bore water with restriction on use
No
Long term campers have a better understanding of its environment
No
No
Less van access
Less caravan access
No
As above
keep it the way it is so everyone can enjoy it for years
leave Warroora station the way it is !
Leave it like it is ! Bush camping is great
I would like to see the return of long stay camping, not 28 days or 2 weeks
Do not bring in limited staying time eg 14/28 days
The concept of beach camping
Leave it as it is
Long stay availability
Government intervention
Long stay period
I would like to see beach camping continue at 14 mile. I do not want limited time access to area
Beach camping
Government run, beach camping banned
Leave as is
that this area remain available in this state for future generations. This is a gift to stay here
Camping area to be managed by station
Dogs allowed and no time restriction
Keep camping on beach, station run campsites
Camping on beach helps my disability (left Hemi) lessens pain, gives quality of life
Unrestricted/limited time stay
Unrestricted/limited time stay
Camping on beach
Present station owned/managed campsites maintained
Camping on and near the beach
No
Camping on the beach foreshore
I don't want to see camping banned on the beach - it is what brings us here. We have a huge coast, this is such a small area for such great freedom.
Don't want to see camping on the beach banned
No
Any future development and or price rise
Government control (DEC CALM) not wanted
DEC control not wanted
don't let CALM take over - they will cock it up and reduce amount of frozen fish people take away
Keep it away from CALM and not advertise over East as they don't look after our coastline

Radical changes to time permits of camping on 14 mile peg. It is a winter lifestyle for bi-socio economic groups
Leave 14 mile as is
Keep it simple and affordable
Not so close together camps
No
Camping on the foreshore
No
Leave as is
Fine as is
Dogs allowed
Allow more access without stupid restrictions. Allow people to use the coastline for recreational use. Locking it up serves no useful purpose
More access
Preservation of existing campsite options
Keep as is
The magic scenery
Stay the same
Nil (No DEC run campsites)
No change regarding campsites
Not in the hands of CALM. It is nice the way it is now
Put into the hands of CALM
Leave as is as it is perfect
Don't change anything, leave as is
Anything
Being able to book
Don't want DEC taking it over
I think that running of camping here should be left to station owners because they have been doing a great job. Too much has been taken from the Auzzie holiday
I would like it to remain as is
If you don't like it "leave"
Development to residential
No

WARROORA STATION SOUTHERN CAMP AREAS

I hope nothing changes, its amazing
Everything
Campsite moved back from beach
It is really nice, left how it is
Over development and poor management.
No DEC
May be managed by DEC
Leave as it is
Yes Calm telling people what to do & camp
No
No Govt interference in beach camping at Warroora
It is beautiful, pristine clean, well managed. Don't charge a thing.
Make it harder to access to keep hoons out that do not respect this land, this place. To keep it prestige for my grandchildren and their children and generations to come.
Don't want DEC to change and make designated sites. Does more damage.
Retain camping areas with no facilities.
Freedom to camp near beach

Our freedom to camp along coast i.e. already appears well controlled by station.
Keeping a limit on No of each campsite. i.e. Ned's camp etc. (Exmouth)
Having camp to camp.
No generators, take your rubbish home, reduce multiple access. i.e. to many tracks through dunes etc.
No changes please
Left as is
We would like to go on camping at Warroora St as we are now
No changes necessary
Stations should be allowed to continue managing their own campers - DEC/CALM cannot "police" the areas they have now and there is not enough money for funding. All the resorts, parks, cost too much for ordinary pensioners - we always get the raw deal
Access to camping
Letting DEC involved
Prices going up through the roof (ie Gnaraloo)
Keep it simple
Access to area
I would like to see station staff remain as caretakers post 2015
Keep it hard to access that will keep numbers down to sustainable level
Stay station run and not concentrate campsites to limited areas
Don't get too commercialised
Resorts and amenities overprices and targeting the wealthy
More sanctuary zones
No resorts, more chemical toilet dump sites
No resort, more chemical toilet dump sites
No resorts. To be kept in pristine condition. No boats, jet skis etc.
No resorts
Don't change policy re vehicle access - ie make people keep to tracks
Keep as is now ie change nothing
Maintain access tracks as they are
Ocean ride, camping, boat access, overcrowding
Don't change a thing! It is perfect the way it is
Change nothing
Less DEC involvement. More community involvement
Run by station
Leave it as it is!!!!
No more bitumen roads, signs, buildings, infrastructure or regulations!
Leave it as it is. No bitumen roads
Minimal regulation. People are capable of looking after the place themselves. No signs
Natural campsites
Additional charges becoming unaffordable for families
Additional charges
Accessibility, crowds, ease at finding a spot
Sealed roads - want it all left as it is
Like it as it is
It to be left to Station owners and retirees to look after and run, not DEC
Beach access
Happy to see anything change that will facilitate ongoing health and vigor of the Ningaloo Eco-system, but my preference would be for no change
Access to beach
Beach access
Keep some areas with minimal infrastructure to keep crowds away
Don't change camping areas - maintain the isolation effect

Everything
Everything
Banning of fires. Should be left as is - no infrastructure!
Keep Warroora station run and continue to allow dogs/fires
Access to many more beach front sites for camping. Not to be over commercialised property investments. Maybe stations should stop squatters sitting on prime sites when not used daily (this should be changed)
More beach front camp sites. Better water so people wouldn't have to travel for drinking water thus less environmental impact
Keep it open to public use but don't over commercialise it ie. No hotels etc
Not expensive - keep close to nature
No
Tank water!! Needed
We like being self sufficient but water supplied
Higher fees, Stricter rules. No camp fires
Not to have it expensive or heavily policed!
Affordable camping
No perfect as it is
Access for boating launch areas "increased". Camping etc on the beach areas
The true image of Australia i.e. no resorts
No resorts, camping for average people
Current camping arrangements
Current camping arrangements
Campfires
Free camping including campfire
No more protected areas
Don't want restrictions of camping options and styles. If CALM organisation of campsites and availability was better, we would love to spend time in National Parks but they tend to be full!!
Retain remote station camping - no more National Parks
Just leave the camping the way it is!!
Would not like to see camping restrictions that diminish our opportunity to experience this fantastic coastline in its pristine state.
I really love this place and I don't want it to change and no cost to see great beaches
Would not like to see variety of camping offered change i.e. homestead, National Park, Caravan Park etc. All offer something different
No upgrade to roads and tracks Thank you
Development of resorts
No coastal buildings
Developments
No
CALM control
Station Management of camp site
Change nothing
No
Station camping at Quobba, 3 Mile etc.
Do not want caravan parks
Not commercialised
Generally great
Access to area
Freedom, wilderness experience. DEC restrictions
DEC restrictions, no dogs, no fire twirlers.

Cheaper groceries at Coral Bay !
Cheap camping, less amenities, wilderness style
No CALM control of area
Don’t change anything
No CALM management. Greater restraint on old people (rude)
Get rid of grey nomads who abuse under?? and think they own the place. Good idea, min stay of 28 days at 14 Mile

GNARALOO STATION

Don't want to seek resort built
Current fishing sanctuary zoning
Price Reduction
No resorts
Its great
Relationship to environment
No resorts!!
Don't seal road
No development
Don't change anything
Nope it is Golden!
fishing regulations
Nothing
No on-site vans etc. Camping only
Development and formalised accommodation. Destruction of the unique North West
Dog access
No development
No
None
Leave the roads unsealed. To keep it's main attraction of isolation
Campsites not to increase in size
Keep it low key - minimum facilities - no surf comps
Loss of remote spots - happy to pay to use. No bitumen! Equals more people and more impact.
Is pretty good. Difficult road limits access which is probably good for environment if not your car.
No government
Keep the stations
Number of campsites.
No
Affordability - already too expensive
Camping close to beach/low volume sites/minimal regimentation like Warroora
No power
Gnaraloo good set up
None
Gnaraloo-Warroora- Leave it alone and station run.
Number of people
No more development
keep it natural, allow dogs on lead.
Numbers of people
Hotels, powered campsites, tar roads
Keep size of camp sites small. Minimal development
If you made clean power gen.

Allow campfires. Define tracks & pathways, not to many rules and regulations. People love freedom. To be original. Allow long term cheap campgrounds. Keep it real and earthy and friendly

QUOBBA STATION

Quobba Homestead
Commercialism
Commercialism
Existing minimal rules (Quobba)
Keep minimal rules and regulations and keep camps close to coast line
No big tourist developments
Do not move campsites away from coastline
Any new restrictions
Leave it as it is
More restrictions
Need for more parks in towns that promote themselves for tourism
More shelter from wind and sun
No
Red Bluff
No more people at a time
Don't change the isolation
No
Over managed, heavy restrictions, people camping here have an awareness of protecting the environment they chose to spend time at.
Would like to see the DEC control the Ningaloo coastal strip
No sealing of roads
Yes the building of the shacks
Keep it as rigid and simple as it is
Commercialism
No Bitumen roads
No freeway or tarred roads
Don't make it too easy to access - e.g.. Bitumen road. Also provide some environmental protection from goats
The roads, I don't want them bitumised
No progress
Keep it low-key and low-impact.
More Eco-friendly appearance
Everything
Big roads and resorts
Sealed access
tourist development resorts etc.
Don't build hotels, motels
Spear fishing should be embraced, it is more selective than conventional fishing and requires people to be active
All good
No further development or permanent buildings. Do not seal road
I don't want to see any more development at Red Bluff. We love it for what it is now not what it could be
Overcrowding and cost
No changes, no development
Clean environment, clean water, simplicity
Development and government control/limitations

Keep it simple. Its unique ! Don't over analyse
Keep it simple, no resorts, no shops, no major surf contests.
Like it how it is
Don't reduce low cost camping by bringing in high cost resort style accommodation
The long drop toilet systems works incredibly well
Higher fees
No development at Bluff
Restriction of access to camping as experienced now
Restricting access to beach areas
The style of camping at Red Bluff
Leave Red Bluff as it is
The way the stations operate - you're given your freedom without feeling you are under scrutiny to do the right e.g. like DEC sites sometimes
No commercialisation
Dogs being allowed at campsites
No government beurocracy
No government beurocracy
No main roads and no CALM
Leave coastal land leased to private station owners. Don’t let the government obtain leases.
Station owned
Station managers to manage camping
More accessible tracks, permanent dwellings
Camping taken away from station control
Camping taken away from Station control
The ability to 'camp rough' (i.e. caravan parks) and use of open fines.
Wilderness experience. Not caravan park style
No commercialised resorts taking over - leave it as it is.
Don't commercialise
do not want major resort development

BLOWHOLES CAMP

Keep small beach campsites
No changes
No changes
Stop all off-shore fishing competitions by boaters
No developers
Resort/buildings just leave it alone
Don't want it to change happy how it is
Easy lifestyle
no Changes
Keep the Quobba Pt shacks.
Don't change anything
Leave as it is
We like the Blowholes as it is
Price
Yes, don't change the price
Leave camping at Blowholes as it is
Upgrading with price hikes
DO NOT change a thing
No leave all alone
All
No 4 WD on the beach

Restrictions on cheap camping/commercialization
Price is good
Would like it left as it is
More free camping
Leave the blowholes alone
As above
Leave as it is (No CALM)
No development
Leave Blowholes as it is
Do not want it to become commercialized, leave it as natural as is
Better and more toilets (like Yardie Creek)
No
A welcome environment
I want to see a development
Keep allowing dogs. Have more recycling facilities
Better toilets, easy access to fresh water
High rise development
Limit sites to current levels - encourage people to enquire whether sites are available by having a notice board at the main road turnoff, with phone numbers displayed for assistance with availability
Building of large dwellings
Do not develop further, encourage more use. Do not introduce more marine parks where no fishing allowed. Do not increase costs. We are prepared to be self sufficient and live without facilities
Satisfied with present situation
Resort development of coastline
No resort development of coastline
Price and everything about it
Don't commercialise caravan park
Not commercialised
No changes , we already have paradise, the Ozzi spirit is alive and well at this location
Leave as is apart from above
Overcrowding
No.
Water. Bore or tank provided
Current practices at Blowholes meet my needs
Yes, to keep them run as they are and not turned into commercial caravan parks
Do not change the camps, charge a few dollars more and oversee the camp more, so there is less impact - have info boards about how to camp properly and enjoy
No
No regimented/caravan parks/no power/minimal t/facilities
No bureaucracy, no price hikes, some booking system so it is not necessary to go elsewhere if there is no sites available
We would like it to remain the same except for the above
don't change anything. Retain toilet facilities. Don't increase fees. Don't restrict fishing
As above, we are slowly seeing places like this disappear. This is an Australian way of life. Camping and also money that comes into Carnarvon would surely be missed
No
No
No resorts unless 'low impact'. No more camping restrictions