

**HARVESTING STRATEGIES OF FUELWOOD AND  
KRAALWOOD USERS AT MACHIBI: IDENTIFYING THE  
DRIVING FACTORS AND FEEDBACKS**

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## **Abstract**

Forest and woodland ecosystems provide a variety of natural resources such as fuelwood, brushwood and kraal posts to local communities, as well as possess important cultural and spiritual value. However, many forests and woodlands worldwide have been unsustainably used and managed. Thus, under pressure from the international conservation community to recognise the importance of people's relationships with their surrounding natural environment, particularly for the natural resources it can provide, and given a move away from the management of forests and woodlands for sustained yields, and according to simple cause and effect models, in favour of systems approaches, South Africa has developed some of the most progressive natural resource management policies in the world.

Nevertheless, for these policies to be sensitive to local contexts, there remains a need for a better understanding of how local people in different contexts, determine forest and woodland ecosystems to be of use to them, and what 'usefulness' means to different groups of resources users. This is a case study, which examines the role of fuelwood, brushwood and kraal posts in the rural livelihoods of the people of Machibi village, located in the Eastern Cape province of South Africa, through people's preferences for particular landscapes and species, accessed for these purposes, and the trade-offs people make between resource availability and resource accessibility. Key objectives of the study are to 1) determine the preferred landscapes and species for fuelwood, brushwood and kraal posts at Machibi, 2) determine the landscapes and species actually used for fuelwood, brushwood and kraal posts, and 3) with the help of a conceptual model, and using iterative modelling as a tool, determine the factors that influence people's harvesting strategies in terms of the costs and benefits associated with the different landscape and species options. On the basis of this knowledge, the study provides some guiding principles for the better use and management of these landscapes and species for fuelwood, brushwood and kraal posts.

An innovative research approach and methodology that integrates social and ecological systems, works across disciplines, and draws on different types of knowledge is used to develop and test a conceptual model of the harvesting strategies of fuelwood and kraalwood users at Machibi. Participatory methods such as workshops, participatory resource mapping, ranking exercises and trend-lines were

used to tap into local knowledge while plotless vegetation sampling and GIS maps were used to capture the scientific information.

Results showed that people did not always use the landscapes and species they preferred. However, the local people did behave in a rational manner by weighing up the returns from harvesting and accessibility costs associated with the respective options available to them, before selecting the option(s) associated with the greatest net benefits. At the landscape level, people made trade-offs between the returns from harvesting and the accessibility costs of using particular landscapes in addition to costs associated with the physical work of harvesting fuelwood, brushwood or kraal posts from these landscapes. At the species level, people made trade-offs between the returns from harvesting and the accessibility costs of harvesting particular species for fuelwood, brushwood and kraal posts, or the costs of commercial alternatives. Cost-benefit factors that influenced people's resource use patterns also differed across landscapes and species for fuelwood, brushwood and kraal posts, respectively.

Consequently, a range of diverse and flexible management options and strategies is recommended for the wise use and management of these landscapes and species, focused on short, medium and long term goals. These strategies examine the use of cost - benefit incentives to influence people's landscape and species use patterns.

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# 1. INTRODUCTION

## **Executive summary**

Forest and woodland ecosystems perform a multitude of social and ecological functions across varying temporal and spatial scales. At the local scale, these ecosystems provide a variety of natural resources such as fuelwood and construction timber to local communities, as well as possess important cultural and spiritual value. However, many forests and woodlands worldwide have been unsustainably used and managed. Thus, under pressure from the international conservation community to recognise a broader definition of forestry that encompasses the relationships between people and natural resources, and given the shift in focus of forest and woodland management from sustained yields and simple cause and effect models to systems approaches, South Africa has developed some of the most progressive natural resource management policies in the world. Nevertheless, for these policies to be sensitive to local contexts, there remains a need for a better understanding of how local people determine forest and woodland ecosystems to be of use to them, particularly in terms of the natural resources they provide, and what ‘usefulness’ means to different groups of resources users. This is important as the ways in which people interact with their environment, and the natural resource use decisions they make, ultimately affects the well-being of current and future generations. Consequently, this study aims to identify what factors influence people’s natural resource use decisions, using the village of Machibi, situated in the Eastern Cape Province of South Africa as a case study, and focusing on two natural resources, fuelwood and kraalwood (which consists of brushwood and kraal posts), that play an important role in the local people’s livelihoods. Key objectives are to determine the preferred landscapes and species for fuelwood, brushwood and kraal posts at Machibi, as well as which of the preferred ones are actually used by the local people. By distinguishing between people’s preferences and actual use patterns, the study then aims to determine the factors that influence people’s harvesting strategies in terms of the costs and benefits associated with the different landscape and species options, with the aid of a conceptual model, and using iterative modelling as a tool. Ultimately, this knowledge will be used to provide guiding principles for the better use and management of these landscapes and species.

### **1.1 The need to assess the ‘usefulness’ of forests and woodlands to local people**

A pattern of co-evolution has for many centuries existed between humans and nature, characterised by people’s adaptations to changes in their environment (Holling et al 1998; Lane and McDonald 2002). Consequently, major socio-economic, political and ecological changes have shaped the various ways in which societies view ecosystems (Berkes et al 2000; Shackleton and Scholes 2000; Kennedy et al 2001), and forests and woodlands are no exception. This has significant implications for how various resource users determine ecosystems to be of use to them, and ultimately, for the way in which they are managed (Biggs et al 2004; Mortimore and Turner 2005; Sizer et al 2006).

In the context of this study, the ‘usefulness’ of an ecosystem is defined by the criterion/criteria for which it is judged to have a certain utility (More et al 1996). For example, a particular woodland area can be judged as useful for the harvesting of fuelwood by a certain group of resource users, given criteria such as its fuelwood density and distance from the village (Grundy et al 1993; Luoga et al 2002; Pote et al 2006). However, a different user group may judge the same woodland to be of greater use for the harvesting of timber than fuelwood, given criteria such as the density of timber species, as well as distance from the village (Liengme 1983). This has implications for the management of the particular woodland for multiple uses (Bembridge and Tarlton 1990).

Forest and woodland ecosystems perform a multitude of ecological, social and economic functions across varying temporal and spatial scales (Gunderson et al 1995; Berkes and Folke 1998; Gunderson and Holling 2002; Biggs et al 2004). These functions include the support of ecological processes such as greenhouse gas regulation, the maintenance of the hydrological cycle, nutrient cycling and the persistence of genetic and species diversity at the global level (Klooster and Masera 2000; Rao and Pant 2001; Awasthi et al 2003). At the local level, forests and woodlands provide a variety of natural resources such as fuelwood, timber, fencing, medicinal plants, fruits, honey, meat, grazing and water to local communities (Campbell et al 1997; Kituyi et al 2001; Nel and Illgner 2004; Shackleton and Shackleton 2004), as well as possess important cultural and spiritual value (Klubnikin et al 2000; Salmon 2000; Tabuti et al 2003; Bodin et al 2006).

However, many forests and woodlands worldwide have been used and managed in a manner which is unsustainable in the long term (Ainslie et al 1997; Geist and Lambin 2002; International Institute for Sustainable Development 2005). For example, many studies on the use of natural resources by local communities have documented an increasing scarcity of resources (Ainslie et al 1997; May et al 1997), increased distances covered in search of resources (Gandar 1984; Shackleton et al 1994; Pote et al 2006), and the supplementation of fuelwood and kraalwood resources with commercial alternatives (Mahapatra and Mitchell 1999; Lawes et al 2004; Madubansi and Shackleton in press). Hence, there is a need for the development of strategies for the better use and management of these ecosystems.

## **1.2 Historical context: trends in forest and woodland use and management**

Traditional hunter-gatherer societies relied heavily on the abundant forest and woodland resources that surrounded them (Lane and McDonald 2002; Fabricius 2004). Consequently, these societies generally appreciated the ways in which nature could be useful to them, and incorporated nature into their worldviews, metaphors, folklore and belief systems (Nabhan 1997; Sullivan 1999; Che and Lent 2004). Many of their systems of governance included rules and procedures designed to maintain ecosystem processes and functions. This incorporated nurturing sources of ecosystem renewal by creating small-scale disturbances, improving productivity and boosting the resilience of the system through adaptive management (Turner et al 2000; Toledo et al 2003; Bodin et al 2006).

These practices have been carried down from generation to generation by cultural transmission, and are now recognised as customary (Berkes and Folke 1998; Berkes et al 2000). They include practices such as succession management in forests, and the management of landscape patchiness, designed to buffer these systems against consecutive, small-scale disturbances that may or may not interact with each other to trigger a bigger change (i.e. ecological pulses) or single, big-change events and surprises (Berkes et al 2000; Fabricius 2004; Fox 2005).

Other customs have developed to nurture biodiversity stocks, and encourage renewal after resource depletion – for example, taboos and superstitions around the use of

specific tree and plant species, or certain forests that were considered sacred, and therefore, protected (Klubnikin et al 2000; Von Maltitz and Shackleton 2004; Bodin et al 2006). For example, Che and Lent (2004) showed that species such as *Olea europaea ssp. africana* (Umnquma) and *Ptaeroxylon obliquum* (Umthathi) were left undisturbed in the indigenous, Afromotane forests of the Eastern Cape, South Africa, or collected in the wild and re-planted within people's homesteads, as Xhosa-speaking families believed that such trees influenced the weather and would protect them from thunder and lightning. Eeley et al (2004) documented the preservation of sacred forests by various African cultures, as spiritual centres for cultural and religious ceremonies, as well as for their association with certain important tree and plant species. Some taboos regarding the use of fuelwood species were broken in times of extreme scarcity, suggesting that their function was partly to nurture resources upon which to fall back on in times of hardship (Tabuti et al 2003).

However, although many of these practices still exist, they were more prevalent and effective in the past because of low human population densities, high mortality rates, and low impacts on natural resources caused by human activities (Lane and McDonald 2002; Fabricius 2004). At Machibi, for example, *O. africana* and *P. obliquum* are used for kraal posts, and although these species are believed by the local people to have protective powers against thunder and lightning, there is no evidence of the species having been collected in the wild and re-planted in people's homesteads. Instead, people would harvest a branch from these species and hang it above the entrance to the main house to ward off the bad weather. Furthermore, although the people of Machibi do acknowledge certain sites, most often associated with pools of water such as dams or streams, as sacred, there are signs of resource harvesting taking place here.

The hunter-gatherer stage of societal development was followed by one of colonisation, settlement and commercialization from the mid-17<sup>th</sup> century through to the 1900s (Lane and McDonald 2002; Fabricius 2004). An influx of European settlers to South Africa sparked an era of intense use of the indigenous forests predominately for timber, and woodlands for hunting and later agriculture, which lasted approximately 200 years (Von Maltitz and Shackleton 2004; Willis 2004). Thus, the focus of forest and woodland management was on the maintenance of sustained yields

of timber and other forest resources needed to support rapid economic growth and growing urban, industrial regions, as well as the maintenance of long-term forest productivity (Kennedy et al 2001; Tewari 2001; Lane and McDonald 2002). Furthermore, the establishment of plantations of fast-growing, exotic species such as *Eucalyptus* to keep up with growing timber demands had positive and negative impacts on forest and woodland stocks. While commercial plantations caused loss of biodiversity in woodlands, as exotic species out-competed the indigenous species for resources (McNeely 2002), they simultaneously served to reduce the pressure on natural forest stocks, and even facilitated the recovery of natural forest biodiversity and the expansion of forests in certain regions (Von Maltitz and Shackleton 2004).

It was not until the early 1900s that law-makers in Southern Africa started realising that natural resources would inevitably be depleted if something was not done to conserve dwindling forests and combat land degradation. Prompted by political and economic events in developed countries such as the American dust bowl, associated with the depression in the 1930s, a preservationist attitude towards the use of natural resources in southern Africa emerged (Schroeder 1999). The emphasis of conservation strategies shifted to that of controlled use of natural resources from forest lands, associated with the establishment of protected areas by the state and other provincial conservation authorities, as well as the efforts of private landowners to create conservancies (Fabricius 2004; Von Maltitz and Shackleton 2004). An extensive process of surveying, demarcating and gazetting forests was implemented by the then Department of Forestry (under the Cape government), with the aim of excluding all human settlement from taking place within these areas and restricting people's access to resources (Von Maltitz and Shackleton 2004).

In contrast, woodlands received far less attention from the colonial government and were not managed as a specific vegetation type. Vast areas were transformed for cultivation, while livestock farming was the primary activity on pristine woodland. In areas that were unsuited for farming, due to disease outbreaks or unfavourable climates, woodland was also set aside for wildlife conservation (Von Maltitz and Shackleton 2004).

However, the restrictions put on resource use (often through the implementation of a quota system), mechanisms of restricting access (e.g. fencing in protected areas) and the capacity of the management authority, in terms of adequate time, finances and manpower, to enforce these restrictions, differed across conservation authorities (Mabunda et al 2003; Von Maltitz and Shackleton 2004). For example, national parks were managed under a no-use policy while people were allowed to harvest resources from state forests with a permit for subsistence use only (i.e. no harvesting for commercial use was allowed). All national parks were at least partially fenced while most state forests were not fenced, except for a few in more developed areas such as Mount Coke, to exclude livestock and goats. Reserves, managed by provincial conservation authorities were also fenced, and adjacent communities lost all rights to woodland resources in these areas (Willis 2004; Von Maltitz and Shackleton 2004).

In addition, many poor, black communities which lacked political clout during the colonialist and apartheid eras were forcibly removed from their homes to make place for such protected areas, without adequate compensation, and relocated to new areas that were more densely populated, less productive and poorer in biodiversity than the land from which they had come (Fabricius 2004). Furthermore, their social situation had become more fragmented than ever with the breakdown of relationships and social networks that had previously formed an integral part of people's coping mechanisms for dealing with ecological events and surprises (Madzwamuse and Fabricius 2004). Exclusion from protected areas also instilled the local people with negative attitudes towards conservation, and illegal harvesting of natural resources increased (Abbot and Mace 1999; Nagothu 2001). The Makuleke is a well known South African example of where local people were forcibly removed from their land during 1969 in order to expand Kruger National Park northwards from the Pafuri River to the Limpopo River, which forms the border with Zimbabwe, for conservation as well as military reasons (Reid and Turner 2004). However, in the spirit of democracy, and in an attempt to right the wrongs of the apartheid era, ownership of this land was restored to the Makulekes in 1996, as part of a successful land claims process, associated with the land restitution programme, which was launched in 1994 (after South Africa's first democratic elections).

Moreover, local people who were forcibly removed from their land were relocated to 'Betterment Planning Villages,' with a strong emphasis on promoting agriculture as the mode of development (Von Maltitz and Shackleton 2004; Cundill 2005). The then agricultural department of government lobbied for more scientific agricultural practices as the answer to improving agricultural outputs, and provided incentives by way of government subsidies to promote by-in from the people. In addition, these villages came with demarcated areas for livestock grazing and crop farming, which constituted communal woodlands (Cundill 2002). However, due to a variety of contributing factors including inadequate resources, poor planning and confusion over the roles and responsibilities of the local people and government, these communal woodlands were ultimately managed as open access areas with no exclusivity rights (Scheepers 2001; Cundill 2002; Fabricius 2004; Von Maltitz and Shackleton 2004).

Consequently, the preservationist approach placed increased pressure on forest, and particularly, woodland resources, as many local communities were resettled within woodland areas, and a new people-centred approach to natural resource management emerged as an alternative (Rao and Pant 2001; Tewari 2001; Lane and McDonald 2002; Awasthi et al 2003). This approach recognised that natural resources played an important role in the livelihoods of local communities, and paved the way for co-management arrangements between governments, parastatals, private sector companies and local communities, aimed at biodiversity conservation as an integral part of wider development programmes (Gandar 1984; Geldenhuys 1997; Sibanda 2004; Reid and Turner 2004).

These arrangements may take on many different forms, and have been applied to a variety of management contexts with mixed successes and failures (Fabricius et al 2004a), associated with the establishment of legally-recognised and representative community trusts to manage multiple use areas in Botswana (Boggs 2004), the delineation of range management areas, and formation of grazing associations to manage them in Lesotho (Turner 2004), and the creation of communal area conservancies in Namibia (Nott and Jacobsohn 2004) to name some examples. Arguably the most famous Southern African example is that of the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) in Zimbabwe, which aimed to provide benefits from wildlife conservation to local users through co-

management arrangements with government, and the decentralization of land and other resource administration to the district level (Child 2004; Sibanda 2004).

The key underlying principle is that of a sharing of benefits, responsibilities, control and decision-making authority over natural resources between government and local users for multiple purposes, which include 1) the conservation, development and protection of biodiversity, 2) provision of equitable access to resources to contribute to improved human well-being and 3) the promotion of sustainable resource use (Grundy and Michell 2004; Reid and Turner 2004). However, while these co-management arrangements are participatory in nature, the meaning of ‘participation’ varies between contexts. ‘Participation’ can range from the management authority possessing all the decision-making power with token involvement of local people to a form of collective action in which the local people own and manage the resource themselves (Grundy and Michell 2004).

In South Africa, for example, the Participatory Forestry Management (PFM) programme, championed by the Department of Water Affairs and Forestry (DWAF), aims to promote co-management of indigenous forests, whether state or communally-owned (Grundy and Michell 2004). In the case of state forests, this means a shift from exclusionary practices and protection of resources towards joint management and use therefore by neighbouring local communities (i.e. while the state remains the primary management authority, local communities also have some decision-making power). Within communal areas, it means providing local people with improved ‘extension services’ by way of providing training and expert technical advice on a broader range of resource management issues, addressing agriculture, conservation, forestry and water issues (Willis 2004). Biodiversity conservation, improved access to resources, tangible benefits (including economic returns), capacity building and sustainable resource use are goals of this initiative, with a long-term vision of promoting sustainable forest management through an adaptive approach, which also emphasizes self-assessment and consequent adjustment of activities (Grundy and Michell 2004). There are pilot sites where PFM is being tested in South Africa, and Machibi does have an active PFM committee, which works closely with DWAF on a range of resource management issues.

However, there were also other reasons for the shift in conservation thinking from a preservationist to a people-centred approach in South Africa. This included pressure from the international conservation community to recognise a broader definition of forestry that encompassed the relationships between people and the resources provided by forest and woodland ecosystems (Shackleton 2000a). On an international scale, an important milestone was the development of the Convention on Biological Diversity (UNCBD 1992) at the United Nations Conference on Environment and Development in Rio De Janeiro, which emphasized the sustainable use of biological resources (i.e. genetic resources, organisms or parts thereof, populations, or any other biotic component of ecosystems with current or potential use for humanity), and the fair and equitable sharing of benefits from their use (Glazewski 2000).

In South Africa, national policies now embody these same principles. The Constitution of the Republic of South Africa (No. 108 of 1996) established everyone's right to use and protect the natural environment. The National Environmental Management Act (No. 107 of 1998) (NEMA) provided management principles and procedures for co-operative governance of the environment, and the sustainable use of natural resources.

NEMA (No. 107 of 1998) was succeeded by the promulgation of the National Environmental Management: Biodiversity Act (No. 10 of 2004) that provided for the establishment of a National Biodiversity Institute for research, and the National Environmental Management: Protected Areas Act (No. 57 of 2003), which allowed for the declaration of protected areas ranging from nature reserves to national parks. Similarly, the Eastern Cape Environmental Conservation Bill (2001), when enacted will provide for the establishment of provincial nature reserves and wilderness areas, local nature reserves, private nature reserves and conservancies.

With particular attention to forest and woodland resources, the White Paper on Sustainable Forest Development in South Africa (DWAF 1996) and the National Forests Act (No. 84 of 1998) aimed to promote a thriving forestry sector to be used for the lasting benefit of the total community, and developed and managed to protect and improve the environment (Willis 2004). For the first time, the forest policy in South Africa recognised 'forests of all kinds,' that included indigenous woodlands. It

also recognised that government had a role to play towards fostering a spirit of stewardship, regardless of the ownership of forest land (i.e. whether it was state, private or communal land) (Shackleton 2000a; Willis 2004).

The arrival of democracy in South Africa on the wings of rapid resource depletion, further exacerbated by political propaganda leading people to assert their perceived rights to wider access of resources, also placed additional pressure on natural resource management agencies to consider the needs of local communities for greater recognition and improved access to natural resources, and involve them in conservation efforts (Fabricius 2004; Grundy and Michell 2004). Consequently, community-based natural resource management (CBNRM) initiatives were seen as the answer to poverty relief and the lack of basic services in rural areas. These initiatives aimed to promote resource-related, rural development and diversify the economy to include tourism and the commercial use of biodiversity (Fabricius 2004; Shackleton et al 2004). A number of Spatial Development Initiatives (SDIs) and Integrated Development Plans (IDPs) were launched to stimulate nature tourism industries and diversify the rural economy, as part of a wider development programme to foster entrepreneurs and beneficiaries in new resource-based industries (Baviaans Municipality 2003; Cacadu Municipality 2003; Sunday's River Valley Municipality 2003).

Another catalyst for this change in approach was the realisation by government that it lacked the financial and human resources to effectively prevent resource degradation. Thus, the devolution of authority to local communities was seen as a way to reduce the transaction costs of managing natural resources, as well as encourage local people to take ownership of, and responsibility for the use and management of their own resources (Murphree 1997; Nott and Jacobsohn 2004; Fabricius et al 2004a).

Ultimately, it remains to be seen whether the people-centred approach to natural resource management will stand the test of time. While some initiatives have certainly enhanced the protection of forest and woodland resources, they have not all been win-win solutions in terms of also satisfying people's basic needs (Reid and Turner 2004; Sibanda 2004).

### **1.3 How changes in conservation thinking have influenced advances in systems ecology**

During the 19<sup>th</sup> and 20<sup>th</sup> centuries, the focus of forest and woodland management was on the maintenance of sustained yields of timber, needed to support rapid economic growth and urbanization, as well as the maintenance of long-term forest productivity (Kennedy et al 2001; Lane and McDonald 2002). However, this period was associated with the liquidation of many forest and woodland resources (Lane and McDonald 2002).

Scientific perceptions of an ordered, segmented and mechanistic world promoted the fragmentation of traditional sciences into separate disciplines and specialties (Holling et al 1998; Kennedy et al 2001). Economists and natural resource scientists in forest, wildlife and watershed management developed their perceptions and theories on the functioning of these systems based on a machine or clockwork model of economies and/or ecosystems (Holling et al 1998; Kennedy et al 2001; Lane and McDonald 2002).

Research viewed the causes of natural resource management problems such as deforestation and land degradation as simple and linear (Lambin et al 2001; Nagothu 2001). The focus of research was on producing simple cause and effect models (Kennedy et al 2001). For example, deforestation and land degradation were viewed as consequences of the widening gap between the increasing demand for resources, resultant from population growth, and the decreasing resource supply (Lambin et al 2001; Nagothu 2001).

Rural economies were traditionally viewed as separate and distinct from global economies in terms of space and time, as well as less diverse and sophisticated. In addition, it was for these reasons that rural economies were regarded as less resilient than global economies (Kennedy et al 2001).

This view was influenced by Malthus's arguments that population growth is limited by resource availability, and that population growth is only kept equal to resource availability by the existence of poverty for some people (Glass 1953). However, Malthus presupposed a closed economy with inflexible limits, and the external

influence of technology in determining these limits (Malthus 1951; Lambin et al 2001).

Subsequent research during the 21<sup>st</sup> century has shown that simple answers found in population growth, poverty and the use of technology rarely provide adequate understanding of the human-nature relationship, and the underlying causes of natural resource management problems (Lambin et al 2001). Holling et al (1998) identified natural resource management problems as being complex, non-linear in nature, cross-scale in time and space, and having an evolutionary character. In addition, Holling et al (1998) recognised that while the causes were sometimes simple when fully understood, they were always multiple with some aspects of unpredictability.

Numerous case studies showed that local people adapt their livelihood strategies in response to a wide range of factors in their environment. These factors include economic conditions such as market prices (Awasthi et al 2003; Toledo et al 2003), institutional factors such as weak formal and informal rules regarding the use of resources (Rao and Pant 2001; Toledo et al 2003), social factors such as cultural taboos (Nagothu 2001), induced innovation or intensification of traditional practices (Lykke 2000; Awasthi et al 2003) and inappropriate management interventions (Lykke 2000; Lambin et al 2001), giving rise to rapid changes of landscapes and ecosystems. Ecological constraints also impact on these factors (Lambin et al 2001; Folke and Fabricius 2004).

Consequently, economists and natural resource scientists have begun to realise that economic, social and ecological systems do not exist or function independently of each other, but rather that the boundaries of these different systems are arbitrary, with feedback loops existing between the different components (Scheepers 2001; Rohde et al 2006; Sendzimir et al in press). This new way of thinking has led to the development of the ecosystem management approach to natural resource science.

The systems approach highlights the need to develop adaptive socio-economic and ecological models and theories that require an understanding of how social, cultural, economic, political and ecological factors change, interact and impact on one another

over time, and at different spatial scales, to influence the livelihoods of rural people all over the world (Holling et al 1998; Kennedy et al 2001).

#### **1.4 Impact of consumptive use and human disturbance on biodiversity and ecosystem functioning**

Although many human activities have gained a negative reputation for causing land degradation and deforestation (Lane and McDonald 2002), not all types of disturbance have negative implications for biodiversity and ecosystem functioning. For example, managing ecosystems with small-scale disturbances that encourage ecosystem renewal can lead to improved productivity, and boost the resilience of the system through increased biodiversity. Toledo et al (2003) showed that by way of the maintenance of a variety of landscape types, indigenous communities in the tropical rain forest areas of Mexico could take advantage of the natural process of forest restoration, and derive benefits from the various stages of succession, thus using the available resources with maximal efficiency. Fox (2005) also showed that local communities in the Kat River Valley, South Africa, managed landscape patchiness in order to obtain multiple benefits.

Furthermore, many researchers have argued that intermediate levels of disturbance are necessary to release stored resources such as moisture, nutrients and light needed to promote the colonisation of new micro-habitats and ecosystem renewal (Grime 1979; Sousa 1984; Armesto and Pickett 1985). However, this depends on the duration of the disturbance, as well as the structure and composition of the vegetation communities.

Assuming that every species performs some ecological function, the distribution and abundance of species at a particular scale, whether that of an individual, community, population or ecosystem, has implications for the way the system is structured, functions and responds to disturbance (Hansen and Walker 1985; Peterson et al 1998). Hence, there are many competing models that attempt to describe how an increase in species richness increases ecosystem stability (MacArthur 1955; Lawton 1994; Walker 1995; Peterson et al 1998). However, central themes to all of them are the complementarity of function of different species within an ecosystem, and the notion that a certain amount of redundancy makes for a more robust system, which is better able to cope with disturbance.

MacArthur (1955) proposed that the addition of species to an ecosystem increases the number of ecological functions present, and therefore, contributes to greater stability of an ecosystem (i.e. the more functionally diverse an ecosystem as a result of increased species richness, the better it is able to cope with disturbance). However, when subsequent studies revealed that despite dissimilar species compositions, different ecosystems could perform similar ecological functions, Lawton (1994) proposed an alternative model – that species are organised into functional groups, and that these groups are determined by regional ecological processes. Lawton (1994) thereby introduced the concept of functional redundancy among species to the scientific community, which Walker's (1995) drivers and passengers hypothesis expanded on by proposing that ecological function resides in 'driver' species or in functional groups of such species.

However, it was Peterson et al (1998) that explicitly incorporated an additional element to their model – that of cross-scale linkages within an ecosystem, which is critical to understanding how stability and ecological function may mean different things depending on the 'lens' through which the system is studied. Understanding interactions among species requires understanding how species interact within and across scales. This model proposed that it is the distribution of functional diversity within and across scales that give a system its stability (i.e. a species may occur at one scale but function at another within the broader system).

Studies have shown positive and negative impacts of intermediate disturbance on different types of species. For example, Grundy et al (1993) and Shackleton et al (1994) showed that fast-growing, r-strategist species were favoured by increasing disturbance intensity associated with the harvesting of natural resources such as fuelwood by local communities in Zimbabwe and South Africa. In contrast, Lykke (2000) showed that slow-growing, k-strategist species were negatively impacted by increasing disturbance intensity. However, further research is needed to be able to understand the cross-scale linkages within a system.

In addition, the method used to create a disturbance contributes to its impact on the environment. For example, the harvesting of deadwood or fresh branches from a tree

(e.g. for fuelwood) does not result in tree mortality (Shackleton 1993; Shackleton et al 1994) and can therefore be considered less destructive to the environment than the harvesting of the entire tree stem (e.g. for timber and fencing materials) (Liengme 1983; Obiri et al 2002). However, some damaged or felled trees do produce coppice shoots in response to disturbance. Hence, in quantifying the disturbance impact, one need also consider the disturbance-recovery processes of the plant species. Recovery measures employed by plants include their natural regeneration (through seedling or vegetated regeneration), growth rates, rates of re-growth and coppice re-growth. One can also determine whether the tree is able to be propagated in a nursery as an alternative to natural regeneration in the wild (Geldenhuys 2004).

Some studies have looked at the disturbance-recovery processes of medicinal plant species after bark harvesting, predominately along the Southern Cape coast of South Africa (Geldenhuys 2004). However, little information is available on the disturbance-recovery processes of species used for fuelwood and kraalwood.

High levels of disturbance result in a loss of biodiversity, regeneration potential of useful tree species and ecosystem resilience, and in extreme cases, can cause a system to irreversibly flip from one state to another (Walker 1993; Ludwig et al 1997; Scheffer and Carpenter 2003). Studies such as Fabricius et al (2002) and Fabricius et al (2003) also showed that high levels of disturbance over a prolonged period can cause a reduction in land element diversity (i.e. landscape patchiness), and therefore in habitat diversity for arthropod groups such as ants, crickets, grasshoppers and spiders.

Social factors can further exacerbate such ecosystem disturbances. These factors include weak institutions regarding the use and management of natural resources (Abbot and Mace 1999; Tabuti et al 2003), as well as their poor enforcement by local authorities, often linked to the erosion of local knowledge and traditional practices as a result of external influences (Awasthi et al 2003; Cundill 2005), the disempowerment of traditional systems of authority (Manona 1992; Ainslie 1999), and the imposition of western systems of governance such as courts, fines and fences on local people (Fabricius 2004).

For example, Awasthi et al (2003) and Madzwamuse and Fabricius (2004) showed how changes in lifestyle and the livelihood strategies of local communities in India and Botswana, brought about by external factors such as market changes or changes in land and conservation legislation, contributed to the reduced capacity of these systems to adapt to disturbance, and resulted in increased land degradation. Other studies such as Manona (1992) and Ainslie (1999) showed how the replacement of traditional authorities such as the chief and headmen system in rural South Africa with new, democratically-elected systems of government, based on western concepts of conservation, such as Residents Associations, resulted in much confusion surrounding whose responsibility it was to control natural resource use by local communities, and contributed to the over-exploitation and degradation of many forests and woodlands.

Ultimately, designing sustainable harvesting systems for natural resources requires an understanding of the entire resource area, the growing stock of those species harvested, the response to harvesting and the market demand (Geldenhuys 2004; Seydack and Vermeulen 2004). However, this study only focuses on the latter by trying to understand which landscapes and species people prefer and/or actual use for fuelwood and kraalwood at Machibi, and what social and ecological factors (i.e. costs and benefits) influence demand.

### **1.5 Threats to the Albany Thicket Biome**

The study area falls within the Albany Thicket Biome, which is characterised as a dense, woody, semi-succulent and thorny vegetation type with an average height of two to three metres that is relatively impenetrable in its pristine state (Acocks 1953; Everard 1987; Thompson et al 2001). Within the context of this study, the term ‘thicket’ is used to describe very dense, tangled vegetation, usually formed by low or tall shrubs and some trees (Mucina and Rutherford 2006), with a total tree canopy cover of greater than nine percent, and canopy height of between two and five metres (Thompson et al 2001).

In turn, the Albany Thicket Biome is made up of various vegetation units across a wide variety of plant communities of varying structure and species composition. Buffels Thicket is one example (Mucina and Rutherford 2006), and constitutes the

dominant vegetation type of the study area, occurring along the slopes of river valleys within the highly dissected and hilly parts of Mount Coke State Forest (Mount Coke), and in smaller patches along stream channels over the moderately undulating plains of the adjacent village of Machibi (see chapter 3; section 3.4).

However, the dense thicket grades into more open, shorter thornveld at the edges of the valley slopes (Mucina and Rutherford 2006), and where it has been degraded and ‘opened-up’ due to poor management practices such as over-stocking, land transformation through cultivation and expanding rural settlements (Boshoff et al 2000; Lloyd et al 2002; Palmer et al 2004), associated with the establishment of Machibi during the Betterment Planning period in South Africa (Manona 1992; Cundill 2002). ‘Thornveld,’ in the context of this study, is defined as woodland savanna dominated by trees with thorns, mainly *Acacia karroo* (Mucina and Rutherford 2006). The term ‘woodland’ can be used synonymously with ‘savanna’ to describe a vegetation type which is a mix of grasses and trees. ‘Savanna’ is typically characterised as vegetation with a grass-dominated herbaceous layer and scattered low to tall trees (Shackleton and Mander 2000; Mucina and Rutherford 2006).

Buffels Thicket constitutes of a wide range of growth forms, and a high diversity of plant species, including leaf and stem succulents, small trees, tall and low shrubs, climbers, geophytes and grasses (Mucina and Rutherford 2006). This vegetation unit is inclusive of VT 1 Coastal Forest and Thornveld (40%) and VT 23 Valley Bushveld (39%) (Acocks 1953), LR 48 Coastal Grassland (31%) and LR 5 Valley Thicket (30%) (Low and Rebelo 1996), and STEP Mountcoke Grassland Thicket (45%) and STEP Buffels Thicket (32%) (Vlok and Euston-Brown 2002). Although this study did not call for a classification of the vegetation in terms of its structure, biogeography or otherwise, notes were made of important species in the field (excluding geophytes, succulent herbs and grasses not used for fuelwood and kraalwood). A list of plant species is provided in chapter three but *Euphorbia triangularis* and *Aloe ferox* are examples of succulent tree species that occur in the study area. Small trees included *Calodendrum capense*, *Harpephyllum caffrum*, *Ptaeroxylon obliquum*, *Schotia latifolia* and *Sideroxylon inerme*. Shrubs such as *Scutia myrtina*, *Coddia rudis*, *Gymnosporia arenicola*, *Carissa bispinosa*, *Olea europaea subsp. africana*,

*Hippobromus pauciflorus* and *Rhus lucida* were also found, in addition to woody climbers such as *Plumbago auriculata* and *Rhoicissus tridentata*.

The vegetation is adapted to a semi-arid environment, which experiences a rainfall of 500 to 840 mm per annum, and has a coefficient of variation of between 22 and 29 percent. Consequently, the plant species employ different mechanisms such as below-ground storage organs, sclerophylly, CAM photosynthesis and succulence to cope with the semi-arid conditions (Shackleton and Mander 2000; Mucina and Rutherford 2006). But unlike other semi-arid ecosystems, intact thicket does not support a regular or widespread fire regime because of its low availability of fuel and high degree of succulence (Kerley et al 1995; Kerley et al 1999). However, where thicket has been degraded, and the non-flammable succulent component replaced with a potentially more flammable field layer (which is not necessarily a herbaceous layer), the occurrence of fire may be increasing (Vlok and Euston-Brown 2002), producing vegetation that is more typical of thornveld in the case of Machibi.

Thicket vegetation has also historically supported a high diversity and density of indigenous herbivores, and their impact on the vegetation is marked with the evolution of defence mechanisms against browsing in many plant species (Everard 1987). However, two key traits of this vegetation type make it vulnerable to high disturbance over a prolonged period, namely, a low annual production and very slow recovery rates after the disturbance (Mucina and Rutherford 2006).

Consequently, many explanations have been provided for the degradation of the Albany Thicket Biome. These include the excessive use of fire to manipulate the species composition and structure of the vegetation, livestock overgrazing, land transformation through cultivation, expanding urban and rural settlements (particularly between East London and Bisho in the Eastern Cape) and the invasion of alien species, which out-compete the indigenous species for moisture, light and space (Boshoff et al 2000; Lloyd et al 2002). In addition, Ainslie et al (1997) and Palmer et al (2004) identified the harvesting of natural resources such as fuelwood and construction timber at unsustainable levels (i.e. where demand exceeds supply) as both a present and future threat to thicket vegetation for as long as these resources continued to play an important role in rural livelihoods (Table 1.1).

Table 1.1: Annual, gross direct-use figures (S.A. Rand) per household of timber use by rural households in South Africa (adapted from Shackleton et al (1999), Shackleton and Shackleton (2000a, b), Motinyane (2001), Twine et al (2003) and Shackleton et al (2002))

Province	Site	Fuelwood (R)	Housing timber (R)	Fence/kraal timber (R)	Total (R)
Eastern Cape	Pikoli	1 596	156	132	1 884
	Kat River	1 145	1	22	1 168
KwaZulu-Natal	KwaJobe	726	54	154	934
	Hlabisa	212	6	15	233
Limpopo Province	Mogano	1 736	0	5	1 741
	Mametja	706	3	17	726
	Hagondo	1 569	2	106	1 677
	Bushbuckridge	465	62	156	683
MEAN		1 019	36	76	1 131

There are many signs of growing natural resource shortages, particularly in rural, communal areas in South Africa. For example, many households supplement fuelwood use with commercial alternatives such as paraffin, gas and electricity, as well as livestock and agricultural residues (Lawes et al 2004; Madubansi and Shackleton in press). Others travel increased distances from their villages to access these resources (Gandar 1984; Vermeulen 1996; Kirubi et al 2000; Pote et al 2006).

Numerous studies have shown that people make trade-offs between resource abundance and travel cost (Liengme 1983; Boudreau et al 2005). Motinyane (2001) documented an increase in the density of preferred fuelwood species with increasing distance from the village of Pikoli in the Eastern Cape. Shackleton et al (2004) also reported an increase in the quantities of fuelwood collected over greater distances in areas of resource scarcity. However, long distances travelled by the resource users,

where this was not an option, were often offset by decreased frequency of gathering and reduced fuelwood consumption.

Moreover, some people resorted to harvesting live wood when insufficient deadwood was available to meet their fuelwood requirements. Where this practice was taboo, people sometimes choose to harvest species that dried quickly, or were easy to camouflage as deadwood (Shackleton 1993; Madubansi and Shackleton in press). Although people were often reluctant to talk about it, studies also show that when resources are scarce, people sometimes resort to illegal harvesting from adjacent farms or protected areas to meet their needs (Shackleton 1993; Kituyi et al 2001; Rao and Pant 2001). Some local communities neighbouring protected areas in the Eastern Cape, however, term their use of protected resources as ‘legalised stealing’ because they believe that historically these resources belong to them (Shackleton et al 2004).

Similarly, people’s marked selection of useful timber species within the Albany Thicket Biome has led to a direct decline in certain species. For example, Scheepers (2004) found that although *Eucalyptus* was not identified as a preferred kraal post species by the local people of Machibi in the Eastern Cape, it was used with abundance for their kraals, as they could no longer obtain the species they preferred from the community woodlands. Other studies have also showed that households supplement the use of indigenous species for kraal posts with exotic alternatives in areas of scarcity (Van Eck et al 1997; Ham and Theron 2001; Jagger and Pender 2003).

However, although thicket constituted the dominant vegetation type of the study area, there were small, indigenous forest patches (i.e. less than 10 ha), which characterised FOz 5 Scarp Forest (Mucina and Rutherford 2006), found within certain Mount Coke valley bottoms. ‘Forest,’ in the context of this study, is defined as a multi-layered vegetation unit, dominated by trees (largely evergreen or semi-deciduous) and possessing a canopy cover of greater than 75 percent, where graminoids in the herbaceous stratum (if present) are generally rare. Stand height ranges from high forest (i.e. over 30 m) to scrub forest (i.e. over 3 m) (Mucina and Rutherford 2006).

FOz 5 Scarp Forest forms part of the Transkei Coastal Belt – a narrow coastal strip consisting of a mosaic of grassland vegetation on the hill tops and upper hill slopes, alternating with bush clumps and small forests occurring along the steep river valleys of the highly dissected, hilly landscape, which extends along the Wild Coast of Transkei and the Indian Ocean seaboard between Port St Johns in the north and the Great Kei River in the south (Mucina and Rutherford 2006). This classification is inclusive of Pondoland Coastal Plateau Sourveld and Transitional Coastal Forest (Acocks 1988), and Coastal Forest (Low and Rebelo 1996).

Hence, FOz 5 Scarp Forest constitutes tall (i.e. between 15 and 25 m), species-rich and structurally diverse, multi-layered forests with well developed canopy and understorey tree layers but a poorly developed herb layer. Tall, conspicuous tree species found at Mount Coke include *Harpephyllum caffrum* and *Millettia grandis*.

The distribution of these forest patches, in particular their age and persistence on site, is related to their proneness to fire (i.e. their sensitivity to fire regimes), and the shift between C<sub>3</sub> and C<sub>4</sub> dominated ecosystems with fluctuating carbon dioxide levels over time (Mucina and Rutherford 2006). However, despite mounting evidence for the role of climate and fire in shaping the current patterns of forest cover, human activities such as heavy forest clearing (particularly from the mid 17<sup>th</sup> century through to the 1900s to keep up with the rapid economic growth in South Africa) have also played their part (Fabricius 2004; Willis 2004; Von Maltitz and Shackleton 2004).

Almost five percent of FOz 5 Scarp Forest across South Africa has been transformed for cultivation or plantations, in the case of Mount Coke. The forests have further been degraded by the invasion of alien species (Mucina and Rutherford 2006). In the Eastern Cape of South Africa, the collapse of traditional authorities has also led to the uncontrolled use of these forests for natural resources such as medicinal bark harvesting and deadwood extraction for fuelwood (Mucina and Rutherford 2006). For example, as the average annual deadwood harvested from community forests in the Eastern Cape, South Africa, (i.e. 1531 tonnes per annum) comprised a significant proportion of that which was produced annually (i.e. 1898 tonnes per annum), Obiri (2002) concluded that this use was probably unsustainable. In other forests in the Umzimvubu district of the Eastern Cape, there was also indiscriminate use by the

local people of all species whose stems were of suitable size for building, fencing and kraal posts, resulting in the depletion of the most ‘wanted’ species (Shackleton et al 2004).

### **1.6 Shortcomings in forest and woodland policies**

South Africa possesses some of the most progressive forest policies in the world in terms of their sustainability principles, often linked to rural development, and the provision for local communities to be included in the use, maintenance, development and management of forest and woodland resources (Fabricius 2004; Willis 2004). However, as the factors influencing people’s interactions with the natural resource base are often multiple, cross-scale in time and space and with numerous linkages and feedbacks between them (Gunderson et al 1995; Lynam et al 2004; Rohde et al 2006), our predictive understanding of these relationships remains weak.

At the heart of ensuring the sustainable use of South Africa’s forest and woodland resources lays the issue of demand and supply, where the reality of the situation is that in many cases the former outweighs the latter (see section 1.5). Thus, the challenge for scientists, managers and policy-makers alike remains to find ways in which to optimise use while ensuring sustainability (Willis 2004). This necessitates understanding how people make their natural resource use decisions, and the factors that influence them – by no means an easy task.

Supported by previous studies, there are a number of critical ingredients often necessary to engage local people in sustainable resource use practices, including improved access and rights to natural resources (Boggs 2004; Sibanda 2004), the maintenance or revival of local institutions which embody sustainability principles (Sullivan 1999), and the promotion of a diverse and flexible range of livelihood options (Toledo et al 2003; Fabricius et al 2004a). Hence, there is a clear need for policies to be more responsive to differences in local contexts and to emphasize adaptive management (Du Toit et al 2003; Willis 2004).

One way to achieve this goal is through the recognition and inclusion of elements of local management and knowledge systems, which complement the principles of adaptive management (Holling et al 1998; Sullivan 1999; Berkes et al 2000), in forest

policies. In theory, this is true of most current policies. However, the reality of the situation is that local knowledge is seldom afforded any status (Fabricius 2004), and forest policies remain biased towards the use of conventional scientific logic and principles.

In addition, although the policy trend has been towards increased participation and the devolution of responsibility to local communities to manage their own resources, the interpretation of 'participation' on the ground varies widely (Fabricius 2004). In many cases, for example with the Tchumo Tchato project in Mozambique (Johnson 2004), local communities remain passive participants rather than playing an active role in the planning, development and management processes.

In the absence of adequate participation by local communities, policies are sometimes implemented on the false assumption that local communities 'speak with one voice' (Fabricius 2004), whereas studies such as Johnson (2004) and Sithole (2004) have demonstrated the opposite; that local groupings or user groups constantly redefine themselves and their aspirations for the future. Hence, there is a need for policies to place greater focus on the adoption of group-based initiatives (Pretty and Ward 2001) and the management of forests and woodlands for multiple uses (Bembridge and Tarlton 1990).

### **1.7 Project scope**

This study addresses the need for a better understanding of how local people determine forest and woodland ecosystems to be of use to them, particularly in terms of the natural resources they provide, and what 'usefulness' means to different groups of resources users (Chipeta and Kowero 2004). This is important as the ways in which people interact with their environment, and the natural resource use decisions they make, ultimately affects the well-being of current and future generations (Biggs et al 2004; Mortimore and Turner 2005; Sizer et al 2006). Consequently, this study has important implications for the better management of these systems, and a better understanding of how to buffer them against radical, and often irreversible, changes (Walker 1993; Anderies et al 2002; Scheffer and Carpenter 2003).

To this end, this study aims to identify which factors influence people's landscape and species preferences and patterns of natural resource use at Machibi, Eastern Cape. 'Landscape,' in this context, is used in a generic sense to refer to various forest and woodland patches, differing across a number of social and ecological characteristics, used for the harvesting of natural resources by the local people of Machibi. These landscapes constitute Mount Coke State Forest (Moke Coke), several community woodlands and old agricultural fields surrounding Machibi, as well as neighbouring community land in the form of Rodi Farm (see chapter three; section 3.1). The term, 'species,' refers to the different types of trees and/or shrubs that constitute these landscapes.

However, given time limitations, the study focuses on the use of two natural resources by the local people, rather than the complete range of available resources (see chapter three) These are fuelwood and kraalwood, which form important components of rural livelihoods at Machibi. Fuelwood consists of the stems or stout branches of woody tree and shrub species that are used as fuel for cooking and heating purposes (Bembridge and Tarlton 1990; Dyer 1996; Shackleton 1993; Motinyane 2001) (Figure 1.1).



Figure 1.1: Women with their fuelwood bundles

Kraalwood refers to the wood used in the construction and maintenance of livestock corrals, known locally as ‘kraals’. Based on the form and structure of a typical Xhosa kraal, kraalwood is divided into two categories; brushwood and kraal posts (Scheepers 2001; Pote et al 2006). Brushwood refers to the branches of woody tree or shrub species that are loosely piled on top of each other or compacted to construct the sides of the kraal. Kraal posts constitute the stems or stout branches of trees that are set vertically at kraal entrances, and used intermittently along the sides of the kraal to reinforce the packing material or brushwood (Figure 1.2).



Figure 1.2: Traditional Xhosa kraal, constructed from brushwood and kraal posts

The study distinguishes between those landscapes and species that people most desire to use (i.e. people's preferences), and those that they actually do use (i.e. people's natural resource use patterns) for fuelwood, brushwood and kraal posts, respectively. However, in so doing, the study draws on paradigms and principles from other fields of study such as resource economics, behavioural ecological and wildlife management (see chapter two; section 2.2)

A resource user's 'preference' for a particular landscape or species is defined as the measure of his/her desire to use that resource. This is synonymous with the concept of a 'preference' in the economic sense, as a measure of satisfaction, because it reflects how much he/she 'wants' to use that resource (Dasgupta and Pearce 1972). Supported by Pearce and Turner (1990) and Field (2002), this definition also allows that people's experiences with nature, and natural resources, often encoded in their systems of knowledge and belief, culture, traditions, customs and ethics can influence these preferences (Sullivan 1999; Klubnikin et al 2000; Turner et al 2000). However, it differs from the economic definition in that it does not assume a local user's

'preference' for a particular landscape or species to be constrained by resource limitations. Consequently, a species such as *Schotia latifolia* (Umngxam) may continue to be preferred for kraal posts long after its depletion due to over-utilisation (Scheepers 2004). People's preferences are based on their past experiences of the landscapes and species, and their historical perceptions, rather than facts, for example, concerning resource abundance (Pahl-Wostl in press).

In reality, this is seldom the case as resources are limited, and people are forced to exercise choice over the landscapes and species they use for fuelwood, brushwood and kraal posts (Curtis 2004). This choice is determined by the trade-off between the benefits obtained from the use of a particular landscape or species, and the costs incurred to use it (Dusgupta and Pearce 1972; Pearce and Turner 1990; Field 2002). Consequently, the 'actual use' of a particular landscape or species by a local user can be reflected in what he/she is willing and able to sacrifice in order to use it (i.e. his/her willingness to pay) (Pearce and Turner 1990). It is in this sense that a 'preference,' in terms of the economic definition, is synonymous with a local user's pattern of natural resource use at Machibi.

The level of utilisation or 'active selection' of each landscape or species, as referred to in this study, is determined by its proportional utilisation relative to its availability. Thus, when a landscape is scarce in a particular resource (e.g. a diversity of kraal post species), and yet exhibits signs of high utilisation, possibly attributed to the presence of one or two high quality species, it is then referred to as 'actively selected'. Conversely, if a particular species is abundant, and can be harvested at a low cost to the resource user, and yet displays little signs of utilisation (e.g. the removal of branches for fuelwood), it is regarded as 'avoided' by the local people. Consequently, 'utilisation/availability ratios,' as referred to in this study, are synonymous with 'preference ratios,' as defined by Neu et al (1974) and Shackleton et al (1994), where a resource is regarded as 'actively selected' when its utilisation/availability ratio is greater than one, and 'avoided' when its ratio is less than one.

### **1.8 Aims and objectives**

By comparing people's preferences with their patterns of landscape and species use, the study then aims to identify the factors that influence people's harvesting strategies

for fuelwood, brushwood and kraal posts. Therefore, the objectives of this study include:

- 1) Determine the preferred landscapes and species for fuelwood, brushwood and kraal posts at Machibi,
- 2) Determine the landscapes and species actively selected by the local people for fuelwood, brushwood and kraal posts, and
- 3) With the help of a conceptual model, and using iterative modelling as a tool, determine the factors that influence people's harvesting strategies in terms of the costs and benefits associated with the different landscape and species options.

On the basis of this knowledge, the study hopes to provide some guiding principles for the better use and management of these landscapes and species for fuelwood, brushwood and kraal posts, which are sensitive to the local context, and promote a diversity of options. These principles can serve to guide the development of any future management system for resource use at Machibi.

The outline of this thesis then follows such that chapter one paints the natural resource management problem, and provides the broader scientific, resource use and management background for the local case study at Machibi. Chapter two incorporates this background information into a conceptual model of the harvesting strategies of resource users at Machibi, and provides a basis for some hypothesis formulation about the socio-ecological factors that influence the individual resource users' preferences and landscape and species use patterns for fuelwood, brushwood and kraal posts. Chapter three describes the socio-economic and ecological profile of the resources users at Machibi, and highlights their heavy reliance on natural resources for their livelihoods. Chapter four provides an overview of participatory and scientific, and resource economic and behavioural theory methods available to researchers, and highlights their various strengths and weaknesses such that one can understand why the methods used in this study were chosen. Chapters five and six test the assumptions of the conceptual model with respect to people's resource preferences, and the factors that influenced their use patterns. Chapter seven links the empirical findings of chapter five and six to the original conceptual model, highlights where the findings either did or did not support the model, and refines the model. Chapter eight summarises the findings of the study, and comments on the usefulness

of borrowing ideas and paradigms from resource economics and behavioural ecology, and using local and scientific knowledge to better understand people's resource use decisions.

## **2. CONCEPTUAL MODEL (VERSION I): HARVESTING STRATEGIES OF FUELWOOD AND KRAALWOOD USERS AT MACHIBI, AND THE FACTORS THAT INFLUENCE THEM**

### **Executive summary**

Natural resource management problems are complex given that they are non-linear in nature, cross-cutting in space and time, often have multiple causes, and contain an element of unpredictability. Hence, conceptual models are important tools to help ecologists, scientists, policy-makers and natural resource users conceptualise the linkages and feedbacks between the different components, and develop a common understanding of the problem. This chapter presents a conceptual model of the harvesting strategies of fuelwood and kraalwood users at Machibi in order to enhance our understanding of the factors that influence local people's resource use decisions, and facilitate the better use and management of natural resources. This model integrates social and ecological systems, borrows principles and paradigms from other fields of study such as resource economics and behavioural ecology, and draws on local and scientific knowledge to ensure that it is sensitive to the local context, and that any management recommendations are credible and legitimate to the local people.

### **2.1 Using a conceptual model to understand natural resource use problems at Machibi**

The people of Machibi share a close relationship with their surrounding environment, where elements from the ecological system such as various landscapes and species used for the harvesting of natural resources are captured in the people's local knowledge and belief systems, culture and traditions (Che and Lent 2004). Moreover, natural resources such as fuelwood, brushwood and kraal posts play an important role in the livelihoods of the local people by providing cost-saving benefits at the household level, and performing an important safety net function during times of

hardship (Twine et al 2003; Shackleton and Shackleton 2004) (see chapter three, section 3.3).

However, there are signs that these resources are not being used and managed sustainably. Supported by previous studies, the local users note changes in their preferences and use patterns (Scheepers 2004; Pote et al 2006), an increasing scarcity of resources (Ainslie et al 1997; May et al 1997), increased distances covered in search of resources (Gandar 1984; Shackleton et al 1994; Pote et al 2006) and the supplementation of preferred species for fuelwood, brushwood and kraal posts with commercial alternatives (Mahapatra and Mitchell 1999; Lawes et al 2004). Consequently, there is a need for the development of strategies for the better use and management of these resources, based on an understanding of the local people's resource preferences, and the factors that influence their choices over which landscapes and species to use for fuelwood, brushwood and kraal posts (Biggs et al 2004; Fabricius et al 2004a).

As this natural resource management problem has a diversity of social and ecological elements with numerous inter-linkages across different spatial scales, ranging from the landscapes to species people prefer to, and do use, for natural resources, as well as across different temporal scales, taking into account past management practices at Machibi from 1960 until present day, and embodies a selection process in the form of learning from past experiences, it is complex (Kurtz and Snowden 2003). For example, there may be multiple drivers of the system related to resource availability, resource accessibility and the availability and cost of alternatives (Shackleton and Scholes 2000). There may be non-linear elements and the lack of simple, cause and effect relationships given that the decline in a preferred species can result in increased distances covered in search of it (Vermeulen 1996; Pote et al 2006), changes in people's resource use patterns (Shackleton et al 2004) and/or the use of alternatives (Van Eck et al 1997; Vermeulen 2001). Furthermore, people differ in their capacity to adapt to ecosystem changes, which has implications for the management of complex systems (Brooks et al 2005; Lebel et al 2006; Metzger et al 2006), as the decisions they make, and their responses, affects the well-being of current and future generations (Mortimore and Turner 2005; Sizer et al 2006).

Hence, developing a conceptual model can help to conceptualise, examine and test the effect of multiple factors on the functioning of the system in a simplified manner so as to enhance a broader understanding of the problem (Starfield et al 1990; Starfield and Bleloch 1991; Lynam et al 2002). In addition, a model can provide a novel approach to integrate the social and ecological components of the system through guiding the selection of a combination of methods from the ‘hard’ and ‘soft’ sciences, where the former emphasizes factual knowledge and the relationship between factors in the real world, and the latter emphasizes people’s perceptions and socially constructed reality (Chapin and Whiteman 1998; Pahl-Wostl in press).

Numerous studies such as Gunderson (2001), Huggert (2005) and Zurlini et al (2006) use models to demonstrate ecological thresholds, and help manage an ecosystem for a particular desired state. This ability to identify thresholds in natural and/or human-impacted systems also assists natural resource planners and practitioners to make difficult decisions that involve tradeoffs, where promoting one benefit results in a decrease of other benefits (Rose and Chapman 2003; Biggs et al 2004; Wei and Hoganson 2005). For example, threshold knowledge can be used to develop landscape designs that promote heterogeneity and the optimal use of resources (Seppelt and Voinov 2002; Huggert 2005).

This chapter presents a harvesting model for Machibi using a flow diagram to conceptualise the linkages and feedbacks between components of the social system (i.e. people’s local knowledge, beliefs, culture and traditions etc.) and ecological system (i.e. landscapes, and the associated species for fuelwood, brushwood and kraal posts), and how these relationships may influence the local people’s harvesting strategies, and ultimately, their natural resource use patterns (Woodwell 1998; Lynam et al 2002). The conceptual model provides a framework for hypothesis testing with regards to the factors that influence people’s preferences (Starfield et al 1990; Hutchinson and McNamara 2000), and the trade-offs they make when actively selecting which landscapes and species to use for fuelwood, brushwood and kraal posts (see chapters five and six). Empirical manipulations of the model data then allows for the refinement of the conceptual model (see chapter seven), and the screening of management strategies to assess their potential effects on system functioning (Scheffer et al 2001; Lynam et al 2002).

## **2.2 Building blocks of the harvesting model for Machibi**

The harvesting model does not delineate between the social system and ecological system because it assumes interconnections between the two system types (Berkes and Folke 1998; Pierotti and Wildcat 2000). These interconnections take the form of social and cultural practices that incorporate ecological elements such as landscapes and species that are used for the harvesting of fuelwood, brushwood and kraal posts (Lykke 2000; Luoga et al 2002; Awasthi et al 2003) but may also be associated with sacred areas (Klubnikin et al 2000; Fox 2005), predominately sacred pools of water along local streams in the case of Machibi, and the maintenance of local taboos associated with specific plant species (Salmon 2000; Che and Lent 2004), which influence people's preferences and natural resource use patterns, and ultimately, impact on the natural resource base.

However, changes in the natural resource base can in turn influence people's use patterns and preferences, and eventually, their local knowledge and belief systems, culture and traditions (Berkes and Folke 1998). For example, Fox (2005) and Bodin et al (2006) showed how taboo areas can become refugia for important species and perform an important safety net function for local people during times of crisis. Thus, the local people do not view themselves as separate from nature but rather as part of the system. They are linked to the natural environment in which they live through cultural traditions and interactive relationships (Salmon 2000; Turner et al 2000). Hence, the term 'socio-ecological system,' in the context of this model, refers to the integrated concept of humans-in-nature (Berkes and Folke 1998).

However, the integration of the social and ecological systems necessitates working across disciplines in order to incorporate the different perspectives people may have of the same environment, and what this means for its 'usefulness' (Cundill et al 2004; Ericksen and Woodley 2004; Pahl-Wostl in press). 'Soft' sciences such as the social sciences emphasize people's perceptions and socially constructed reality (Chapin and Whiteman 1998; Pahl-Wostl in press). On the contrary, 'hard' sciences such as the biological sciences focus on presenting the facts (Pahl-Wostl in press). The harvesting model for Machibi incorporates elements from both perspectives in a common approach that is used across disciplines such as resource economics, behavioural

ecology and wildlife management – that of optimal choice – to assess the ‘usefulness’ of various landscapes and species for fuelwood, brushwood and kraal posts to the local people (Hutchinson and McNamara 2000; Kacelnik and Marsh 2002; Field 2002).

Conventional consumer behaviour theory assumes that an individual’s ‘desire’ to use a particular resource is reflected in their willingness to pay for it (Pearce and Turner 1990). This measure takes into account the benefits obtained from the use of the resource, as well as the costs and risks associated with its use (Sikhakhane 2001; Field 2002; Turner et al 2003), where the optimal choice is represented by the option that affords them the greatest net benefit.

Optimal foraging theory also states that animals behave in a particular manner so as to maximise some increasing function of expected benefit and decreasing function of expected cost (Hutchinson and McNamara 2000; Kacelnik and Marsh 2002). Numerous behavioural ecology and wildlife management models have shown that when making foraging decisions about which resource patches to exploit and which to avoid, animals weigh up the benefits of improved calorie intake with the cost of energy expenditure or risk of predation before choosing the option that affords them the greatest net benefit (Hurly and Oseen 1999; Olsson et al 2002; Arcis and Desor 2003), whether measured as the net rate of gain (gain-expenditure/time) or efficiency (gain/expenditure) (Kacelnik and Marsh 2002). Therefore, as animals also make trade-offs between the costs and benefits of obtaining particular resources, willingness to pay is comparable to optimal foraging.

Similarly, the harvesting model for Machibi assumes that local users behave like conventional consumers in that they exercise choice over the landscapes and species they use for fuelwood, brushwood and kraal posts. The model assumes that this choice is made in a rational manner by weighing up the costs and benefits associated with the different options available to them before choosing the best one.

In order to capture, as far as possible, the qualitative and quantitative elements of the ‘usefulness’ of particular landscapes and species to the people, the model also draws on different types of knowledge regarding the natural resource base (More et al 1996;

Ericksen and Woodley 2004). Formal knowledge is accumulated through applied learning and education within formal institutions such as schools and universities (Colley et al 2002). Scientific knowledge is an example of formal knowledge that is accumulated through a series of logical and empirical methods that includes systematic observations of the world, hypothesis formulation to explain these observations, and hypothesis testing to verify these explanations (Holling et al 1998; Ericksen and Woodley 2004). Consequently, the model draws on scientific knowledge to identify what factors influence the local people's landscape and species choices, and to quantify their effects (i.e. determine the costs and benefits).

In contrast, informal knowledge is accumulated through informal processes and practical experiences outside of a formal learning setting (Colley et al 2002). Local knowledge, also sometimes referred to as traditional knowledge (Huntington 2000; Klubnikin et al 2000; Turner et al 2000), is an example of informal knowledge that is accumulated through cultural transmission, about the relationship humans have with one another, and their surrounding environment (Berkes and Folke 1998; Berkes et al 2000). Thus, the model uses local knowledge, with a basis in history and comparisons between the past and present, to explain the linkages and feedbacks in the system (e.g. between people's patterns of use, and their impacts on the natural resource base).

### **2.2.1 'Usefulness' of landscapes and species**

In the context of this study, the 'usefulness' of a landscape or species is defined by the criterion/criteria for which it is judged to have a certain property (More et al 1996). For example, a landscape can be judged to be useful for the harvesting of fuelwood given criteria such as its fuelwood density and distance from the village (Grundy et al 1993; Luoga et al 2002). Similarly, a species can be judged to be useful for kraal posts given criteria such as its durability, straightness and termite resistant properties (Van Eck et al 1997; Shackleton et al 2004).

In turn, the criteria by which a particular landscape or species is defined as useful for fuelwood, brushwood or kraal posts can be used to specify relationships between the different available options (Brown 1984; More et al 1996). For example, people may actively select landscapes of high resource density, and avoid landscapes of low density (Campbell and Du Toit 1988; Grundy et al 1993; Lynam et al 2004).

Similarly, people may actively select landscapes near their homes (i.e. villages or settlements), and avoid those far away (Vermeulen 1996; Kirubi et al 2000; Shackleton et al 1994). Supported by Liengme (1983), Bembridge and Tarlton (1990), Abbot et al (1997) and Van Eck et al (1997), people may actively select hardwoods over softwoods for fuelwood species because they produce better coals.

This has implications for the harvesting model for Machibi, which examines the influence of a number of social and ecological factors (i.e. criteria) on people's preferences and patterns of use of landscapes and species for fuelwood, brushwood and kraal posts. The model also assesses the relative importance of the options available to the local people (see chapter five).

### **2.2.2 The underlying principle of cost-benefit analysis**

Ecosystems such as forests and woodlands are capable of producing a multitude of benefits for society (Shackleton and Mander 2000; Eeley et al 2004). However, as all benefits of a resource cannot be maximised concurrently, people are forced to make trade-offs between the benefit obtained from its use for one purpose at the cost of its use for another (More et al 1996; Turner et al 2003). For example, the use of a forest for the production of timber comes at the cost of its conservation. Thus, a consumer's preference for a particular resource is reflected in what he/she is willing and able to sacrifice in order to use it (i.e. his/her willingness to pay) (Pearce and Turner 1990).

Conventional consumer behaviour theory, upon which public policy is based, assumes that consumers will choose the option that affords them the highest benefits (after cost deductions) when faced with trade-offs that involve such difficult choices (Turner et al 1994; Ward and Beal 2000; Field 2002). This behaviour is said to be rational because the consumer weighs up the costs and benefits associated with the different options in order to determine his/her optimal choice. The term 'cost' refers to the price or penalty incurred by the consumer for the use of a particular resource or good, which need not be a monetary cost (Dasgupta and Pearce 1972; Pearce and Turner 1990; Field 2002). The price or penalty could take the form of the opportunity cost of the consumer's time or the travel cost (i.e. distance travelled) incurred to obtain the resource (see 2.3.2b). In contrast, the gain or satisfaction obtained from using this

resource or good is referred to as the 'benefit' (Dasgupta and Pearce 1972; Pearce and Turner 1990; Field 2002).

A number of assumptions underpin rational choice. The assumption of complete ordering refers to two properties of rational decision-making, namely transitivity and regularity (Tversky 1969; Dasgupta and Pearce 1972; Huber et al 1982; Tversky and Simonson 1993). Transitivity applies to a series of binary choices such that a consumer is said to behave rationally when the order in which he/she displays a preference for the respective options from a given set (A, B and C) remain in the same direction (i.e. when A is preferred to B, and B is preferred to C, then A is also preferred to C) (Dasgupta and Pearce 1972; Bateson et al 2002). This assumption has implications for the ranking of landscapes and species preferred for fuelwood, brushwood and kraal posts by the local people such that any option with a lower rank than another should not be associated with greater benefits (Bembridge and Tarlton 1990; Van Eck et al 1997).

The assumption of regularity states that the addition or subtraction of a less acceptable option from the range of available options should not influence the consumer's relative preferences for the original options (Dasgupta and Pearce 1972; Bateson et al 2002). An example includes the failure of woodlots as a probable solution to resource scarcity because of the insecurity of land and tree tenure, or lack of early economic returns associated with this option, relative to existing options available to local people, where resources are effectively treated as 'open access' within communal areas, due to weak or non-existent institutional controls, and the payoff is immediate (Ainslie et al 1997; Shackleton et al 2004). Similarly, this assumption can have implications for the establishment of new landscapes and species for fuelwood, brushwood and kraal posts at Machibi.

An additional assumption of rational choice includes that of continuity of choice (i.e. that the user is consistent in his/her reasons for choices) (Dasgupta and Pearce 1972). For example, Van Eck et al (1997) showed that multi-purpose trees are consistently preferred over single-purpose trees for fuelwood, building posts and wild fruit in the Eastern Cape Province, South Africa. The assumption that a sufficient number of non-indifferent options exists (i.e. that there is a range of difference in the amount of

satisfaction to be gained from the various options available to users, beyond which preference can be said to exist) also has implications for the ranking of fuelwood, brushwood and kraal post landscapes and species at Machibi, according to people's stated preferences (Dasgupta and Pearce 1972).

### 2.2.2a Willingness to pay

The 'usefulness' of a resource or good is reflected in what the consumer is willing to pay to use it (More et al 1996; Field 2002). However, as the number of units of the resource or good consumed increases, the willingness to pay for additional units normally decreases. This concept is referred to as 'diminishing willingness to pay' (Dasgupta and Pearce 1972; Sikhakhane 2001; Field 2002).

This relationship is reflected in the shape of the demand curve (Figure 2.1), where as the quantity of the resource or good increases from  $Q$  to  $Q_1$ , the price decreases from  $P$  to  $P_1$  (Dasgupta and Pearce 1972). The 'total willingness to pay' is represented by the area under the resource demand curve (Sikhakhane 2001).

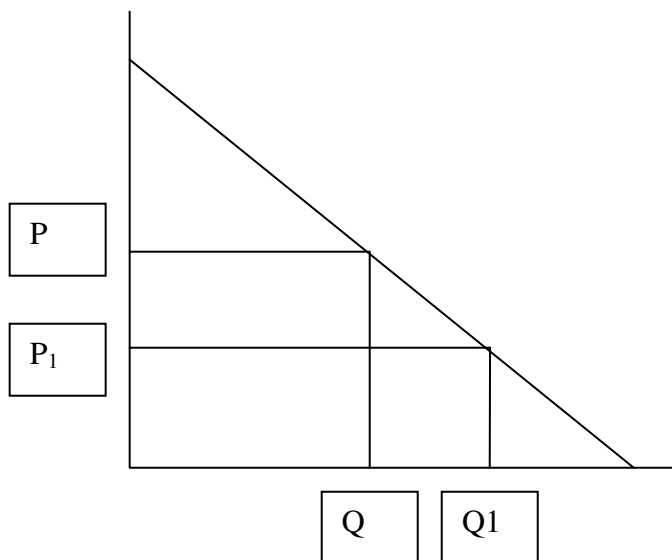


Figure 2.1: Typical demand curve, showing that the quantity of a resource is negatively correlated to its price (where  $Q$ =original quantity of the resource;  $Q_1$ =higher quantity of the resource;  $P$ =original price for the resource;  $P_1$ =lower price for the resource) (taken from Dasgupta and Pearce 1972)

However, a number of critical assumptions are made when using willingness to pay as a measure of the 'usefulness' of a resource or good. These assumptions include that the willingness to pay pattern for a particular resource or good is critically affected by the consumer's ability to pay for it (e.g. by money or time constraints) (Sikhakhane 2001; Field 2002), and that a consumer's preferences are influenced by his/her knowledge of the resources or goods, and remain constant over a long enough time (Pearce and Turner 1990). Furthermore, it is assumed that the consumer has a complete understanding of all information and attributes pertaining to the decision context, and knows all past and future choices, in order to develop an absolute preference ranking for the various available options (Gans 1996).

However, as research has showed that 1) most consumers do not scan the choice set and consciously pick a maximal element from it, 2) computing the optimal choice is often quite difficult, and even if they wanted to, most consumers would be unable to do it, 3) consumers sometimes fail to conform to some of the basic assumptions of rational choice, 4) the conclusions of rational analysis sometimes fail to conform to reality and 5) the conclusions of rational analysis sometimes seem unreasonable, even on the basis of simple introspection, the theory of bounded rationality, first proposed by Herbert Simon, has enjoyed recent strong support in opposition to neoclassical economics (Aumann 1997; Sent 2004). Bounded rationality opposes the strong assumptions of rational choice, disapproves of the restricted interpretation of strategic behaviour where the decisions of multiple players within a specific context are likened to that of a two player scenario, and desires the development of dynamic models where the decision-makers can learn and better their choices over time, towards being optimal (Sent 2004).

Consequently, bounded rationality refers to a stable set of rules (i.e. rules of thumb) by which consumers, acting with incomplete knowledge, can satisfactorily make decisions towards meeting a specific target (near but not necessarily the optimal choice) (Gans 1996; Sent 2004). These rules of thumb could include using Bayesian formulas, least squares (or adaptive control) algorithms, or neural networks to help consumers learn more about the decision context, and make better decisions. Therefore, the consumer's learning involves changing their choices on the basis of

past outcomes to move nearer towards optimality (Sent 2004). If the rules work well, they are retained and refined by the consumer whereas if the rules work poorly, they are used less and less, and eventually abandoned (Aumann 1997).

Ultimately, the concept of willingness to pay has implications for feedback mechanisms, which help regulate the system. Supported by studies such as Shackleton et al (1994) and Vermeulen (1996), the harvesting model for Machibi assumes that a gradient of decreasing utilisation with increasing distance from the village exists such that the local users express an increasing disinterest in harvesting an additional load of fuelwood, brushwood or kraal posts, as the distances they are required to travel to access these resources increases, until eventually a threshold is reached at a certain distance from the village where the travel cost becomes prohibitive.

### **2.2.2b Travel cost model**

The ‘usefulness’ of resources or goods that are formally traded in markets can be measured in terms of their price. However, a major problem associated with determining the ‘usefulness’ of natural resources that are used on a subsistence basis, is that they are characterised by non-exclusivity (i.e. the use of a resource to the benefit of one resource user detracts from the benefits available for other resource users), and are not traded in markets (Ward and Beal 2000; Sikhakhane 2001). Thus, the ‘usefulness’ of these resources has typically been measured with travel cost or hedonic models, recognising that, although many of these resources may be unpriced, consumers still make sacrifices in terms of the distances travelled, or the cost of their time, in order to use them (Pearce and Turner 1990; Turner et al 1994; More et al 1996; Razafindralambo 1998; Field 2002).

Assumptions made when using this method include that the consumers can be grouped into zones surrounding the resource where they would have similar preferences because of similar socio-economic characteristics. It is also assumed that the consumers reach a point where they would no longer be willing to use the resource because the travel costs are too high (Sikhakhane 2001).

### **2.2.3 The underlying principle of optimal foraging theory**

The majority of normative animal behavioural models are based on the concept of optimisation, and underpinned by the assumptions of rational choice such as transitivity and regularity (Hutchinson and McNamara 2000; Bateson et al 2002). They predict that animals behave in a particular manner so as to maximise some increasing function of expected benefit and decreasing function of expected cost (Hutchinson and McNamara 2000; Kacelnik and Marsh 2002). These models have been applied to a wide variety of phenomena including foraging (Shafir et al 1999; Hutchings et al 2001), predator avoidance behaviour (Olsson et al 2002; Arcis and Desor 2003), intra-specific competition (Elkin and Baker 2000) and life history decisions about growth and reproduction (Hutchinson and McNamara 2000; Olsson et al 2002).

In the context of behavioural ecology and wildlife management, the 'benefit' derived by an animal from using a particular resource is often associated with energy gain or calorie intake, improving their safety from predators or improving their chances of successful reproduction (Hutchinson and McNamara 2000; Olsson et al 2002; Arcis and Desor 2003). In contrast, the 'cost' of using the resource comes in the form of the animal's use of effort or energy in accessing it. The distance travelled and/or time spent travelling are indicators of effort or energy expenditure during resource use activities (Hill et al 2001; Kacelnik and Marsh 2002).

Normative behavioural models have been used to predict an animal's optimal resource use choices by weighing up the costs and benefits associated with the different options available (Hurly and Oseen 1999; Alm et al 2002; Grafen 2002). The option that elicits the maximum net rate of gain (i.e. gain-expenditure/time) or maximum efficiency (i.e. gain/expenditure) is referred to as the 'optimal choice' (Hutchinson and McNamara 2000; Kacelnik and Marsh 2002).

#### **2.2.4 Local and scientific knowledge**

'Knowledge' pasted from Merriam-Websters dictionary (2006) is defined as 1) the fact or condition of knowing something with familiarity gained through experience or association, 2) acquaintance with or understanding of a science, art, or technique, 3) the range of one's information or understanding and 4) the sum of what is known: the body of truth, information, and principles acquired by humankind. Similarly, Ericksen

and Woodley (2004) refer to 'knowledge' as a construction of a group's perceived reality, which the group members use to guide behaviour toward each other and the world around them. Knowledge systems have a social context, and in many instances, environmental knowledge is important to a group's identity.

These definitions encompass two types of knowledge; formal knowledge, of which scientific knowledge forms part, and informal knowledge, an example of which is local knowledge (Holling et al 1998; Colley et al 2002; Ericksen and Woodley 2004). However, the distinction between formal and informal knowledge is not absolute, and at the level of broad principles, similar principles of use and validation apply, although the procedures may differ (Fabricius et al 2004b). Consequently, despite differences in subject matter and characteristics, methodological and epistemological approaches to investigate reality and historical contexts, scientific and local knowledge do share like elements (Agrawal 1995).

For example, scientific knowledge that is accumulated through a series of systematic observation and inquiry with the help of logical and empirical methods, and subject to strict standards of scientific objectivity and quality, enforced through a peer review process (Mitchell 1997; Holling et al 1998; Ericksen and Woodley 2004), is considered coarse-grained and universal in its subject matter, as it incorporates a variety of contexts while aiming to reduce the inherent uncertainty in complex systems to a point where the acceptance of the results among the scientific community is undisputed (Holling et al 1998; Fabricius et al 2004b). This structured and standardised format of scientific knowledge facilitates easy identification of cause and effect relationships and the study of case comparisons, as any one scientist can replicate the work of another (Ward and Beal 2000; Ericksen and Woodley 2004). Furthermore, it allows the scientist to formulate scientific statements without necessarily having personally observed or experienced the topic of research (Berkes and Folke 1998; Berkes et al 2000).

Consequently, the strength of scientific knowledge is that it allows for detailed, quantitative analyses and reduces bias in the interpretation of the data. However, because of its structured nature and strict adherence to scientific validation through peer review, scientific knowledge does not always allow for different perspectives and

explanations of natural resource management problems or open itself to criticism from other stakeholders and non-scientists (e.g. local communities, government) (Ericksen and Woodley 2004).

In contrast, local knowledge is accumulated through practical experience, and by a process of trial and error, and is carried over from generation to generation in people's folklore, societal norms, management systems and social memory (Berkes and Folke 1998; Berkes et al 2000; Colley et al 2002; Fabricius et al 2004b). This adaptive process more often than not acts as a filter on the quality and validity of knowledge that is transferred. Useful knowledge, rules of thumb etc. are carried over to the next generation while poor knowledge is abandoned and becomes extinct (Fabricius et al 2004b). In particular, local knowledge concerning the natural environment and natural resources is referred to as traditional ecological knowledge (TEK), and has been shown to influence indigenous management strategies ranging from biodiversity conservation through the protection of specific areas and/or species (Gadgil et al 1998; Sullivan 1999) to multiple land use practices and agro-forestry (Toledo et al 2003). Consequently, local knowledge is considered fine-grained and highly context specific (Fabricius et al 2004b).

The strength of local knowledge, resultant of its holistic worldview, is that it inherently captures the importance of linkages and feedback mechanisms between the various components of complex systems (Holling et al 1998; Pierotti and Wildcat 2000; Kennedy et al 2001). In this way, local knowledge can allow for the identification of new paradigms and perspectives by which scientists, managers and resource users can understand the human-nature relationship (Mitchell 1997; Huntington 2000).

However, local knowledge can sometimes fall short where the rate of change in social-ecological systems is faster than the rate of knowledge evolution (Fabricius et al 2004b). For example, despite the increasing scarcity of culturally significant and preferred species such as *O. africana* and *P. obliquum* for kraal posts at Machibi, due to their over-utilisation, no culture of seed or seedling collection in the wild for replanting at people's households has occurred.

Local knowledge also rarely responds to slow processes such as gradual changes in the vegetation composition (Fabricius et al 2004b). For example, there has been an increase in fast-growing, r-strategist, thorny species such as *A. karroo* in the community woodlands at Machibi. Local resource users even state the increase in abundance of *A. karroo* as a reason for its preference as fuelwood (see chapter 6, section 6.3.1a). Simultaneously, there has been a decline in slow-growing, k-strategist species such as *O. africana* and *P. obliquum* due to their over-exploitation in the community woodlands (see chapter 6, section 6.3.3a). However, the local people do not automatically make the link between increasing degradation of the community woodlands, associated with the removal of the tall, woody component from the vegetation, opening it up to increasing grass cover, and possibly more frequent fires.

Moreover, as local knowledge is very seldom documented (except through intermediaries such as researchers) and captured across a variety of sources such as people's social practices and belief systems, it is often less structured than scientific knowledge, and more qualitative than quantitative. This poses a challenge for making case study comparisons, and calls for other ways of interpreting and validating the data than by conventional scientific methods and statistics (e.g. by the researcher making self-critical notes, the triangulation of data across multiple sources, having cyclical feedback sessions with the local community and a review of the data by stakeholders at higher and lower levels of the study) (Ericksen and Woodley 2004; Fabricius et al 2004b). The integrity of local knowledge can never be guaranteed, but by using the various techniques in a complementary way a form of 'local peer review' is introduced which greatly enhances the credibility of informal knowledge (Fabricius et al 2004b).

There are differences between scientific and local knowledge with respect to their subject matter and distinctive characteristics. However, with increasing globalization, the presumption that local knowledge originates, and is held, at the first interface of the environment and people's daily livelihoods while scientific knowledge attempts to construct general explanations, and is more removed from the daily lives of people, no longer holds (Agrawal 1995).

In addition, while many researchers of knowledge agree that it encompasses non-technical insights, wisdom, ideas, perceptions and innovative capabilities, there are also similarities between some aspects of local knowledge and scientific knowledge (Agrawal 1995), for example, between agro-forestry and the multiple use of forest patches in different stages of succession (Toledo et al 2003), and between taxonomy and indigenous plant classification systems (Nabhan 2000).

Drawing a strict distinction between scientific and local knowledge also seeks to separate and fix in time and space these two knowledge systems when contact, exchange, communication, learning and transformation among different systems of knowledge throughout the world, and between researchers and local communities, suggests a fluidity and flexibility to such systems (Agrawal 1995).

With regard to their methodological and epistemological approaches, scientific knowledge was developed under a mechanistic view of the natural world, where scientists believed that complex phenomena could be studied and controlled by reducing them to their basic components (Holling et al 1998). The result is that researchers argue that scientific knowledge is open to criticism (through the peer review process), systematic, objective and analytical. It advances by building rigorously on prior achievements (Agrawal 1995). On the other hand, local knowledge embodies a holistic worldview (Holling et al 1998; Pierotti and Wildcat 2000), and is often encoded in social, cultural and belief practices with strong links to the natural environment and the local context (Nabhan 1997; Berkes and Folke 1998; Berkes et al 2000). Consequently, local knowledge is often said to be closed, non-systematic, holistic rather than analytical, and without an overall conceptual framework. It advances on the basis of new experiences, not on the basis of a deductive logic (Agrawal 1995). However, as no criteria have been developed to successfully distinguish science from non-science, it is impossible to insist upon the openness of science to attempts to dislodge it, or the closed nature of traditional knowledge systems (Agrawal 1995).

Furthermore, in terms of their contextual differences, local knowledge is often seen to exist in a local context, anchored to a particular social group in a particular setting at a particular time whereas some researchers argue that scientific knowledge has been

divorced from an epistemic framework in the search for universal validity. However, if one of the major critiques of technical, solution-orientated natural resource management policies has been that they were not sensitive to the particular socio-ecological context, it is likely that these technical solutions are as anchored in a specific context as any other system of knowledge (Agrawal 1995; Fabricius et al 2004b).

Thus, by incorporating both scientific and local knowledge, the model aims to capture the qualitative and quantitative elements of the ‘usefulness’ of particular landscapes and species for fuelwood, brushwood and kraal posts to the local people. This approach also ensures that optimal use is made of existing knowledge about the interactions between the local people and the natural environment, and natural resources.

### **2.2.5 Socio-ecological system**

Conventionally, social systems constitute systems of knowledge and belief, traditions, worldviews and ethics pertaining to the environment and natural resources while ecological systems are characterised by the natural environment and ecosystems themselves (Berkes and Folke 1998; Holling et al 1998). However, it was not until the late 20<sup>th</sup> century that forest research and management recognised the importance of understanding the linkages and feedbacks between these systems (Kennedy et al 2001; Lambin et al 2001; Lane and McDonald 2002).

Prompted by the development of a complex systems approach to natural resource science and management (Holling et al 1998; Kennedy et al 2001), numerous studies showed the influence of social and cultural practices such as the harvesting of natural resources, agriculture and livestock farming on the natural resource base (Berkes et al 2000; Lykke 2000). For example, Luoga et al (2002) showed that past land use patterns impacted on the future availability of natural resources such as fuelwood, poles and timber for local settlements neighbouring communal miombo woodlands in eastern Tanzania. Studies such as Shackleton et al (1994) and Obiri et al (2002) showed that certain species responded differently to prolonged heavy utilisation for fuelwood. Whereas the majority of woody species were negatively affected, *Acacia*

species were favoured by increasing utilisation (i.e. the density of *Acacia* species increased).

In turn, studies also showed the influence of the natural environment in shaping people's knowledge and belief systems and culture (Salmon 2000; Toledo et al 2003). For example, Turner et al (2000) and Toledo et al (2003) showed how the stages of forest succession inspired people's identification of ecological indicators to track changes in the environment, and influenced people's land use practices, increasing landscape productivity and the resilience of the system through adaptive management. Bodin et al (2006) showed how local people adapt to times of hardship, for example, due to resource scarcity, by changing the rules, and permitting the use of taboo areas as refugia of important resources and species.

Similarly, the harvesting model for Machibi views the local people as part of the ecosystem rather than separate from it, and does not, therefore, delineate between the social and ecological systems. The model aims to identify the linkages and feedbacks between the natural resource base (i.e. fuelwood, brushwood and kraal post landscapes and species) and people's social assets (e.g. knowledge, beliefs, culture etc.).

### **2.3 Harvesting model for Machibi**

The harvesting model conceptualises the linkages and feedbacks between the social and ecological systems at Machibi, and shows how these relationships may influence the local people's harvesting strategies for fuelwood, brushwood and kraal posts, and ultimately, their natural resource use patterns. It assumes that people's preferences (Figure 2.2; Box 1.3), shaped by their past experiences and historical perceptions of the landscapes and species (Figure 2.2; Box 1.1) used for fuelwood, brushwood and kraal posts (Figure 2.2; Box 1.2) at Machibi influence their harvesting strategies (Figure 2.2; Box 2) in terms of identifying the most desired options (Bembridge and Tarlton 1990; Van Eck et al 1997; Pahl-Wostl in press). However, in reality, a number of ecological and social factors place restrictions on the use of the preferred landscapes and species (Figure 2.2; Box 1.4) in the form of the benefits obtained from their use, and the costs and risks incurred to do so, whereby it is assumed that the option with the highest net benefit is chosen by the local people. Hence, people's

willingness to pay to use particular landscapes and species for fuelwood, brushwood and kraal posts (Figure 2.2; Box 2) influences their use patterns, and impacts on future resource availability (Pearce and Turner 1990; Field 2002).

However, as the linkages and feedbacks in the system are assumed to be non-linear, changes in the landscapes and species for fuelwood, brushwood and kraal posts (e.g. increasing resource scarcity) may also interact with people's patterns of use and harvesting strategies by influencing their willingness to pay for various options (Shackleton 1993; Kirubi et al 2000; Vermeulen 2001). Changes in the landscapes and species for fuelwood, brushwood and kraal posts may also influence people's preferences by altering their experiences or perceptions (Pearce and Turner 1990; Field 2002).

In addition, although not a focal point of this study, the model recognises that external, ecological factors such as droughts (Figure 2.2; Box 3), as well as external, socio-economic factors such as institutional changes (Figure 2.2; Box 4) could influence the functioning of the socio-ecological system (Biggs et al 2004).

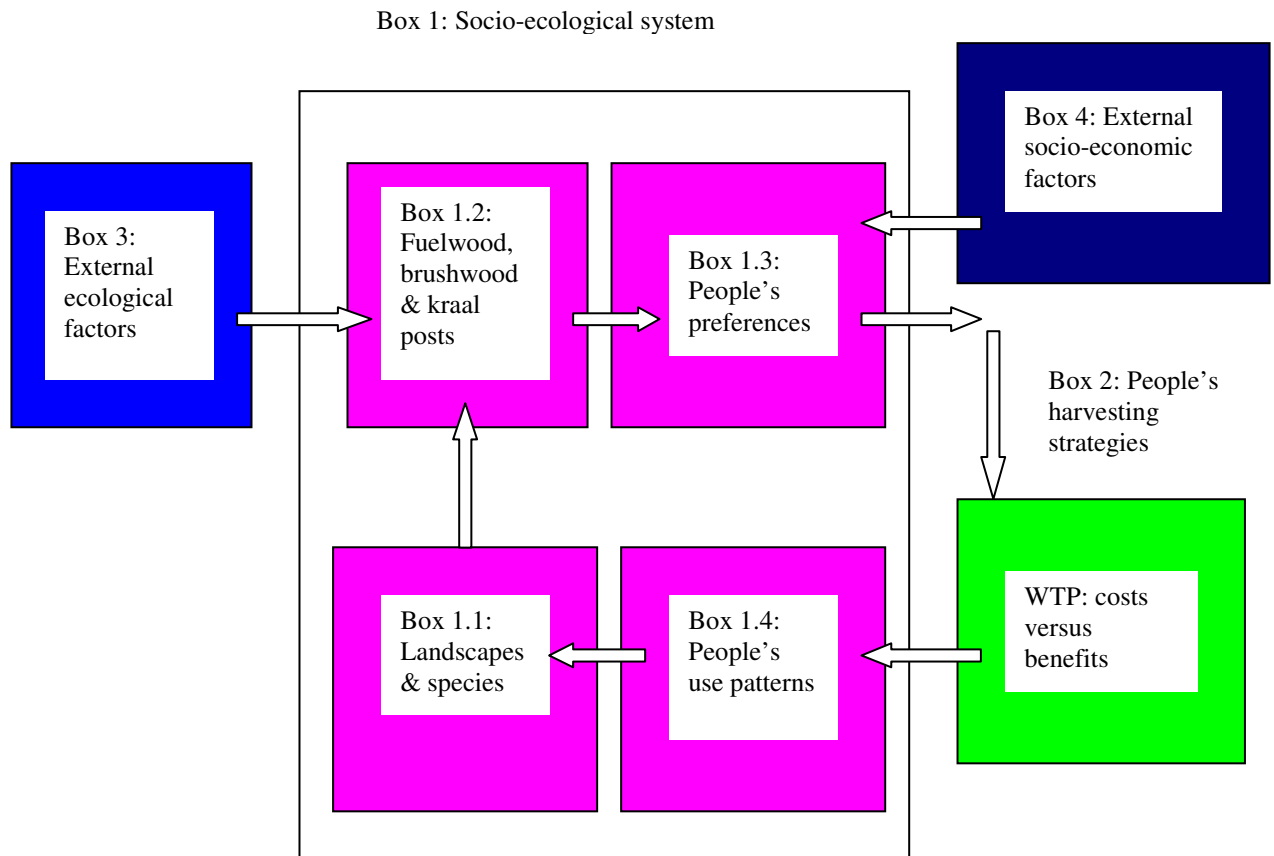


Figure 2.2: Simplified conceptual model, showing how social and ecological factors interact to influence people's harvesting strategies and natural resource use patterns in terms of the landscapes and species they use for fuelwood, brushwood and kraal posts

### 2.3.1 Natural resource base

The natural resource base, synonymous with the ecological system (Berkes and Folke 1998; Holling et al 1998), constitutes several community woodlands surrounding the village of Machibi (i.e. Tyip Tyip, Qeqe, Gqumehlo, Ntsunguzi, Wani and Mbomboyi), abandoned, old agricultural fields (i.e. Rhenene and Jejane), neighbouring community land in the form of Rodi Farm and Mount Coke State Forest (Mount Coke). Although different across a number of social and ecological characteristics such as vegetation type, distance from the village, accessibility, landscape attributes and their association with formal (e.g. laws) and informal institutions (e.g. local rules or codes of conduct) (see chapter three, Table 3.1), the community woodlands, old agricultural fields, Rodi Farm and Mount Coke are

collectively referred to as ‘landscapes’ used for the harvesting of fuelwood, brushwood and kraal posts within the context of this study (Figure 2.3; Box 1.1). Each landscape is distinguishable from the next by the local people, with clearly defined boundaries (often denoted by gravel roads, footpaths or local stream channels), and each with its own local name. Furthermore, the woody tree and shrub species that comprise these landscapes, and are used by the local people for fuelwood, brushwood and kraal posts, also form part of the natural resource base (Figure 2.3; Box 1.1).

### **2.3.2 People’s natural assets**

Fuelwood, brushwood and kraal posts constitute people’s natural assets (Figure 2.3; Box 1.2), and are harvested from the landscapes and species that make up the natural resource base at Machibi.

### **2.3.3 People’s social assets**

The social system constitutes the local community of Machibi, where people’s social assets (Figure 2.3; Box 1.3) include their local knowledge, beliefs, culture and traditions pertaining to the natural resource base, and natural resources (Berkes and Folke 1998; Holling et al 1998). As the local people share a long tradition of reliance on natural resources such as fuelwood, brushwood and kraal posts for their livelihoods, the model assumes that they possess an intimate knowledge of the landscapes and species from which these resources are harvested (Salmon 2000; Toledo et al 2003). The local people’s close identification with ancestral places and sacred areas associated with pools of water along local stream channels within the community woodlands, and traditionally managed with a non-consumptive use policy, rituals associated with particular species (e.g. the use of *Olea europaea subsp. africana* and *Ptaeroxylon obliquum* as kraal posts, and their branches as dishes at rituals of ancestral worship, centred on the kraal), as well as beliefs that acknowledge the power and spirituality of nature (e.g. the belief that *O. africana* and *P. obliquum* can ward off lightning and thunder), also demonstrates a long-standing relationship between their culture, belief system and the natural resource base (Turner et al 2000; Eeley et al 2004; Che and Lent 2004). Consequently, people’s past experiences and historical perceptions (Pahl-Wostl in press), often encoded in their systems of knowledge and belief, culture and traditions, are assumed to influence their landscape and species preferences for fuelwood, brushwood and kraal posts in terms of what

they most desire to use (Dasgupta and Pearce 1972; Pearce and Turner 1990; Field 2002).

#### **2.3.4 People's landscape and species use patterns**

People's use patterns describe the landscapes and species they use for fuelwood, brushwood and kraal posts (Figure 2.3; Box 1.4), where the level of utilisation is determined by a ratio of use divided by availability (Neu et al 1974; Shackleton et al 1994). Consequently, when a landscape or species is used in greater proportion to its availability, it is considered 'actively selected.' In contrast, when a landscape or species displays little signs of utilisation, relative to its availability, it is referred to as 'avoided.' Landscapes or species with utilisation/availability ratios equal to one are neither 'actively selected' nor 'avoided' (see chapters five and six)

#### **2.3.5 People's harvesting strategies**

The landscapes and species available to the local people offer multiple benefits in terms of fuelwood, brushwood and kraal posts (Van Eck et al 1997). However, as all benefits cannot be maximised concurrently, the local people are forced to make trade-offs between the benefit obtained from the use of a particular landscape or species for one purpose at the cost of its use for another (More et al 1996; Turner et al 2003). For example, the use of a particular species of tree for kraal posts requires that it be harvested at the stem, which comes at a cost of the use of its branches for fuelwood and brushwood, as the entire tree is removed. Consequently, the local user's choice of a particular landscape or species can be reflected in what he/she is willing to pay to use it (Pearce and Turner 1990) (Figure 2.3; Box 2).

Supported by previous studies (Shackleton et al 1994; Lynam et al 2004), the benefit from harvesting from a particular landscape is determined by its resource abundance, measured in terms of its density in fuelwood, brushwood or kraal posts. Hence, the return from harvesting fuelwood from a particular landscape, for example, is determined by its total number of trees of all fuelwood species. Similarly, the benefit from harvesting fuelwood from a particular species is determined by the number of trees of that species available for the local users to harvest.

The model also assumes that the quality of the fuelwood, brushwood or kraal posts associated with the respective landscapes and species, as reflected by people's relative preferences for the different options, influences the returns from harvesting. Supported by Shackleton et al (1994) and Shackleton and Mander (2000), the model assumes that landscapes and species of good quality are used in greater proportion to their availability while those of poor quality are avoided. For example, tall tree species which are durable, straight and termite-resistant are actively selected for kraal posts while those species of poorer quality are avoided (Van Eck et al 1997; Shackleton et al 2004). Similar trade-offs in quality have also been documented for fuelwood and brushwood landscapes and species (Motinyane 2001; Scheepers 2001).

On the flip side, the use of particular landscapes and species in greater proportion to their availability comes at an accessibility cost to the local people. For example, Grundy et al (1993), Vermeulen (1996) and Kirubi et al (2000) showed that local people actively select landscapes and species for fuelwood and timber that are located nearby their homes or settlements, while avoid those located further away. Luoga et al (2002) also documented a gradient of decreasing fuelwood utilisation with increasing distance from major access routes near local settlements in the communal miombo woodlands of eastern Tanzania. Other studies such as Rao and Pant (2001) showed that slope significantly influenced people's active selection of particular landscapes for natural resources. Consequently, the model assumes that the location of the respective landscapes relative to the village, their accessibility via roads/footpaths, and the topography, with regard to the steepness of the slopes on which they are situated, are determinants of the accessibility costs.

Travel cost accounts for the distance local people have to walk from their homes in the village to where they harvest fuelwood, brushwood or kraal posts from particular landscapes (Pearce and Turner 1990; Turner et al 1994; Razafindralambo 1998; Sikhakhane 2001). However, the actual path taken by the local user can be influenced by the presence of roads/footpaths, which make for easily identifiable landmarks, and can provide for a more direct means of access to particular landscapes in terms of the total distance covered than if the local user were to travel through unfamiliar terrain (Luoga et al 2002). In addition, local users may spend more time, and cover a greater

distance, traversing steep rather than gradual slopes during collection trips (Wagtendonk and Benedict 1980; Luoga et al 2002).

Furthermore, formal and informal institutions can restrict people's access to, and use of particular landscapes and species. For example, studies such as Klubnikin et al (2000) and Turner et al (2000) showed how local people's close identification with ancestral lands, sacred areas, and taboos associated with particular species, contributed towards their conservation by prohibiting their consumptive use. The maintenance of such local taboos formed an important link between people's beliefs and the natural environment, as well as helped to preserve their culture (Eeley et al 2004; Che and Lent 2004).

However, institutions are only effective so far as they can be enforced (Abbot and Mace 1999; Nagothu 2001). For example, Tabuti et al (2003), Fox (2005) and Bodin et al (2006) documented a weakening of local rules regarding the protection and preservation of taboo areas associated with times of hardship, such that these areas then provided a safety net function as refugia of important natural resources and species. When faced with zero options, studies have also showed that local people sometimes resort to the illegal use of natural resources from neighbouring protected areas (e.g. state forests) and neighbouring community land (Lawes et al 2004), in violation of formal laws such as the National Forests Act (No. 84 of 1998) and Communal Land Rights Act (No. 11 of 2004) in South Africa.

Consequently, the model assumes that people's active selection of particular landscapes and species is associated with an element of risk, introduced by the existence of formal laws and local rules regarding people's access to, and use of them. For example, local people at Machibi incur the risk of angering their ancestors, and falling into disfavour with the community, to harvest natural resources illegally from sacred areas associated with certain landscapes. In the case of local people harvesting fuelwood, brushwood or kraal posts illegally from Mount Coke and Rodi Farm, they incur the risk of being caught and prosecuted as criminals under South African law.

Lastly, the model also considers the influence of the availability and cost of alternatives on people's active selection of landscapes and species. For example,

studies such as Shackleton et al (1994), Geldenhuys (1997), Klooster and Masera (2000) and Akinbami et al (2003) documented the failure of many tree planting programmes (e.g. woodlots, agro-forestry initiatives) to replace community woodlands (i.e. landscapes) as a source of natural resources during times of hardship. In the case of species, Bhagavan and Giriappa (1995), Masera and Navia (1997) and Vermeulen (2001) showed that people supplemented the use of fuelwood species with commercial alternatives such as paraffin and electricity in response to increasing scarcity and/or improved buying power. Van Eck et al (1997), Jagger and Pender (2003) and Lawes et al (2004) found that people supplemented the use of indigenous kraal post and timber species with exotic, commercial alternatives such as *Eucalyptus* species. Similar trade-offs between indigenous resources and exotic or commercial alternatives are assumed to occur at Machibi.

Thus, supported by the assumptions of conventional consumer behaviour theory (Turner et al 1994; Ward and Beal 2000; Field 2002) and optimal foraging theory (Hutchinson and McNamara 2000; Kacelnik and Marsh 2002), the model assumes that local users behave in such a manner so as to maximise their benefits from harvesting while minimising the associated costs and risks. This means targeting the landscapes and species of the highest density and quality of fuelwood, brushwood and kraal posts, which can be obtained at the lowest accessibility and/or monetary costs, and with the lowest risk.

### **2.3.6 Linkages and feedbacks**

The model also assumes numerous linkages and feedbacks between the various components. Supported by Bembridge and Tarlton (1990), Van Eck et al (1997) and Shackleton and Mander (2000), people's preferences for particular landscapes and species (Figure 2.3; Box 1.3) are assumed to influence their harvesting strategies (Figure 2.3; Box 2) in terms of identifying the most desired options. However, people's willingness to pay to use the preferred landscapes and species is determined by the trade-off between the benefits obtained from their use, and the costs and risks incurred to do so, where a number of social and ecological factors place restrictions on people's desires (Figure 2.3; Box 2). Consequently, differences between people's preferences and actual use patterns are not uncommon (Blin and Dodson 1980; Shackleton 1993).

In turn, people's landscape and species choices (reflected by their willingness to pay) influence their use patterns (Figure 2.3; Box 1.4), and ultimately, impact on the natural resource base (Figure 2.3; Box 1.1). For example, studies such as Lykke (2000), Shackleton (2000b) and Luoga et al (2003) showed how people's previous landscape and species use patterns influenced the future availability of resources for fuelwood and construction timber.

However, changes in the natural resource base (Figure 2.3; Box 1.1) may also interact with people's patterns of use (Figure 2.3; Box 1.4) and harvesting strategies (Figure 2.3; Box 2) by influencing the ratio of benefits to costs associated with the different landscape and species options. For example, studies such as Shackleton (1993), Kirubi et al (2000) and Vermeulen (2001) documented changes in people's use patterns in response to resource scarcity. While some users were prepared to travel greater distances to use the preferred species, others substituted inferior alternatives for the preferred species that were located nearby their villages. Supported by Pearce and Turner (1990) and Field (2002), changes in the natural resource base may also influence people's landscape and species preferences by altering their experiences or perceptions.

In addition, the model recognises that external factors could influence the functioning of the socio-ecological system. Ecological events or surprises such as droughts, floods or biological invasions (Figure 2.3; Box 3) could affect people's natural assets and, in turn, their preferences and use patterns (Biggs et al 2004; Fox 2005). Similarly, socio-economic events and surprises (Figure 2.3; Box 4) such as infrastructural developments (e.g. development of road networks), institutional changes (e.g. in forest laws) or economic changes (e.g. increased wages/incomes) could affect people's social assets and thus, the interactions between people's harvesting strategies and the socio-ecological system (Biggs et al 2004; Cundill 2005).

Finally, the model assumes that there are also cross-scale linkages between the factors that influence people's landscape and species use patterns (Senft et al 1987). Therefore, although people may be concerned with what species to actively select or avoid for fuelwood, brushwood and kraal posts at the species level based on a very

localised set of cost and benefit factors (e.g. species density and quality), and concerned with where to focus their harvesting efforts (e.g. where to spend the most time harvesting) at the landscape level, based on a broader spatially explicit set of cost and benefit factors (e.g. total density of all fuelwood species available within the landscape, distance from the village, distance from roads/footpaths, distance from taboo areas and slope), a species level factor may have a disproportionate influence on landscape level use patterns. Furthermore, Senft et al (1987) states that individual resource use decisions are likely to be less frequently made but more significant at the landscape level than the species level. For example, the loss of a landscape would be more devastating than the loss of a species because species are more substitutable.

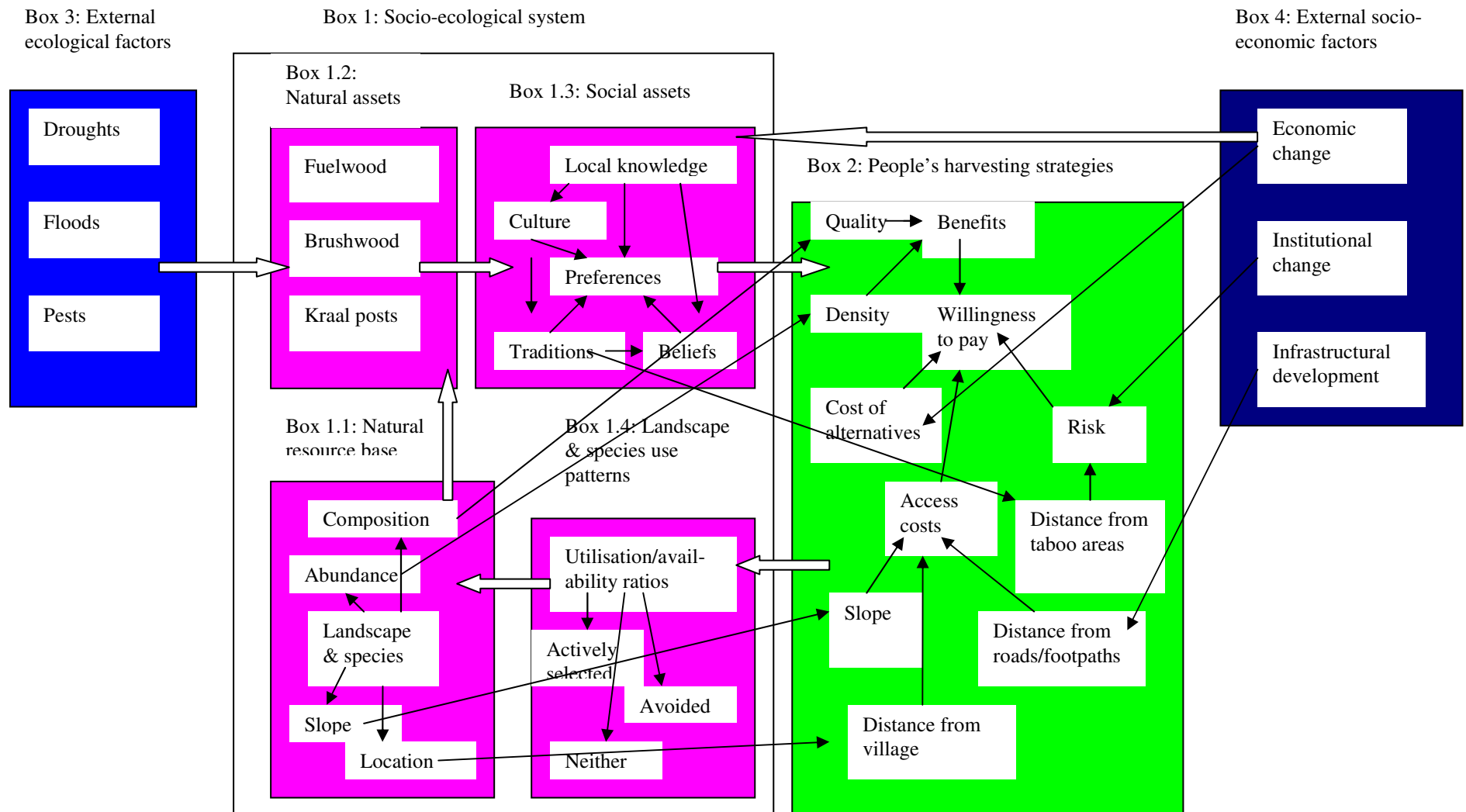


Figure 2.3: Conceptual model, showing how social and ecological factors interact to influence people's harvesting strategies and natural resource use patterns in terms of the landscapes and species they use for fuelwood, brushwood and kraal posts

### **3. STUDY AREA**

#### **Executive summary**

The study area includes the village of Machibi, Mount Coke State Forest and a number of community woodlands or 'landscapes' surrounding the village that are used for fuelwood, brushwood and kraal posts by the local people. The area, which formerly formed part of the Ciskei Bantustan under the Apartheid system, now falls under the Ngushwa municipality. However, a long history of empowerment and disempowerment of local leadership, and the different types of administration employed in the former Ciskei homeland, from the 16<sup>th</sup> century until today, have contributed towards the unchecked use of natural resources, which continues at Machibi. The vegetation consists of Kaffrarian Succulent Thicket and Xeric Succulent Thicket, which form part of the Subtropical Transitional Thicket vegetation unit. This vegetation is characterised by a mixture of transitional species from the Tongaland-Pondoland Regional Mosaic and Afromontane phytochoria; some resilient to disturbance, and others less so. Hence, the degradation of the vegetation due to unsustainable natural resource use by local communities, among other threats, is of great concern. The population of Machibi consists of approximately 1500 people, of which only six percent is formally employed. Most households are poor, and depend on the use of natural resources, and the generosity of others to survive. Fuelwood is harvested for cooking and heating purposes, and used by 61 percent of the households in Machibi. Brushwood and kraal posts are used for the construction of kraals to house livestock, as well as for cultural purposes. Consequently, more than 80 percent of the households in Machibi have kraals. Ultimately, this information is vital to provide a context for research aimed at the better use and management of these resources.

#### **3.1 Introduction**

This chapter presents a detailed description of the study area, including a brief history of natural resource use and management within the former Ciskei homeland of which Machibi was part. A general description of the biophysical and socio-economic characteristics of Machibi is also provided, as well as a broad overview of people's livelihoods, and the role played by fuelwood, brushwood and kraal posts in these livelihoods. The information presented in this chapter represents a combination of

government statistics and original research conducted at Machibi between 2000 and 2003 as part of the Participatory Forestry Monitoring (PFM) initiative underway in the area (Rhodes University et al 2000).

The study area includes the village of Machibi, Mount Coke State Forest (Mount Coke), and a number of community woodlands surrounding the village (Scheepers 2001), which are known locally to the people as Tyip Tyip, Qeqe, Gqumehlo, Ntsunguzi, Wani and Mbomboyi. The community woodlands constitute grazing lands that were allocated to Machibi at the time of its establishment between 1958 and 1960, due to Betterment Planning (Rhodes University et al 2000; Cundill 2005). However, these lands are also used for the harvesting of natural resources, including fuelwood, brushwood and kraal posts.

Old agricultural fields, represented by Rhenene and Jejane, that have long since been abandoned and colonised by fast-growing, pioneer species such as *Acacia karroo*, are also used for fuelwood and brushwood harvesting. Furthermore, although people are reluctant to talk about it, natural resources are sometimes harvested from neighbouring community land. Rodi Farm constitutes grazing land belonging to the adjacent village of Tshabo but is also accessed by villagers from Machibi in search of brushwood and kraal posts.

In the context of this study, Mount Coke, the community woodlands, old agricultural fields and Rodi Farm are collectively referred to as 'landscapes' associated with the harvesting of fuelwood, brushwood and kraal posts by the people of Machibi. However, these landscapes differ across a number of social and ecological characteristics such as vegetation type, distance from the village, accessibility via roads/footpaths, landscape and topography (e.g. slope), and their association with formal laws and informal institutions (e.g. local rules or codes of conduct) regarding people's access and use of these landscapes (Table 3.1).

Table 3.1: Social and ecological differences across Mount Coke, the community woodlands (i.e. Tyip Tyip, Qeqe, Gqumehlo, Ntsunguzi, Wani and Mbomboyi), old agricultural fields (i.e. Rhenene and Jejane) and Rodi Farm

Landscape	Vegetation type	Distance from village	Accessibility	Landscape attributes	Institutional arrangements
Mount Coke	Predominantly Buffels Thicket with isolated small patches of FOz 5 Scarp Forest confined to steep river valleys. Some thicket has been transformed into commercial plantations.	Far – greater than three kilometres from Machibi	Easily accessible	Highly dissected, hilly landscape	State-owned and managed with controlled access to local communities. Local taboos associated with the forest are adhered to – e.g. areas associated with dangerous spirits are avoided
Community woodlands	Predominantly thornveld with small patches of intact Buffels Thicket occurring along local stream channels	Near – between one and three kilometres from Machibi	Easily accessible	Moderately undulating landscape	Communally-owned and managed as open access areas. Local taboos are not always adhered to – there are signs of harvesting within sacred

					areas
Agricultural fields	Thornveld	Near – between one and three kilometres from Machibi	Easily accessible	Moderately undulating landscape	Communally -owned and managed as open access areas. No local taboos.
Rodi Farm	Predominantly thornveld with small patches of intact Buffels Thicket occurring along local stream channels	Near – between one and three kilometres from Machibi	Easily accessible	Moderately undulating landscape	Adjacent community land, managed as an open access area. Illegal harvesting of natural resources by villagers from Machibi does occur.

### 3.2 Location

Machibi (27°27'E, 33°00'S) is located adjacent to Mount Coke (27°28'E, 32°59'S), and approximately ten kilometres from King William's Town on the R346 road between King William's Town and Kidds Beach, East London (Figure 3.1). The area, which formerly formed part of the Ciskei Bantustan under the Apartheid system, now falls under the Ngushwa municipality.

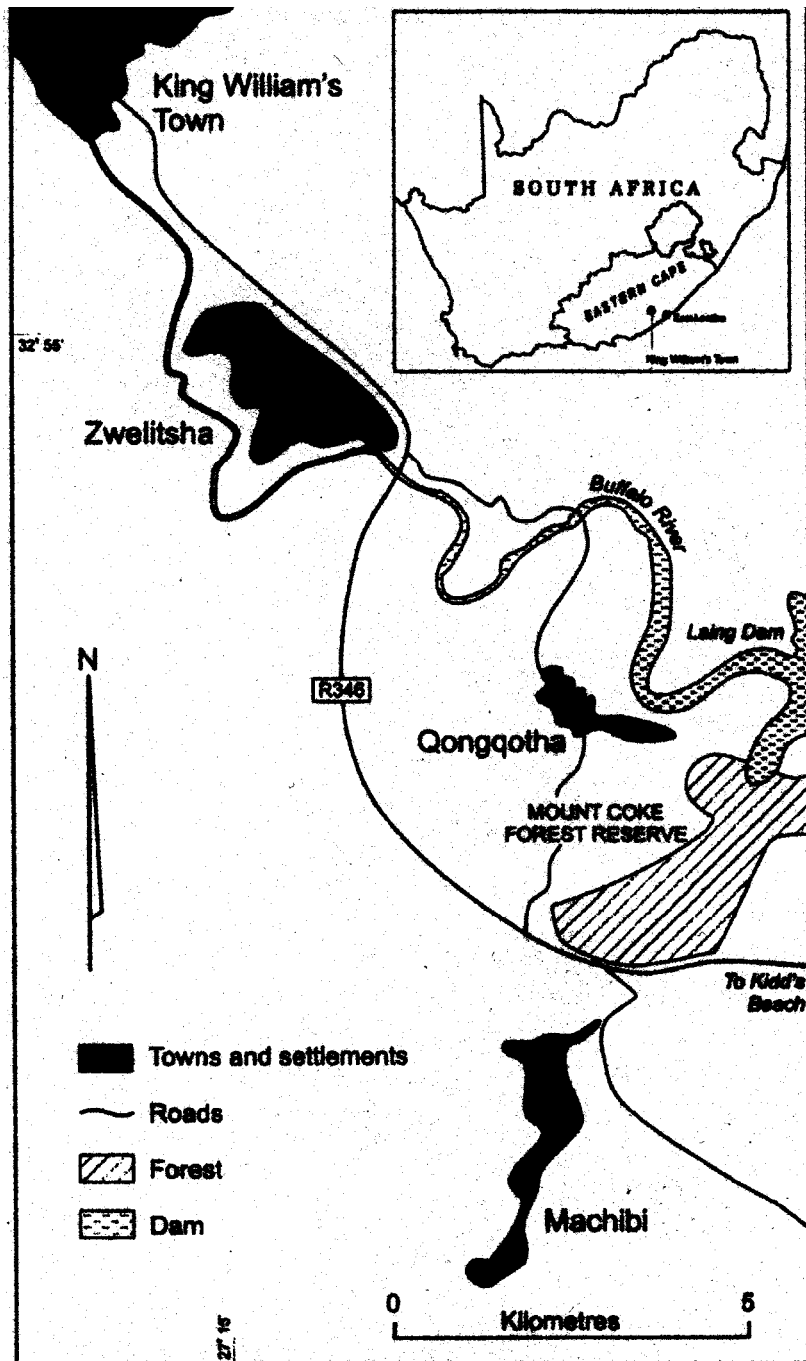


Figure 3.1: Map showing the location of Machibi relative to King William's Town

### 3.3 Socio-economic profile

The Eastern Cape has a population of approximately seven million people, 67 percent of whom live in rural areas. This figure for the Eastern Cape Province exceeds South Africa's national average by more than 20 percent (Lehohla 2001; Cundill 2005). Furthermore, 75 percent of the poor call these rural areas home, and with an unemployment rate of just below 49 percent, the Eastern Cape has the highest

unemployment rate in the entire country (Statistics South Africa 2001). The main sources of income include pensions and social grants, with civil service salaries, migrant remittances, local agriculture and self-employment in the informal sector making a relatively small contribution to the livelihoods of the Eastern Cape's rural poor (Ainslie et al 1997; Rhodes University et al 2000; Cundill 2005).

Over the past few decades, population growth rates have remained relatively stable in the former-Ciskei (Cundill 2005), only fluctuating between 2.2 percent between 1996 and 2001 (Statistics South Africa 2001). However, migration rates have declined substantially since 1970 in response to a combination of declining economic conditions, political upheaval and drought (Cundill 2005).

The livelihoods of the people of Machibi closely follow this provincial narrative. The population of the rural village has increased from 1134 to 1584 people over the period from 1996 to 2001 (Statistics South Africa 1996; Statistics South Africa 2001), including 741 men and 843 women, largely due to natural increase, as the local people report very few newcomers to the village (Cundill, 2002). It is a youthful population with 49 percent of the people less than or equal to 19 years of age. 41 Percent are between 20 and 59 years (Statistics South Africa 2001), and should constitute economic earners. However, only six percent of the population is formally employed (Figure 3.2).

Jobs are scarce, and the lack of a matric education for most people, which is the entry level qualification for the formal job market, does not help to find employment. 22 Percent of the residents of Machibi have no schooling, while the majority have completed up until grade ten. Less than one percent of the population has received any form of tertiary education (Statistics South Africa 2001). Of those who do earn an income, the highest number of earners receives between R401 and R800 per month (Figure 3.3).

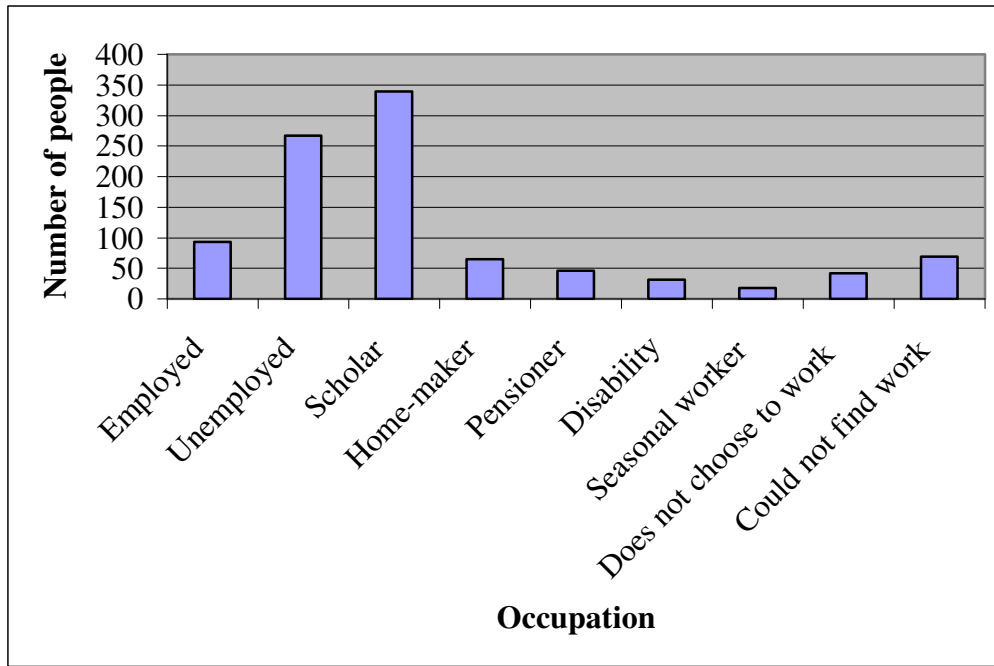


Figure 3.2: Employment status per weighted person in Machibi (Statistics South Africa 2001)

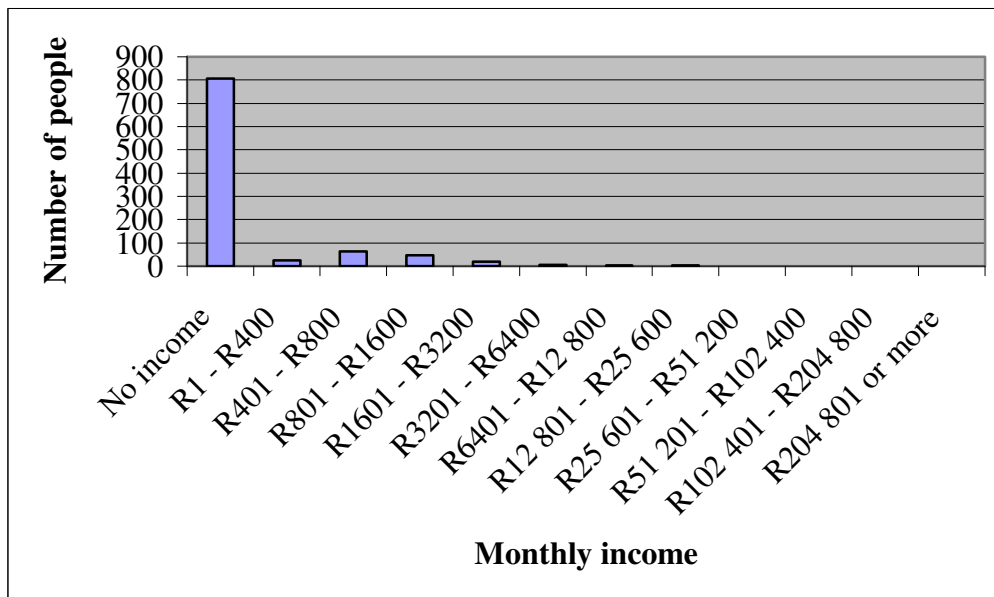


Figure 3.3: Individual monthly income per weighted person in Machibi (Statistics South Africa 2001)

Most households are poor (Table 3.2), and rely heavily on natural resources to supplement what little income they receive, or to act as a ‘safety net’ during times of hardship (Shackleton and Shackleton 2004). Pensions and disability grants make up

the biggest contribution to household incomes, followed by the development of small businesses and services to the community, some of which are based on the use of forest and woodland resources (Table 3.3).

Table 3.2: Wealth categories for Machibi, as defined by the local people (taken from Rhodes University et al 2000)

Category	Percentage of village	Description
Abangathathi ntweni (very poor)	17	Households with no source of income. They cannot afford electricity so cook over an open fire outside. They have no livestock. They depend on fuelwood, building materials and medicinal plants.
Abasokolayo (poor)	44	Households not earning an income but that may receive a disability grant. They have up to two cows, two rondavels (i.e. dwellings) and cannot afford electricity. They depend on fuelwood and building materials.
Abaphakathi (better-off)	30	Households that receive a pension and have one member that is working. They use electricity and can afford the transport to send their children to school. Homes are built with bricks. They have more than three cows.
Abangcono (well-off)	8	Includes shop-owners and households where more than two members are working. Homes are large and built with bricks. May have up to forty cows, large fields, tractors, cars, and are able to send their children to tertiary institutions.

Table 3.3: List of household income sources for Machibi, where the highest rank represented the largest contribution and the lowest rank represented the smallest contribution to household income (adapted from Rhodes University et al 2000)

Ranking	Source of income
20	Pensions and disability grants
18	Small business
16	Community services
14	Sale of medicinal plant
12	Sale of food crops
8	Salaries
6	Remittances from migrant labour
4	Sale of livestock
2	Sale of meat and skins from wild animals

A wide variety of forest and woodland resources is used by the local people, including building poles for housing, fuelwood for cooking and heating purposes, and kraalwood for kraal construction (Table 3.4).

Table 3.4: List of forest and woodland resources used at Machibi (taken from Rhodes University et al 2000)

Resource	Use
Building poles	House construction
Fuelwood	Cooking
Medicinal plants	Curing ailments
Brushwood	Ritual fires
Kraalwood	Kraal construction
Wild fruits	Consumption
Honey	Consumption
Meat	Consumption
Bush willow	Seclusion house construction
Reeds	Mats
Palm	Brooms
Grass	Grazing

Thatching grass	Thatching of roofs
Soil/land	Construction
Sand	Construction
Stones	Construction
Skins	Thongs
Water	Drinking, cooking, washing, livestock watering
Mushrooms	Consumption
Forests and rivers	Ancestral veneration

Fuelwood is used on a subsistence basis by 61 percent of the households in Machibi (Rhodes University et al 2000). One to two fuelwood headloads (i.e. approximately 30kg) is used per household per day, per week, or sometimes fortnightly. Fuelwood is harvested by the women of the village as it is considered their responsibility to cook for their families, and oversee the general upkeep of the home (which, on cold, winter nights includes the maintenance of indoor fires to keep everyone warm and comfortable) (Bembridge and Tarlton 1990; Shackleton et al 1994). However, in addition to its practical use, the open fire is of significant cultural importance to the local people as a gathering place to meet and talk among friends and family (Masera and Navia 1997; Shackleton et al 2004).

Similarly, brushwood is used on a subsistence basis but some local users do sell wagonloads of surplus brushwood to other members of the community for R150 per load. One to three wagonloads of brushwood are either harvested by the local users themselves or purchased from local sellers for kraal construction and maintenance on an annual basis (see chapter six)

Kraal posts are durable, with some lasting up to 30 years before needing to be replaced (Van Eck et al 1997; Shackleton and Shackleton 2000a; Ham and Theron 2001; Shackleton et al 2004). At which point, most local users harvest the new posts from the community woodlands. However, in response to increasing resource scarcity, the local users that can afford to do so, rather purchase exotic, *Eucalyptus*

*grandis* (Gham) posts from Mount Coke (see chapter six). These commercial posts sell for R2-R3 per post, depending on their size (Rhodes University et al 2000).

As it is considered the men's responsibility to safe guard the livestock, they are also in charge of the construction and maintenance of the kraals, and the harvesting of brushwood and kraal posts. In addition to their practical use, kraals possess cultural significance to the local people (Fox 2001). For example, ritual feasts, involving the slaughter of an animal (e.g. cow or goat), are centred on the kraal (Che and Lent 2004). Consequently, more than 80 percent of the households in Machibi have kraals, even if they are not used to house livestock (Rhodes University et al 2000; Scheepers 2001).

However, ensuring a continued supply of these natural resources to the people of Machibi over the long term necessitates their wiser use and management, where a history of confusion and uncertainty regarding access to, and use of natural resources has already resulted in more than a decade of unchecked resource use.

### **3.4 Historical background of natural resource use and management at Machibi**

Understanding the history of empowerment and disempowerment of local leadership (Ainslie 1999), and the different types of administration employed in the former Ciskei homeland, from the pre-colonial period up until today, is essential to understanding the current state of natural resource use and management at Machibi. Pre-1800s, several tribes, including the Xhosa, began to migrate south from central Africa in search of new grazing lands for their livestock. They followed a hunter-gatherer lifestyle, and relied heavily on the abundant forest and woodland resources that surrounded them to support various activities, including the provision of fuelwood for cooking and heating purposes, and the supply of timber for housing construction and fencing (Fabricius 2004).

Historical information, as well as the persistence of many customary practices for the management of natural resources today, suggests that systems incorporating local rules, taboos and norms were used, at least in part, to govern the use of forest and woodland resources since these times (Von Maltitz and Shackleton 2004). For

example, studies have showed that taboos and superstitions existed around the use of specific species, or certain forests that were considered sacred, and therefore, protected (Klubnikin et al 2000; Von Maltitz and Shackleton 2004; Bodin et al 2006), probably so as to prevent their over-exploitation.

Although many of these practices still exist, they were more prevalent and effective in the past because of low human population densities, high mortality rates, and low impacts on natural resources caused by human activities (Lane and McDonald 2002; Fabricius 2004). At Machibi, for example, *O. africana* and *P. obliquum* are harvested in the wild, and yet not collected and re-planted in people's homesteads, despite being associated with the power to protect them against thunder and lightning, often interpreted as acts of witchcraft. These species are also used in people's kraals as kraal posts. Furthermore, although the people of Machibi do acknowledge certain sites as sacred, there are signs of resource harvesting taking place here, signalling a defiance of local taboos, perhaps during times of hardship or resource scarcity (Tabuti et al 2003).

During the pre-colonial period, it was the chief and his tribal council that were responsible for setting and enforcing the rules. Chieftaincies were powerful institutions that were respected and obeyed by the people, and whose authority was absolute (Von Maltitz and Shackleton 2004). However, present day sees these tribal authorities dissolved and replaced by democratic institutions.

The colonial period (1800-1940) was characterised by colonisation, settlement and commercialization (Lane and McDonald 2002; Fabricius 2004). Thus, it was in the vicinity of the Great Fish River that the Xhosa came into contact with European settlers that were moving northward with their cattle from the Cape of Good Hope at the southern most tip of Africa (Charton 1980; Cundill 2005). This sparked a century of conflict over land and grazing rights between these groups of people, until the area was eventually annexed into the Cape Colony by the British government.

The conflict over land gave rise to growing concern within government to create discrete, administrative units to promote the separate development of 'blacks' and 'whites' (Cundill 2005). Consequently, this time period was associated with the

development of the Native Land Act (No. 27 of 1913), which formalised the Native Reserve system. This was followed by the Native Trust and Land Act (No. 18 of 1936), out of which the South African Native Trust was established, with the responsibility of ‘rehabilitating’ existing reserves that were perceived as severely degraded by the then government, and establishing new ones through the purchase of additional land (De Wet 1995; Cundill 2005). However, the Land Acts effectively forced local people to make a living off only 13 % of the land area of South Africa (Von Maltitz and Shackleton 2004).

The conflict over resources sparked an intensive use of the indigenous forests predominately for timber, and woodlands for hunting and agriculture, needed to support the rapid economic growth and growing urban, industrial regions, as well as the maintenance of long-term forest productivity (Willis 2004; Von Maltitz and Shackleton 2004). There was also a marked expansion of the commercial forestry sector in response to the rising timber demands.

However, it was not until the early 1900s that law-makers started realising that natural resources would inevitably be depleted if something was not done to conserve dwindling forests and combat land degradation. Hence, the emphasis of conservation strategies shifted to that of controlled use of natural resources from forest lands, associated with the establishment of protected areas by the state and other provincial conservation authorities, as well as the efforts of private landowners to create conservancies (Fabricius 2004; Von Maltitz and Shackleton 2004). An extensive process of surveying, demarcating and gazetting forests was also implemented by the then Department of Forestry (under the Cape government), with the aim of excluding all human settlement from taking place within these areas and restricting people’s access to resources (Von Maltitz and Shackleton 2004).

Consequently, Mount Coke was managed with controlled access to local communities. Forestry officers were employed to monitor resource use levels and a permit system put in place, which remains the management practice at present day.

In contrast, woodlands received far less attention from the colonial government and were not managed as a specific vegetation type. Vast areas were transformed for cultivation, while livestock farming was the primary activity on pristine woodland. In areas unsuited to farming because of disease outbreaks or unfavourable climates, woodland was also set aside for wildlife conservation (Von Maltitz and Shackleton 2004).

During the subsequent apartheid era (1940-93), the Ciskei Bantustan was then formalised into a 'homeland'. Under this policy of separate administration, the management of forests and woodlands became fragmented. However, protected forest and woodland areas were still managed with a preservationist attitude (Von Maltitz and Shackleton 2004). In fact, access to forest resources was in many instances further restricted or outright denied. Dwesa-Cwebe is a famous example where, after the Transkei government's Department of Nature Conservation assumed control, the local people were restricted from access to resources many believed 'belong to them' (Timmermans 1999). In a few homelands, community-run conservation areas were established for resource harvesting and to attract tourism. However, this period was largely characterised by profitable plantation forestry sales, and the growth of the commercial forestry industry, with little or no benefit to local communities (Von Maltitz and Shackleton 2004).

Little attention was paid to supporting the management of natural resources outside of conservation areas, and particularly on communal land. Interventions were often disruptive to rural life and were resisted and resented by local communities (Von Maltitz and Shackleton 2004). For example, in response to the need for better provision of basic services to the growing rural population, and the resultant problems of erosion, land degradation and over-stocking, as perceived by the then government, Betterment Planning was implemented in the Ciskei during the 1960s (Cundill 2005). This initiative constituted the amalgamation of several, scattered villages into larger settlements of fewer numbers in order to facilitate service provision. Thus, it was that the villages of Thafeni and Barrackson were amalgamated to form the village of Machibi between 1958 and 1960 (Rhodes University et al 2000).

Economic and agricultural development were encouraged in an attempt to convert the largely subsistence-based, rural economy into one based on 'proper, scientific management principles and practices' (Cundill 2002). Consequently, the state allocated land to the local people of Machibi for livestock grazing (i.e. several community woodlands) and crop cultivation (i.e. Rhenene and Jejane). Restrictions were placed on livestock numbers allowed per household, based on carrying capacity assessments of the grazing lands, as well as the starting stock numbers for each household. Grazing lands were fenced, and a system of rotational grazing encouraged by the government. In addition, as these grazing lands were also used by the local people for the harvesting of natural resources such as fuelwood, brushwood and kraal posts, a ranger system was instituted to monitor use levels (Rhodes University et al 2000; Cundill 2002).

The roles of the traditional chief and headmen were restructured as government positions (Manona 1995; Cundill 2002). Many of the traditional functions of chiefs were passed to the magistrate, or to forestry and agricultural officials (Von Maltitz and Shackleton 2004). A consequence of this was that the chief and headmen were no longer trusted by the local people to represent their needs (Manona 1992; Von Maltitz and Shackleton 2004). Furthermore, a general feeling of indifference developed among the local people, as the state was perceived to be responsible for the monitoring and management of all natural resources (Cundill 2005), culminating in the total collapse of 'Tribal Authorities' in 1990.

This collapse was sparked by political changes in South Africa, including the recognition of the African National Congress (A.N.C.) as a legitimate political party, which eventually led to a military coupe, and the downfall of the reigning president of Ciskei, amidst outcries of corruption and draconian style leadership. This event resulted in a new military government, aligned with the A.N.C. (Manona 1995; Cundill 2005). Following South Africa's first democratic elections in 1994, which the A.N.C. won, Ciskei was then reintegrated into South Africa, becoming part of the Eastern Cape Province (Rhodes University et al 2000; Manona 1995; Cundill 2005).

In the place of 'Tribal Authorities,' local communities were encouraged to form Residents Associations that would work closely with the traditional chiefs under the

new government. Consequently, the South African National Civic Organisation (Sanco) was formed, which remains the most important community-based organisation in the village (Rhodes University et al 2000). However, although Machibi has an active Sanco committee, the balance of power is skewed as the same community chairperson has occupied consecutive terms in office despite many complaints about his leadership from the community. In addition to the principles of democracy not always winning out community elections, these management changes also resulted in much confusion and uncertainty surrounding the roles of the chief and Sanco in monitoring natural resource use, as no guidelines were provided to explain how these Residents Associations were to operate (Cundill 2005). Consequently, following the withdrawal of state control over grazing lands and community woodlands, natural resource use has continued unchecked at Machibi over the past decade (Rhodes University et al 2000; Scheepers 2001; Fatman 2002; Cundill 2002).

However, it was also during this period that a new people-centred approach to natural resource management emerged as an alternative to the preservationist approach, fuelled by international pressure from the conservation community to recognise the importance of natural resources in rural livelihoods (Shackleton 2000a), as well as political pressure in South Africa to make up for the inequalities of the colonial and apartheid eras, with regard to people's access and use of natural resources, as well as development opportunities (Fabricius 2004; Grundy and Michell 2004). The people-centred approach paved the way for co-management arrangements between government, local communities and the private sector, aimed at biodiversity conservation as an integral part of wider development programmes (Gandar 1984; Geldenhuys 1997; Sibanda 2004; Reid and Turner 2004).

One such initiative, championed by the Department of Water Affairs and Forestry (DWAF), is that of Participatory Forestry Management (PFM) (Grundy and Michell 2004; Willis 2004), which has been active at Machibi since 2000, and aims to promote the co-management of Mount Coke with its adjacent local communities, as well as provide improved 'extension services' by way of providing training and expert technical advice on a broader range of resource management issues, addressing agriculture, conservation, forestry and water issues, as they pertain to the community woodlands. Machibi has an active PFM committee, and to date is involved in setting

up a bee-keeping project at Mount Coke, as part of this initiative. The beginnings of a management plan for the community woodlands has also been put together by the community, with the help of DWAF, Rhodes University, Fort Cox College of Agriculture and Forestry and University of Transkei (Rhodes University et al 2000). However, nothing has been implemented as yet.

### **3.5 Biophysical profile**

The dominant vegetation type of the study area is Buffels Thicket (Mucina and Rutherford 2006). This vegetation type is characterised by short, dense and tangled thicket stands with a canopy height of between two and five metres (Thompson et al 2001) that occurs along the valley slopes within the hilly parts of Mount Coke, and in smaller patches (i.e. less than five ha) along the stream channels of community woodlands surrounding Machibi (i.e. Tyip Tyip, Qeqe, Gqumehlo, Ntsunguzi, Wani and Mbomboyi), as well as Rodi Farm, on neighbouring community land. However, while Buffels Thicket makes up the broader landscape of Mount Coke, small, isolated patches of FOz 5 Scarp Forest (i.e. less than 10 ha) (Mucina and Rutherford 2006) are also found along the steepest valley slopes. Furthermore, commercial plantations of exotic, *Eucalyptus* species make up part of Mount Coke. These are a remnant of the colonial period when plantations were established to keep up with the increasing timber demands of a rapidly growing South African economy while taking some of the pressure off indigenous forests (Von Maltitz and Shackleton 2004).

Within the community woodlands, small patches of intact Buffels Thicket grades into more open, shorter thornveld at the edges of valley slopes (Mucina and Rutherford 2006), where the vegetation has been opened up due to livestock grazing. Thornveld also constitutes the vegetation on old, agricultural fields. During the Betterment Planning period, Rhenene and Jejane were allocated as agricultural fields to the people of Machibi (Rhodes University et al 2000; Cundill 2002). However, these old fields have subsequently been abandoned, and have become overgrown by opportunistic, fast-growing, often thorny, pioneer species such as *A. karroo* and *S. myrtina*, which are suited to colonising bare or disturbed habitats (Teague and Smit 1992).

As a consequence of the different vegetation types that make up the study area, a wide range of growth forms such as evergreen, sclerophyllous trees and shrubs, many of which are associated with stem spines, succulents, climbers and geophytes occur here (Shackleton and Mander 2000; Mucina and Rutherford 2006), as well as a high diversity of species (Johnson 1990; Dold and Cocks 1999). Although this study does not include a vegetation classification component, a list of plant species occurring at Machibi is provided from notes taken in the field and collection trips with the resource users (Table 3.5).

Table 3.5: List of plant species occurring at Machibi (adapted from Rhodes University et al 2000)

Species name (latin)	Species name (Xhosa)	Use	Source
Acacia caffra	Umthole	Fuelwood, brushwood, kraal posts	Community woodlands, Mount Coke, Rodi Farm
Acacia karroo	Umnga	Fuelwood, brushwood	Community woodlands, agricultural fields, Rodi Farm
Acacia mearnsii	Plantish	Kraal posts	Mount Coke (commercial plantations)
Acokanthera oblongifolia	Intlungunyembe	Poisonous tree	Mount Coke
Acokanthera oppositifolia	Intlungunyembe	Poisonous tree	Mount Coke
Aloe africana	Ikhala	Medicinal plant	Community woodlands, Mount Coke
Aloe ferox	Ikhala, Umkhondo	Medicinal plant	Community woodlands, Mount

			Coke
<i>Apodytes dimidiata</i>	Umdakane	Kraal posts	Community woodlands, Mount Coke
<i>Asparagus africanus</i>	Umathunga	Medicinal plant	Community woodlands
<i>Asparagus falcatus</i>	Ubulawu	Medicinal plant	Community woodlands
<i>Bauhinia</i> sp.	No Xhosa name	Exotic species	Mount Coke (nursery)
<i>Boophane distichya</i>	Shwadi	Medicinal plant	Mount Coke
<i>Buddleja salviifolia</i>	Uzintlwa, Iggange	Fuelwood, brushwood, kraal posts, medicinal plant	Community woodlands, Mount Coke, Rodi Farm
<i>Calistemon</i> sp.	No Xhosa name	Exotic species	Mount Coke (nursery)
<i>Calodendrum capense</i>	Umbaba, Umbatha, Umsitshana	No known use	Community woodlands, Mount Coke
<i>Canthium ciliatum</i>	Umnyushulube	Kraal posts	Community woodlands
<i>Canthium inerme</i>	Umnyushulube	Kraal posts	Community woodlands
<i>Carissa bispinosa</i>	Isabetha	Wild fruit	Community woodlands, Mount Coke
<i>Cassine aethiopica</i>	Umbomvane, Umgxube, Umnqayi	Brushwood, building poles, fighting sticks	Community woodlands
<i>Cassipourea</i>	Umemezi	No known use	Community

flanaganii			woodlands
Centella sp.	Iphuzi	Medicinal plant	Community woodlands
Cissampelos capensis	Umayisake	Medicinal plant	Community woodlands
Clematis brachiata	Ithyolo	Medicinal plant	Community woodlands
Coddia rudis	Intsinde	Brushwood	Community woodlands, Mount Coke, Rodi Farm
Combretum caffrum	Umdubu	Building poles	Community woodlands, Mount Coke
Combretum erythrophyllum	Umdubu	Kraal posts, building poles	Community woodlands, Mount Coke
Combretum sp.	Umdubi	Building poles, huts for initiates	Community woodlands, Mount Coke
Convolvulus capensis	Uvuma omhlophe	Medicinal plant	Community woodlands
Cussonia paniculata	Umsenge	Edible roots, wild fruit	Community woodlands
Cymbopogon plurinodis	Ingca	Thatching grass	Community woodlands
Cyperus sp.	Imizi	Mats	Community woodlands
Diospyros lycioides	Umbongisa	Fuelwood, brushwood, kraal posts, medicinal plant, huts for initiates	Community woodlands, Mount Coke, Rodi Farm, agricultural fields
Dovyalis caffra	Umqokolo	Brushwood, wild	Mount Coke

		fruit	(nursery)
<i>Ehretia rigida</i>	Umheli	Brushwood	Community woodlands
<i>Ekebergia capensis</i>	Umgwenye	Wild fruit	Community woodlands
<i>Elephantorrhiza elephantina</i>	Intolwane	Medicinal plant	Community woodlands, Mount Coke
<i>Encephalartos altensteinii</i>	Isundu	Brooms, rituals, dishes	Mount Coke
<i>Eriospermum</i> sp.	Uvuma obomvu	Medicinal plant	Community woodlands
<i>Erythrina caffra</i>	Umsintsi	Maintains the river	Community woodlands
<i>Erythrina humeana</i>	Umsintsi	Maintains the river	Community woodlands
<i>Erythrina latissima</i>	Umsintsi	Maintains the river	Community woodlands
<i>Erythrina lysistemon</i>	Noboyana	Maintains the river, medicinal plant	Community woodlands
<i>Eucalyptus grandis</i>	Gham tree	Fuelwood, kraal posts	Mount Coke (commercial plantations)
<i>Eugenia zeyheri</i>	Isiduli sehlati	Medicinal plant	Community woodlands
<i>Euphorbia bupleurifolia</i>	Intsema	Medicinal plant	Mount Coke
<i>Euphorbia triangularis</i>	Umhlontlo	No known use	Mount Coke
<i>Felicia filifolia</i>	Igangasi	No known use	Community woodlands
<i>Ficus natalensis</i>	Umtombe	Fuelwood, brushwood, kraal	Community woodlands, Rodi

		posts, wild fruit	Farm
<i>Ficus sur</i>	Ikhiwane	Wild fruit	Community woodlands, Mount Coke
<i>Gardenia thunbergia</i>	Umkancaza, Umkangana, Umkangazi	Maintains the river	Community woodlands
<i>Graderia scabra</i>	Uvelabahleke	Medicinal plant	Community woodlands
<i>Grewia occidentalis</i>	Nqabaza	Medicinal plant, wild fruit	Mount Coke
<i>Gunnera perpensa</i>	Iphuza	Medicinal plant	Community woodlands
<i>Gymnosporia arenicola</i>	Umqaqoba	Brushwood, fuelwood	Community woodlands, Mount Coke, Rodi Farm
<i>Haemanthus albiflos</i>	Umathunga	Medicinal plant	Community woodlands
<i>Harpephyllum caffrum</i>	Ingwenye	Wild fruit	Community woodlands, Mount Coke
<i>Hibiscus aethiopicus</i>	Iyeza lamasi	Maintains the river	Community woodlands
<i>Hippobromus pauciflorus</i>	Lathile	Brushwood, kraal posts	Community woodlands, Rodi Farm
<i>Hyperacanthus amoenus</i>	Ithongothi	Wild fruit	Community woodlands
<i>Hypoxis argentea</i>	Inongwe	Medicinal plant	Community woodlands, Mount Coke
<i>Jacaranda sp.</i>	No Xhosa name	Exotic species	Mount Coke (nursery)

<i>Kedrostis foetidissima</i>	Utuvishé	Medicinal plant	Community woodlands
<i>Ledebouria revoluta</i>	Inqwebéba	Medicinal plant	Community woodlands, Mount Coke
<i>Ledebouria</i> sp.	Intelezi (red)	Medicinal plant	Community woodlands, Mount Coke
<i>Lichtensteinia interrupta</i>	Intlwathi	Medicinal plant	Community woodlands
<i>Millettia grandis</i>	Umsimbithi	Walking sticks	Mount Coke
<i>Mimusops caffra</i>	Intunzi	Wild fruit	Community woodlands, Mount Coke
<i>Monanthotaxis caffra</i>	Idwabe	Dishes	Community woodlands
<i>Nicotiana glauca</i>	Umgqomagqoma	Medicinal plant	Community woodlands
<i>Oenothera</i> sp.	Amakholwa	Edible mushrooms	Community woodlands
<i>Olea europaea</i> subsp. <i>africana</i>	Umnquma	Fuelwood, brushwood, kraal posts, sticks, dishes, fencing, wards off lightning and thunder	Mount Coke, Rodi Farm
<i>Olea woodiana</i>	Umgqukunqa	Kraal posts	Community woodlands, Mount Coke
<i>Opuntia</i> sp.	Itolofiya	Wild fruit	Community woodlands, agricultural fields
<i>Ornithogalum</i>	Intelezi (white)	Medicinal plant	Community

<i>congitsaeteatum</i>			woodlands, Mount Coke
<i>Pelargonium</i> sp.	Upaqa	No known use	Community woodlands
<i>Pentanisia prunelloides</i>	Isicimamlilo	Medicinal plant	Community woodlands
<i>Pinus</i> sp.	Uthulwana	Exotic species	Mount Coke (nursery)
<i>Pittosporum viridiflorum</i>	Umkhwenkwe	Medicinal plant	Community woodlands
<i>Plectranthus ambiguus</i>	Irhajojo	No known use	Community woodlands
<i>Plumbago auriculata</i>	Ubushwa, Umatshinintshina	Medicinal plant	Community woodlands
<i>Podocarpus falcatus</i>	Umkhoba	Fuelwood, brushwood	Community woodlands, Mount Coke
<i>Podocarpus latifolius</i>	Umkhoba	Medicinal plant, maintains the river, rituals, dishes	Community woodlands, Mount Coke
<i>Ptaeroxylon obliquum</i>	Umthathi	Fuelwood, brushwood, kraal posts, dishes, wards off lightning and thunder, sticks	Mount Coke, Rodi Farm
<i>Pteronia incana</i>	Ibosisi	Fatal for livestock to eat	Community woodlands
<i>Rhoicissus tridentata</i>	Uchithibhunga	Medicinal plant	Community woodlands, Mount Coke
<i>Rhus incisa</i> var. <i>effuse</i>	Unonqutho	Brushwood, wild fruit	Community woodlands, Mount

			Coke
<i>Rhus lucida</i>	Intlolokoshane, Umchane	Kraal posts, brushwood, wild fruit	Community woodlands, Mount Coke, Rodi Farm
<i>Rubus rigidus</i>	Umgcunube	Rituals	Community woodlands
<i>Rumex lanceolatus</i>	Idolonyana	Wild fruit	Community woodlands
<i>Salix capensis</i>	Umgcunube	Kraal posts, rituals	Community woodlands
<i>Salix mucronata</i>	Umngcumube	Rituals, dishes, maintains the river	Community woodlands
<i>Sarcostemma viminalis</i>	Umbhele-mbhele	Medicinal plant	Community woodlands
<i>Schotia latifolia</i>	Umgxam	Fuelwood, kraal posts, medicinal plant	Mount Coke
<i>Scutia myrtina</i>	Isiphingo	Brushwood, fuelwood, wild fruit	Community woodlands, agricultural fields, Mount Coke, Rodi Farm
<i>Sideroxylon inerme</i>	Umqwashu	Fuelwood, brushwood, kraal posts	Community woodlands, Mount Coke, Rodi Farm
<i>Solanum sp.</i>	Umsobo	Maintains the river	Community woodlands
<i>Strychnos henningsii</i>	Umnonono	Medicinal plant	Community woodlands
<i>Tecomaria capensis</i>	Idywadi	No known use	Community woodlands
<i>Trichocladus</i>	Umgqontsi	Fighting sticks	Community

ellipticus			woodlands
Watsonia sp.	Igotyiba	Medicinal plant	Community woodlands, Mount Coke
Zanthoxylum capense	Umlungumabele	Brushwood, kraal posts	Community woodlands, Mount Coke, Rodi Farm
Zanthoxylum davayi	Umlungumabele	Brushwood, kraal posts	Community woodlands, Mount Coke, Rodi Farm

Forest, thicket and thornveld also have different factors driving the vegetation structure and function. The distribution of the FOz 5 Scarp Forest is related to their sensitivity to fire regimes, climate change associated with the shift between C<sub>3</sub> and C<sub>4</sub> dominated ecosystems with fluctuating carbon dioxide levels over time, as well as heavy forest clearing (particularly during the colonial period in South Africa) (Von Maltitz and Shackleton 2004; Willis 2004; Mucina and Rutherford 2006).

Buffels Thicket is adapted to the semi-arid environment, which experiences a rainfall of 500 – 840 mm per annum, and has a coefficient of variation of 22 – 29 percent (Mucina and Rutherford 2006). However, the study area can receive rain throughout the year as it is situated within a climatic interface between an all-year rainfall zone in the west and summer-rainfall zone in the northeast. Consequently, as the rainfall is unpredictable, and the deep, fine-textured soils of the river valleys, water-limiting, many species have evolved to be opportunistic and fast-growing (Teague and Smit 1992).

However, climate alone does not determine the structure and function of thicket vegetation. While the primary determinants are soil moisture and nutrients, these conditions are often modified by the fire and grazing regimes of the vegetation (Everard 1987; Teague and Smit 1992; Shackleton and Scholes 2000).

Unlike other semi-arid ecosystems, intact thicket does not support a regular or widespread fire regime because of its low availability of fuel and high degree of succulence (Kerley et al 1999; Kerley et al 1995). However, where thicket has been degraded, and the non-flammable succulent component replaced with a potentially more flammable field layer, the occurrence of fire may be increasing (Vlok and Euston-Brown 2002). This is the case at Machibi, where the community woodlands that once constituted intact Buffels Thicket have been degraded through poor grazing practices to the extent that only small, isolated patches of intact thicket remain along narrow stream channels. Towards the edges of these channels, the thicket grades into thornveld, and there is an increase in grass cover.

In turn, these changes in the vegetation influence people's resource use patterns and harvesting strategies. Previous studies in the Eastern Cape have documented changes in people's preferences (Ainslie et al 1997; Pote et al 2006), increased distances travelled in search of resources (Motinyane 2001; Pote et al 2006) and the use of substitutes, including exotics rather than indigenous species (Scheepers 2004), in response to resource shortages. This also impacts on people's livelihood budgets as the use of natural resources supplements their income, and often performs a safety net function during times of hardship (Vermeulen 2001; Dovie et al 2004; Shackleton and Shackleton 2004). Therefore, the use of commercial alternatives for fuelwood or timber (e.g. kraal posts or building poles) has implications for people's resource use patterns.

Conversely, people's resource use patterns can influence the structure and function of the vegetation. For example, although thicket has historically supported a high diversity and density of indigenous herbivores (Everard 1987; Teague and Smit 1992; Spriggs 2001), this vegetation type has a poor record of recovery from disturbance by domestic livestock, as game and cattle exhibit different feeding habits, and therefore, influence the patch dynamics in different ways (Mucina and Rutherford 2006). Key vegetative traits such as a low annual production and very slow recovery periods of the main forage species after browsing also contribute to the degradation of thicket.

The harvesting of natural resources such as fuelwood, brushwood and kraal posts may have similar effects on the thicket vegetation. For example, within similar vegetation

types to thicket, Grundy et al (1993) and Shackleton et al (1994) showed that fast-growing, r-strategist species were favoured by increasing disturbance intensity associated with the harvesting of natural resources such as fuelwood by local communities in Zimbabwe and South Africa. In contrast, Lykke (2000) showed that slow-growing, k-strategist species were negatively impacted by increasing disturbance intensity. Consequently, the regenerative potential of the vegetation has implications for the use and management of particular species and landscapes at Machibi.

### **3.6 Conclusion**

The study area which includes the village of Machibi and its surrounding community woodlands and old agricultural fields, Mount Coke and neighbouring community land in the form of Rodi Farm, is characterised by unique social and ecological attributes related to the species composition and abundance of the vegetation, history of natural resource use management, the community's socio-economic profile and reliance on natural resources. Consequently, this study needs to be sensitive to the local context when developing a conceptual model of the harvesting strategies of fuelwood and kraalwood users at Machibi (see chapter two).

## **4. METHODOLOGICAL CHALLENGES AND SOLUTIONS TO DEALING WITH NATURAL RESOURCE MANAGEMENT PROBLEMS**

### **Executive summary**

Natural resource management problems are complex given that they often have multiple driving factors with numerous linkages and feedbacks between them. These interconnections occur between social and ecological systems, and thus, require research approaches that view people as an integral part of the ecological system rather than as external actors on the system. In addition, as the linkages and feedbacks between the social and ecological system occur across different spatial and temporal scales, the use of local knowledge, with its basis in history and comparisons between the past and present, to complement scientific knowledge, with its basis in systematic observations of the world, hypothesis formulation and testing, is necessary to gain a proper understanding of the driving factors of complex systems problems. Hence, this chapter discusses how an innovative research approach and methodology that borrows paradigms and principles from other fields of study such as resource economics and behavioural ecology, integrates social and ecological systems and incorporates local and scientific knowledge to develop a complex system model is necessary to understand the harvesting strategies of the local people of Machibi with respect to the landscapes and species they use for fuelwood, brushwood and kraal posts. A brief overview of available methodologies is also discussed, as well as their advantages and disadvantages for this study.

### **4.1 Introduction**

Natural resource management problems are complex given that they are non-linear in nature, cross-cutting in space and time, and contain an element of unpredictability (Gunderson et al 1995; Berkes and Folke 1998; Gunderson and Holling 2002). Thus, innovative research approaches and methodologies that borrow paradigms and principles from other fields of study such as resource economics and behavioural ecology (More et al 1996; Kacelnik and Marsh 2002; Field 2002), integrate social and ecological systems (Turner et al 2000; Cundill et al 2004; Walker and Meyers 2004), incorporate local and scientific knowledge (Ericksen and Woodley 2004; Lynam et al 2004; Moller et al 2004) and develop complex systems models is necessary to study natural resource management problems, and improve our understanding of the driving

factors (Fabricius 2004; Willis 2004). This chapter discusses the research approach and methodology adopted by this study with respect to these elements. However, a detailed description of the methods is provided in the results chapters (see chapter five and chapter six).

Natural resource management problems often have multiple driving factors with numerous linkages and feedbacks between them (Anderies et al 2002; Folke and Fabricius 2004). These interconnections occur between social and ecological systems (Salmon 2000; Pierotti and Wildcat 2000), and thus, require research approaches that view people as an integral part of the ecological system rather than as external actors on the system (Berkes and Folke 1998; Lynam et al 2004).

Hence, models are a useful tool to help ecologists, scientists, policy-makers and natural resource users conceptualise, examine and test the effect of multiple factors on the functioning of a system in a simplified manner so as to enhance their broader understanding of complex natural resource problems (Starfield et al 1990; Starfield and Bleloch 1991; Lynam et al 2002). Models can also provide a novel approach to integrate social and ecological systems through the combination of methods from the 'hard' and 'soft' sciences, where the former emphasizes factual knowledge and the relationship between factors in the real world, and the latter emphasizes people's perceptions and socially constructed reality (Chapin and Whiteman 1998; Pahl-Wostl in press).

In addition, as the linkages and feedbacks between the social and ecological system also occur across different spatial and temporal scales, the use of different types of knowledge (e.g. formal and informal knowledge) is necessary to gain the proper understanding of the driving factors of complex systems problems. Formal knowledge is accumulated through applied learning and education within formal research institutions such as schools and universities (Colley et al 2002). Scientific knowledge is an example of formal knowledge that is accumulated through a series of logical and empirical methods that includes systematic observations of the world, hypothesis formulation to explain these observations, and hypothesis testing to verify these explanations (Holling et al 1998; Ericksen and Woodley 2004). Consequently, scientific knowledge is used to answer specific questions related to resource use.

In contrast, informal knowledge is accumulated through informal processes and practical experiences outside of a formal learning setting (Colley et al 2002). Local knowledge, also sometimes referred to as traditional knowledge (Huntington 2000; Klubnikin et al 2000; Turner et al 2000), is an example of informal knowledge that is accumulated through cultural transmission, about the relationship humans have with one another, and their surrounding environment (Berkes and Folke 1998; Berkes et al 2000). Therefore, local knowledge is used to explain the linkages and feedbacks between people's patterns of natural resource use, and their impacts on the natural resource base.

Furthermore, using an iterative modelling process to facilitate the refinement of concepts and ideas is necessary to ensure that models remain flexible to changes in the needs of local users, scientists and other stakeholders (Lynam et al 2002). An emphasis on adaptive management is essential because of the inherent unpredictability of changes in complex systems (Du Toit et al 2003; Biggs et al 2004; Sendzimir et al in press).

However, in order to be an effective decision-making tool, the model needs to be rigorous enough to stand up to scientific scrutiny, and consider, as far as possible, the full costs and benefits of the actions it promotes, while simple enough for policy-makers, which may not necessarily come from a scientific background, to understand and apply to natural resource management problems (Starfield et al 1990; Starfield and Bleloch 1991; Biggs et al 2004). Thus, complex systems models are most powerful in their ability to demonstrate a principle or concept rather than produce quantitative predictions (Hutchinson and McNamara 2000).

This study addresses the need for a better understanding of how local people determine forest and woodland ecosystems to be of use to them, particularly in terms of the natural resources they provide, and what 'usefulness' means to different groups of resources users (Chipeta and Kowero 2004). The 'usefulness' of an ecosystem is defined by the criterion/criteria for which it is judged to have a certain utility (More et al 1996). For example, a particular woodland area can be judged as useful for the harvesting of fuelwood by a certain group of resource users, given criteria such as its

fuelwood density and distance from the village (Grundy et al 1993; Luoga et al 2002; Pote et al 2006).

To this end, the study aims to identify the factors that influence people's landscape and species preferences and patterns of natural resource use at Machibi, Eastern Cape. Using a flow diagram, the linkages and feedbacks between components of the social system and ecological system are shown, and how these relationships may influence the local people's harvesting strategies, and ultimately, their natural resource use patterns (Woodwell 1998; Lynam et al 2002).

The harvesting model (see chapter two) does not delineate between the social system and ecological system because it assumes interconnections between the two system types (Berkes and Folke 1998; Pierotti and Wildcat 2000). These interconnections take the form of social and cultural practices such as the harvesting of woody resources for fuelwood and construction timber (Lykke 2000; Luoga et al 2002; Awasthi et al 2003), the protection and preservation of sacred areas associated with ancestral spirits and ghosts (Klubnikin et al 2000; Fox 2005), and the maintenance of local taboos associated with specific plant species (Salmon 2000; Che and Lent 2004), that influence people's stated preferences and use patterns, and ultimately, impact on the natural resource base.

In turn, changes in the natural resource base can influence people's use patterns and preferences, and eventually, their local knowledge and belief systems, culture and traditions (Berkes and Folke 1998). For example, Fox (2005) and Bodin et al (2006) showed how taboo areas can become refugia for important species and perform an important safety net function for local people during times of crisis. Thus, the local people are linked to the natural environment in which they live through cultural traditions and interactive relationships (Salmon 2000; Turner et al 2000).

However, the integration of social and ecological systems requires that one work across disciplines in order to incorporate the different perspectives people may have of the same environment, and what this means for its 'usefulness' (Cundill et al 2004; Ericksen and Woodley 2004; Pahl-Wostl in press). 'Soft' sciences such as the social sciences emphasize people's perceptions and socially constructed reality (Chapin and

Whiteman 1998; Pahl-Wostl in press). On the contrary, ‘hard’ sciences such as the biological sciences focus on presenting the facts (Pahl-Wostl in press). The harvesting model for Machibi incorporates elements from both perspectives in a common approach to assessing the ‘usefulness’ of particular resources to people that is used across disciplines such as resource economics, behavioural ecology and wildlife management – that of optimal choice (Hutchinson and McNamara 2000; Kacelnik and Marsh 2002; Field 2002).

Conventional consumer behaviour theory assumes that an individual’s preference for a particular resource is a measure of his/her satisfaction gained from its use (Dusgupta and Pearce 1972), and reflected in their willingness to pay for it (Pearce and Turner 1990). This measure takes into account the benefits obtained from the use of the resource, as well as the costs and risks incurred by the resource users to use it (More et al 1996; Sikhakhane 2001; Field 2002), where the optimal choice is represented by the option that affords them the greatest net benefit.

Optimal foraging theory also states that animals behave in a particular manner so as to maximise some increasing function of expected benefit and decreasing function of expected cost (Hutchinson and McNamara 2000; Kacelnik and Marsh 2002). Numerous behavioural ecology and wildlife management models have shown that when making foraging decisions about which resource patches to exploit and which to avoid, animals weigh up the benefits of improved calorie intake with the cost of energy expenditure or risk of predation before choosing the option that affords them the greatest net benefit (Hurly and Oseen 1999; Olsson et al 2002; Arcis and Desor 2003), whether measured as the net rate of gain (gain-expenditure/time) or efficiency (gain/expenditure) (Kacelnik and Marsh 2002). Therefore, as animals also make trade-offs between the costs and benefits of obtaining particular resources, especially with regard to the efficiency with which they use these resources, willingness to pay is comparable to optimal foraging.

Similarly, the harvesting model for Machibi assumes that local users behave like consumers in that they exercise choice over the landscapes and species they use for fuelwood, brushwood and kraal posts. The model assumes that this choice is made in a rational manner by weighing up the costs and benefits associated with the different

options available to them (see chapter two). The benefits take into account the quality of the resource (Shackleton and Mander 2000), as indicated by people's desire to use particular landscapes and species, as well as the density of the resource (Kituyi et al 2001; Lynam et al 2004; Boudreau et al 2005), as a measure of how much is available for use (e.g. the fuelwood and brushwood density of a particular landscape, or the density of a particular species for kraal posts). The costs include the accessibility costs of using particular landscapes and species, related to their distance from the village (Vermeulen 1996; Kirubi et al 2000; Pote et al 2006), distance from roads/footpaths (Luoga et al 2002), proximity to taboo areas (Tabuti et al 2003; Bodin et al 2006), and the steepness of the slopes on which they are found (Luoga et al 2002).

But in order to capture, as far as possible, the qualitative and quantitative elements of the 'usefulness' of particular landscapes and species to the people, the model also draws on different types of knowledge regarding the natural resource base (More et al 1996; Ericksen and Woodley 2004). The model draws on scientific knowledge to identify what factors influence the local people's landscape and species choices, and to quantify their effects (i.e. determine the costs and benefits). However, local knowledge, with its basis in history and comparisons between the past and present, is used to explain the linkages and feedbacks in the system.

#### **4.2 Cost-benefit analysis**

Two different types of methods are traditionally used in resource economics to determine the 'usefulness' of natural resources such as fuelwood, construction timber and fencing materials to the resource users. These are stated preference methods and revealed preference methods (Turner et al 1994; Sikhakhane 2001).

Stated preference methods adopt a participatory approach by directly asking the resource users a number of hypothetical questions designed to elicit an estimate of the 'usefulness' of particular natural resources to them (Newson 1992; Razafindralambo 1998; Field 2002). An example of such a method is contingent valuation where resource users are asked to estimate their willingness to pay for a change in a natural resource (e.g. their willingness to pay to conserve a forest). A variant on this method is to ask the resource users their willingness to accept compensation for a change in a natural resource (e.g. their willingness to accept compensation for the loss of a forest).

The hypothetical questions asked during contingent valuation exercises may be open-ended, in which case the resource user may suggest a willingness to pay or willingness to accept value of their own, or close-ended, where the resource user is asked to indicate whether or not they would be willing to pay or willing to accept a particular amount suggested by the interviewer/researcher (Bohara et al 1998; Field 2002). Both question formats are commonly used in questionnaire surveys to the resource users. However, as open-ended questions often result in a large proportion of protest or non-responses, alternatives to the questionnaire survey have been developed. They include bidding games, the payment card method, trade-off games, take it or leave it experiments and the Delphi technique (Cooper 1993; Sikhakhane 2001), each with their own advantages and disadvantages.

For example, bidding games are based on real life situations in which the resource users are asked to indicate the 'usefulness' of a particular resource in an auction. This technique affords the researcher a better chance of obtaining an accurate measure of the 'usefulness' of the resource than the payment card method, trade-off games, and take it or leave it experiments, as it allows the respondents to consider the importance of the resource to them more fully (Sikhakhane 2001; Field 2002). However, the disadvantage is that there is a potential 'starting point bias' where the respondents may regard the initial bid to reflect the resource's true 'usefulness' (Herriges and Shogren 1996).

In turn, techniques that present the resource users with a range of options, and then ask them to choose the one that best represents their willingness to pay or willingness to accept a change in the resource have an advantage over bidding games in that they provoke a greater proportion of the respondents into making reasonable trade-offs between money and environmental resources. These techniques include the payment card method, trade-off games and take it or leave it experiments. However, the disadvantage is that these techniques are vulnerable to bias associated with the range of options presented to the respondents (Newson 1992; Sikhakhane 2001). The Delphi technique offers an alternative to questioning the resource users themselves by asking experts to suggest willingness to pay or willingness to accept values for the change in a natural resource, in the hope that iterations of this exercise will produce a convergence by the group to a single, highly considered value (Newson 1992).

However, there remain many potential shortcomings to contingent valuation. For example, 'strategic bias' may arise when the respondents think that they can influence the outcome of a policy decision such that they will secure a benefit in excess of the costs they have to pay by not answering truthfully (Razafindralambo 1998). 'Vehicle bias' may arise if the respondents are more sensitive to some 'vehicles' or 'instruments of payment' such as entrance fees or permits, than others (Field 2002). An 'information bias' arises when the respondents are not familiar with the resource (Ajzen et al 1996), and a 'hypothetical bias' arises when the respondents do not take the questions seriously by virtue that they are hypothetical (Sikhakhane 2001).

However, one way to eliminate these biases is to adopt a more scientific approach, as in this study. Revealed preference methods adopt a strictly scientific approach to analysing the relationship between the costs and benefits of using a particular resource and, include intensive data collection and statistical analysis (Sikhakhane 2001). Data collection often involves determining:

- 1) What resources are preferred by the resource users?
- 2) What is the frequency of use of the preferred resources?
- 3) Are there alternatives to the preferred resources?
- 4) What are the costs of the alternatives?

Regression analyses are then performed to determine the relationship between a dependent variable, which represents the benefit derived from using a particular resource, and one or more independent variables that represent the costs and risks involved with using the resource (Turner et al 1994; Ward and Beal 2000). Thus, an advantage of using these methods is their rigor. However, as they require the collection and analysis of large volumes of data, revealed preference methods can be time consuming and not well-suited to research projects with strict time constraints for field work.

Examples of revealed preference methods are the hedonic pricing method and the travel cost method (Turner et al 1994; Razafindralambo 1998; Font 2000). The hedonic pricing method is based on the assumption that a resource is 'useful' by virtue of the resource user finding some characteristic of that resource rather than the resource itself of use to him/her. For example, a forest is 'useful' by virtue that it

provides the resource users with timber for housing development, fencing or the construction of kraals (Liengme 1983; Twine et al 2003). Hence, the 'usefulness' of the forest can be determined as a function of its abundance in timber). The travel cost method is based on the premise that the 'usefulness' of a resource (i.e. the benefit derived from the use of the resource) is equal to the costs incurred by the resource users to do so. These costs are often measured in terms of the distance covered or time taken to use the resource (Pearce and Turner 1990; Ward and Beal 2000).

This study adopts a travel cost approach to determining people's harvesting strategies and natural resource use patterns at Machibi, as the benefit derived from the use of particular landscapes and species for fuelwood, brushwood and kraal posts, measured in terms of their quality and resource density, is assumed to compensate for the accessibility costs associated with using them, measured in terms of their distance from the village, distance from roads/footpaths, proximity to taboo areas and the steepness of their slopes. Regression analyses are also performed to determine the relationship between the dependent variable (e.g. the fuelwood and brushwood density of a particular landscape or the density of a particular species for kraal posts), which represents the benefit derived from using that particular resource, and one or more independent variables that represent the costs and risks involved with using the resource (e.g. its distance from the village or proximity to the nearest taboo area) (Turner et al 1994; Ward and Beal 2000).

### **4.3 Optimal foraging**

In the context of behavioural ecology and wildlife management, choice experiments are designed to exploit the trade-offs animals make between a known set of foraging options (Shafir et al 1999; Hill et al 2001; Kacelnik and Marsh 2002). In most experiments, the animals are presented with a binary choice of foraging options; one which provides a higher net benefit than the other; and the proportion of choices for either option are recorded (Hurly and Oseen 1999; Kacelnik and Marsh 2002).

However, as there are a multitude of trade-offs which can be investigated, choice experiments are very versatile. For example, experiments have been done to test the effect of habitat quality and food abundance (Shafir et al 1999; Fülöp and Menzel 2000; Alm et al 2002), habitat structure (Arcis and Desor 2003), risk of predation

(Olsson et al 2002; Arcis and Desor 2003), and distance to food source (Kacelnik and Marsh 2002) on foraging behaviour.

These experiments are performed within a strictly controlled environment such as the laboratory to eliminate outside influences, and ensure that the animals experience, and then choose between, the specific foraging options presented to them (Hurly and Oseen 1999). However, when the animals are taken from their natural environment and placed in captivity in the laboratory, it is important that they be allowed sufficient time to adjust to their new surroundings as the novelty of the situation can influence their responses to the choice experiments (Arcis and Desor 2003).

Another potential pitfall is that indirect cues that the animals would otherwise gain from their surrounding natural environment to further guide their foraging decisions are excluded from the experiment, and can cause unexpected results. For example, vegetation structure is considered an indirect cue of predation risk such that high vegetation density is associated with greater cover from predators than low vegetation density (Elkin and Baker 2000; Arcis and Desor 2003).

Choice experiments, which are predominately binary, also do not capture the inherent variability of the natural world. Animals, in their natural environment, often encounter more than two or three foraging options simultaneously. However, Hurly and Oseen (1999) and Bateson et al (2002) have overcome this, to some extent, by investigating the effect of an additional option to the choice set on a forager's behaviour. Furthermore, it is common in choice experiments not to vary more than one attribute of the foraging options simultaneously, whereas options in the natural environment often differ in multiple important attributes such as quality, quantity and frequency of rewards (Shafir et al 1999; Fülöp and Menzel 2000; Alm et al 2002).

Due to the limited number of choices provided for in choice experiments, they also do not allow for the possibility that animals make foraging decisions based on the maintenance of multiple energetic thresholds (Hurly and Oseen 1999). Comparing foraging options relative to multiple energetic thresholds such as a starvation threshold and a higher reproductive threshold, separately, and then summing the results, may produce different indices of preferences than assessing the net benefit of

each of the options independently, and then comparing them (Tversky 1969; Shafir 1994; Hurly and Oseen 1999).

This study avoids these pitfalls by observing the local people's harvesting strategies for fuelwood, brushwood and kraal posts within their home environment. The research team accompany local users on collection trips as part of their normal routine to document their landscape and species choices for fuelwood, brushwood and kraal posts, and to determine the factors that influence these choices.

However, unlike most choice experiments that are binary, this study includes a number of landscapes and species, which vary across multiple attributes simultaneously, as part of the local people's choice set. The landscapes available for fuelwood and brushwood, for example, differed in their vegetation composition and structure, distance from the village, distance from roads/footpaths, proximity to taboo areas and slope. Ultimately, the inclusion of multiple resource options ensures that the inherent variability of the system is taken into account in people's landscape and species choices.

#### **4.4 Local knowledge**

A number of Participatory Rural Appraisal (PRA) tools are used to facilitate the capture of people's local knowledge about the natural resources they use, and where these resources are obtained. These methods include ranking exercises to determine people's relative preferences for particular resources (Theis and Grady 1991), and trend-line exercises, used to identify key dates regarding natural resource management issues in chronological order, and to document relative changes in natural resource use and management over a particular period (Chambers 1992). Other methods constitute questionnaires, composed of a series of questions, which are posed to the local people about the resources they use, as well as workshops and collaborative fieldwork, which serve to bring researchers and local communities together to better understand each others perspectives of natural resource management problems (Mitchell 1997; Huntington 2000).

A questionnaire survey is good to identify and quantify the causal links and interactions between the different components of a complex system, and also simplify

comparisons between respondents (Huntington 2000). Questionnaires may be structured to ask the participants direct questions regarding very specific research topics, or semi-structured such that they provide the participants with a general list of topics to be discussed but allow the direction and scope of the interviews to be dictated by the participants' train of thought (Mitchell 1997; International Institute for Environment and Development 1998). The former is better suited to producing quantitative data for statistical analysis than the latter. However, the strength of semi-structured interviews lies in providing an opportunity for unexpected links between different components of the system to be identified (Huntington 2000).

A workshop that brings together scientists and local communities can allow both groups to better understand each other's perspective, and generate new insights. Collaborative fieldwork also offers an excellent means of sharing knowledge between scientists and local people over extended periods (Mitchell 1997; Huntington 2000). For example, local knowledge has often been used to identify study sites and conservation areas (Klubnikin et al 2000), management strategies (Pinkerton 1998; Warren and Pinkston 1998; Gadgil et al 2000), obtain plant specimens and learn of their use (Dold and Cocks 1999), and interpret field results (Lynam et al 2004).

In addition, the use of visual aids such as maps, pictures or other items common to the local people can be used to contextualise questions, improve people's understanding, stimulate people's memories, and facilitate responses to key questions (Mitchell 1997; Huntington 2000). For example, participatory resource maps can be used to show the location of key resources, and resource areas, as well as represent changes in their use or abundance over a particular period (International Institute for Environment and Development 1998).

However, appropriate ethical principles must be followed to ensure that community and individual rights are respected (Huntington 2000; Cundill 2005). Hence, all participants have the right to refrain from answering any questions, or participating in any exercise, that makes them feel uneasy or uncomfortable. Another consideration that applies to all PRA methods is that of the selection of participants. In the absence of personal experience with the pool of potential participants from the community, peer selection is often used to identify key informants (i.e. individuals or groups of

people with specialised knowledge). This process may involve asking the local authority such as the community council or committee to identify these informants, or their identification via chain referrals (i.e. where each participant is asked to suggest the name or names of further experts until such stage as no new names come up) (Huntington 2000). While evaluations of the reliability of a participant will somewhat depend on the judgement of the researcher, a process of cyclical learning that enables participants from the community to add or change any information during iterative stages of the research helps resolve conflicting statements from different participants (Mitchell 1997; Huntington 2000).

In this study, the local forestry committee of Machibi is asked to identify a number of key informants that possess specialised knowledge of the use of landscapes and species for fuelwood, brushwood and kraal posts. The process culminates in the establishment of two user groups; one for fuelwood and another for brushwood and kraal posts.

During workshops, these user groups then participate in ranking exercises (Theis and Grady 1991) to determine people's relative preferences for particular landscapes and species for fuelwood, brushwood and kraal posts, respectively. In addition, they participate in trend-line exercises (Chambers 1992) to identify key dates regarding natural resource management issues at Machibi, and to document relative changes in the intensity of use of the preferred species over the period from 1960 until 2003. Using participatory resource maps, the user groups also depict the locations of the preferred landscapes and species at Machibi, and show trends in fuelwood, brushwood and kraal post densities over this period.

Door-to-door, structured interviews (Motinyane 2001; Fox 2005) are then conducted with a number of individual fuelwood and kraalwood users from Machibi to ensure that the user groups' knowledge was representative of the community as a whole. Consequently, this study uses a range of PRA methods in order to triangulate the sources of information, and verify the data.

#### **4.5 Scientific knowledge**

As scientific knowledge is accumulated through systematic observations of the world, hypothesis formulation and testing, this type of knowledge is usually drawn upon to answer specific, quantitative research questions (Holling et al 1998; Ericksen and Woodley 2004). In the context of this study, these questions pertain to resource availability and level of utilisation. Hence, methods developed for vegetation ecology are used to determine the amount of fuelwood, brushwood and kraal posts available to the local people at the landscape and species levels, as well as the levels of utilisation of these resources. For example, the amount of fuelwood and brushwood available from a particular landscape is determined by its density of fuelwood and brushwood species (Grundy et al 1993; Boudreau et al 2005). On the other hand, the level of utilisation of a particular species for kraal posts, for example, is indicated by the number of trees which exhibit signs of harvesting (e.g. chopped branches) (Shackleton 1993). In addition, the calculation of utilisation/availability ratios for the respective landscapes and species help determine people's natural resource use patterns (Neu et al 1974; Shackleton et al 1994).

Two different types of methods are traditionally used to measure vegetation density; those that make use of quadrats or sample plots to count the number of trees and/or shrubs that occur within a particular area such as belt transects (Shackleton 1993; Shackleton et al 1994), and plotless sampling methods such as the point-quarter method (Mueller-Dombois and Ellenberg 1974; Smith 1996; Motinyane 2001).

A quadrat is simply a standardised sample plot in which a number of characteristics of the vegetation such as the names and numbers of species can be measured in order to determine the vegetation density. However, for statistically reliable estimates, the location of these quadrats needs to be randomised. This creates a problem when the plant species being sampled are not randomly distributed because the sample size then needs to be large in order to accurately determine the vegetation density. Therefore, although the quadrat method is easy to apply in the field, it can be tedious and time-consuming (Mueller-Dombois and Ellenberg 1974; Smith 1996).

A belt transect is a variation of the quadrat method where a single sample plot is divided into a number of subplots or quadrats of equal size (Shackleton 1993;

Shackleton et al 1994). The strength of this method lies in its ability to capture changes in vegetation along the transect, which can then be related to environmental variables such as rainfall or disturbance gradients created by human activities. However, this method is also time-consuming.

In contrast, the point-quarter method uses plotless sampling to determine vegetation density. This method is most useful in sampling communities in which individual plants are widely spaced or in which the dominant species are large shrubs or trees (Smith 1996). A series of random points are selected within a stand of vegetation or alternatively, along a line transect passing through the stand. The area surrounding each point is then visualised as being divided into four quarters or quadrants with the grid lines bisecting each other at the point. The distance and species name of the closest tree to the point is then recorded for each quarter, and these measurements used in a formula to determine the vegetation density. It is also recorded whether the tree shows signs of utilisation.

This study uses a variation of the point-quarter method rather than the belt transect, as the former is less time-consuming than the latter. The point-quarter method is also suited to the vegetation type (i.e. Xeric Kaffrarian Succulent Thicket (Everard 1987) or Xeric Succulent Thicket (Low and Robelo 1996)), which is dominated by large shrubs and trees that are used for fuelwood, brushwood and kraal posts. In addition, the point-quarter method is used rather than the belt transect because the local people do not travel in straight lines as measured along a transect in search of these resources.

#### **4.6 Conclusion**

The study of complex systems requires fresh and integrated research approaches and methodologies. Only by working across disciplines, and integrating social and ecological systems in complex system models can researchers, natural resource use practitioners and policy-makers begin to understand the linkages and feedbacks between the driving factors. In addition, combining local and scientific knowledge to develop different aspects of complex system models is important to ensure that the research is sensitive to the local context, and flexible to changes in the needs of the local users and managers.

## **5. PEOPLE'S LANDSCAPE PREFERENCES AND USE PATTERNS**

### **Executive summary**

Social and ecological changes have shaped the different ways in which people view landscapes, as well as how they are used and managed. This chapter 1) identifies people's landscape preferences for fuelwood, brushwood and kraal posts, 2) determines which landscapes are actively selected by the local people for these purposes, and 3) provides a comparison between people's stated preferences and their patterns of use. A combination of participatory and scientific methods was used to tap into people's local knowledge of these landscapes, and measure the significance of the effect of various social and ecological factors on people's use patterns. Results showed that people did not always use what they preferred. In the case of fuelwood and brushwood landscapes, people made trade-offs between the returns from harvesting, measured in terms of resource density, and the accessibility costs of using particular landscapes, as well as the harvesting costs of fuelwood and brushwood. Trade-offs between resource scarcity and institutional controls governed people's kraal post landscape choices.

### **5.1 Introduction**

Social and ecological systems have co-evolved over many centuries, characterised by people's adaptations to changes, and often crises, in their surrounding environment (Holling et al 1998; Lane and McDonald 2002). These changes have shaped the different ways in which people view landscapes, as well as how they are used and managed (Shackleton and Scholes 2000; Kennedy et al 2001; Lane and McDonald 2002).

Ultimately, the way in which people adapt to these changes and the decisions they make, affect the well-being of current and future generations (Mortimore and Turner 2005; Sizer et al 2006). Therefore, an understanding of the thought processes behind how local people come to arrive at their resource use decisions is critical to managing these systems and knowing how to buffer them against radical, and often irreversible, changes (Gunderson et al 1995; Berkes and Folke 1998; Gunderson and Holling 2002; Biggs et al 2004).

In this chapter, I examine people's landscape preferences for fuelwood, brushwood and kraal posts, as reflected in their desires to use particular woodland patches or 'landscapes' for these respective purposes, as well as the factors that influence them. For example, previous studies have shown that people's experiences with nature and natural resources are often encoded in their systems of knowledge and belief, culture, traditions, customs and ethics (Nabhan 1997; Berkes et al 2000; Salmon 2000), which can influence their preferences (Pearce and Turner 1990; Field 2002).

I also identify the landscapes that were actively selected for these particular resources (i.e. used in greater proportion to their availability), and contrast people's stated preferences with their patterns of use. An explanation of the factors that influenced the decision-making strategies, and ultimately, landscape use patterns of the local people is then discussed, borrowing principles and paradigms from other fields of study.

For example, in resource economics and behavioural ecology, a common approach to choosing which resources to exploit and which to avoid, is that of optimal choice (Field 2002; Kacelnik and Marsh 2002). Conventional consumer behaviour theory assumes that an individual's preference for a particular resource is a measure of his/her satisfaction gained from its use (Dusgupta and Pearce 1972), and reflected in their willingness to pay for it (Pearce and Turner 1990). This measure takes into account the benefits obtained from the use of the resource, as well as the costs and risks incurred by the resource users to use it (Sikhakhane 2001; Field 2002; Turner et al 2003), where the optimal choice is represented by the option that affords them the greatest net benefit.

Optimal foraging theory also states that animals behave in a particular manner so as to maximise some increasing function of expected benefit and decreasing function of expected cost (Hutchinson and McNamara 2000; Kacelnik and Marsh 2002). Numerous behavioural ecology and wildlife management models have shown that when making foraging decisions about which resource patches to exploit and which to avoid, animals weigh up the benefits of improved calorie intake with the cost of energy expenditure or risk of predation before choosing the option that affords them the greatest net benefit (Hurly and Oseen 1999; Olsson et al 2002; Arcis and Desor

2003), whether measured as the net rate of gain (gain-expenditure/time) or efficiency (gain/expenditure) (Kacelnik and Marsh 2002). Therefore, as animals also make trade-offs between the costs and benefits of obtaining particular resources, especially with regard to the efficiency with which they use these resources, willingness to pay is comparable to optimal foraging.

In the context of this study, it is assumed that the local people of Machibi also have preferences for particular landscapes for fuelwood, brushwood and kraal posts, based on their past experiences and historical perceptions (Pearce and Turner 1990; Field 2002; Pahl-Wostl in press), which reflect how much they 'want' to use them (see chapter two). However, as people's use of the preferred landscapes is subject to resource limitations, their landscape use patterns can be determined by the trade-off between the benefits obtained from the use of particular landscapes, and the costs and risks incurred to use them (Dusgupta and Pearce 1972; Pearce and Turner 1990; Field 2002). A number of social and ecological factors are assumed to influence people's choices as the landscapes constitute a number of heterogenous, woodland patches (see chapters two and three). These factors include:

i) Returns from harvesting - As the local people harvest these resources from woody trees and shrubs, the first factor influencing people's resource use patterns is the density of the fuelwood, brushwood and kraal post species within the respective landscapes, as a measure of their natural resource use benefits (Shackleton 1993; Shackleton et al 1994). The quality of these landscapes, as reflected in people's relative preferences for the different options available to them, also influences the returns from harvesting (Abbot et al 1997; Van Eck et al 1997; Shackleton and Mander 2000).

ii) Cost of access to resources - The accessibility costs of using particular landscapes can be measured as a function of their distance from the village (i.e. travel cost), accessibility via transport networks, and the presence of physical obstacles such as steep slopes. Travel cost accounts for the distance local people have to walk from their homes in the village to where they harvest fuelwood, brushwood or kraal posts from the landscapes (Pearce and Turner 1990; Turner et al 1994; Razafindralambo 1998; Sikhakhane 2001). However, the actual path taken by the local user can be influenced by the presence of roads/footpaths, which make for easily identifiable

landmarks and can provide for a more direct means of access to particular landscapes in terms of the total distance covered than if the local user were to travel through unfamiliar terrain (Luoga et al 2002). In addition, resource users may spend more time, and cover a greater distance, traversing steep rather than gradual slopes on hiking trails, or during collection trips (Wagtendonk and Benedict 1980; Luoga et al 2002).

iii) Formal and informal institutions – Laws, local rules and codes of conduct also restrict people's access to particular landscapes. For example, studies such as Klubnikin et al (2000) and Turner et al (2000) have shown how local people's close identification with ancestral lands and sacred areas, associated with particular landscapes, have contributed towards their conservation by prohibiting their consumptive use. However, these institutions are only effective so far as they can be enforced (Abbot and Mace 1999; Nagothu 2001). Studies such as Tabuti et al (2003), Fox (2005) and Bodin et al (2006) have documented a weakening of local rules regarding the protection and preservation of taboo areas associated with times of hardship, such that these areas then provided a safety net function as refugia of important natural resources and species.

In addition, some studies have shown that when faced with zero options, local people resort to the illegal use of natural resources from neighbouring protected areas (e.g. state forests) and communal areas (Nagothu 2001; Lawes et al 2004). The use of these taboo areas by local people is associated with the violation of formal forest and land laws (see chapter two). Consequently, the presence of taboo areas introduces an element of risk to the harvesting of resources from certain landscapes.

## **5.2 Methods**

An assessment of the stated preferences and active selection of landscapes for fuelwood, brushwood and kraal posts was complex as numerous factors could significantly influence the way in which the local people viewed, and ultimately, ranked these landscapes. Hence, a combination of participatory and scientific methods was used to capture all the aspects of preferred and selected landscapes respectively.

### **5.2.1 Participatory methods**

A number of participatory methods were used, including workshops, ranking exercises and structured interviews to tap into people's local knowledge of the landscapes they preferred and actively selected for fuelwood, brushwood and kraal posts. A series of workshops were conducted between the researchers and a core group of resource users from Machibi. The local forestry committee from the village was asked to identify a number of key informants that possessed specialised knowledge of the landscapes used for fuelwood, brushwood and kraal posts at Machibi. This core group comprised of eight to ten members at any one time as people would come to workshops when available to do so, and new members would sometimes be introduced for specific workshop exercises. The core group was made up of men and women across all age groups (Mitchell 1997; Huntington 2000).

However, where exercises required information on the landscapes used for fuelwood and kraalwood (i.e. brushwood and kraal posts), respectively, the core group was split up into two user groups of four to six members each (Huntington 2000; Cundill 2005). The fuelwood user group consisted predominately of women of all ages, as well as two men that harvested and sold fuelwood to the local people in the village for some extra cash. The kraalwood user group comprised of all men, across all age groups. These focus group exercises were used to gain initial insights of the range of landscapes across which individual preferences and use patterns at Machibi may occur. However, no statistical comparisons were drawn between the preferences and use patterns of the core group or fuelwood and kraalwood user groups, and those of individual resource users. These workshops were facilitated by two independent, Xhosa-English speaking interpreters to ensure that all parties understood each other.

During the first workshop, the core group was asked to compile a list of the preferred landscapes for fuelwood, brushwood and kraal posts, respectively. Hence, the core group was asked to name the landscapes they most desired to use for fuelwood, brushwood and kraal posts while assuming the hypothetical scenario that a complete range of landscapes was available to them (i.e. given that there were no resource restrictions). At the second workshop, the core group was then guided through a series of ranking exercises to determine people's relative preferences for particular landscapes for fuelwood, brushwood and kraal posts, respectively (Theis and Grady

1991; International Institute for Environment and Development 1998). The names of the preferred landscapes were written on cue cards, and the core group asked to arrange them such that the landscape which people most desired to use was placed at the top of the list and allocated the highest rank. The landscape which people least desired to use was placed at the bottom of the list and allocated the lowest rank. People's relative preferences for the fuelwood landscapes, brushwood landscapes and kraal post landscapes, respectively, were then calculated out of ten by multiplying each landscape's rank by ten, and dividing this number by the sum of the ranks across all landscapes. Zero was allocated to landscapes which were not identified as preferred for any resource. However, the actual ranking was not as important as the debate generated by the exercise, and the reasons given by the local users for the order of preference of the landscapes (Sithole 2004). Hence, these reasons were carefully documented.

Door-to-door, structured interviews (Mitchell 1997; Huntington 2000) were also conducted with a number of individual fuelwood and kraalwood users from Machibi. A total of 50 households were included in the survey; 25 for fuelwood and 25 for kraalwood (brushwood and kraal posts). However, two households were eventually excluded from the survey due to incomplete questionnaire forms. The households were selected by the research team, with the help of key informants from the village, on the basis that the resource user possessed specialised knowledge of the landscapes preferred and currently used for fuelwood and kraalwood, the household's location in the village (so as to cover the complete range of available landscapes for fuelwood, brushwood and kraal posts), and the resource user's willingness to participate in the survey. Consequently, these results are representative of a select group of people rather than the community of Machibi as a whole. Separate households were interviewed about fuelwood and kraalwood landscapes, where either the female or male head of the household participated in the survey. However, where the head of the household (predominately male) and his female partner (e.g. wife) each possessed specialised knowledge, both were interviewed. Each resource user was asked to list what landscapes they preferred to use, as well as name the landscapes they currently used for fuelwood, brushwood and kraal posts.

### **5.2.2 Scientific methods**

The local users included in the door-to-door questionnaire survey were also asked whether they would be willing to let the research team accompany them on their next collection trip. Fourteen fuelwood users and 14 kraalwood users agreed, provided the exercise not take longer than two to three hours, as they would have to take time out from other daily activities to participate in the trip. Each collection trip started out at the resource user's household and followed their path from home to the fuelwood, brushwood or kraal post landscape from which they currently harvested these resources. The location of the resource user's household and random points along the path to the landscape were recorded using a global positioning system (G.P.S.), and later used to measure the distance of the resource user's harvesting area, defined as the proportional area of that landscape covered by the resource user while in search of fuelwood, brushwood or kraal posts on that particular collection trip, from his/her home.

Once at the landscape, the resource user was asked to provide the research team with a starting point and direction in which to travel, consistent with that of his/her usual harvesting strategy. The resource user led the way across the landscape, as he/she would travel on a collection trip, and at points of random distance apart, G.P.S. coordinates were again recorded, and field measurements taken in order to determine the total density of all tree and shrub species used by him/her for fuelwood, brushwood or kraal posts within that particular harvesting area.

However, as the resource users did not travel in straight lines across the landscape, and exhibited harvesting areas of varying sizes and shapes, a variation of the point-quarter method (Smith 1996) was used to determine fuelwood, brushwood or kraal post density per harvesting area, which is a plotless vegetation sampling technique. For each G.P.S. recording, the distance from that point to the nearest tree or shrub of the fuelwood, brushwood or kraal post species used by that resource user was measured, and any signs of its utilisation (e.g. chopped or cut but not 'broken off' branches in the case of fuelwood and brushwood or chopped stems, with or without the presence of coppicing, in the case of kraal posts). A minimum of 30 points was recorded for each harvesting area so as to ensure that the data was statistically viable (Sutherland 1996). However, more points were recorded where the resource user covered a greater distance.

Furthermore, the distance of each harvesting area from the village, nearest road/footpath and nearest taboo area were measured, as well as its slope. The G.P.S. points for each harvesting area were projected on to 1:7500 digital Telkom images of the study area using the geographical information system, ArcView version 3.5, which is marketed by ESRI. G.P.S. measurements differed from the on the ground reality by up to fifteen metres, and was corrected for in ArcView.

A map of the harvesting areas was then created by linking the G.P.S. points to form polygons, using Arcview's on-screen digitising function. Using Arcview's distance tool, the distance from a central point within each polygon, representing the harvesting area of a particular resource user, to their home in the village, the nearest road/footpath, and the nearest taboo area (as indicated on a participatory map of the current harvesting areas of resource users at Machibi, and verified on collection trips). In addition, digital elevation data in the form of 20 m contours were overlaid on the images of the study area, and the slopes determined from cross-sections of the harvesting areas (Dickinson 1979).

### **5.2.3 Analysis of participatory data**

The fuelwood, brushwood and kraal post landscapes were ranked in order of preference by counting the number of resource users out of the total that were interviewed (24 for fuelwood, 24 for kraalwood), which stated that they preferred the respective landscapes. Similarly, the fuelwood, brushwood and kraal post landscapes were ranked in order of their relative intensity of use as measured by the number of resource users out of the total that were interviewed, which stated that they currently used the respective landscapes. The highest rank was allocated to the most intensively used landscape while the lowest rank was allocated to the least intensively used landscape. People's relative intensity of use of the landscapes were then calculated out of ten by multiplying each landscape's rank by ten, and dividing this number by the sum of the ranks across all landscapes. The stated reasons for the differences in the intensity of use of the respective landscapes were summarised in bar charts.

However, as it soon became clear that people's preferences for landscapes for fuelwood and brushwood were almost identical, these landscapes were combined for analysis purposes.

#### 5.2.4 Analysis of vegetation surveys

The fuelwood and brushwood density, or kraal post density, of each harvesting area was determined using the following formulae (Sutherland 1996):

$$X_i = 1/(2D)^2,$$

Subject to:  $D = \Sigma d/s$

Where  $X_i$  was the total density of trees and shrubs of all fuelwood and brushwood species or the total density of trees of all kraal post species for a particular harvesting area,  $D$  was the mean point-to-tree distance for all G.P.S. points recorded for that harvesting area,  $d$  was the distance to the nearest individual for all points, and  $s$  represented the total number of sampling points.

By aggregating the point-quarter method data across the sampling points for all harvesting areas within the same landscape, average density values for the respective landscapes could then be calculated.

Furthermore, as it was assumed that resource restrictions influenced the resource user's choice of harvesting area and landscape, utilisation/availability ratios (Neu et al 1974; Shackleton 1993) were calculated for the respective harvesting areas of resource users, as well as for all harvesting areas across the same landscape, such that when the harvesting area's or landscape's resources were used in greater proportion to their availability, and the utilisation/availability ratio was greater than one, it was referred to as actively selected. In contrast, the harvesting areas and landscapes that exhibited a high availability of the groups of species harvested for fuelwood and brushwood or kraal posts but showed little signs of utilisation, and had utilisation/availability ratios of less than one, were referred to as avoided. Utilisation/availability ratios equal to zero indicated that the harvesting area or landscape was neither actively selected nor avoided.

For example, by aggregating the point-quarter method data across the sampling points for all harvesting areas within the same landscape, utilisation/availability ratios were calculated for the respective landscapes ( $UI_{L,1 \rightarrow n}$ ) for fuelwood and brushwood, as well as for kraal posts, using the following formulae:

$$UI_{L1 \rightarrow n} = U_{L1}/A_{L1}$$

Where:

$U_{L1}$  = number of utilised trees and shrubs of all fuelwood and brushwood species or kraal post species within landscape 1/total number of utilised trees and shrubs of all fuelwood and brushwood species or kraal post species across all landscapes, and

$A_{L1}$  = number of trees and shrubs of all fuelwood and brushwood species or kraal post species sampled within landscape 1/total number of trees and shrubs of all fuelwood and brushwood species or kraal post species sampled across all landscapes.

The landscapes were then ranked out of ten, according to their utilisation/availability ratios, for fuelwood and brushwood (combined), as well as for kraal posts.

### **5.2.5 Statistical analysis**

All statistical analyses were performed using the statistical software package, STATISTICA, marketed by StatSoft Incorporated (1999). Spearman's rank order correlations were conducted to compare people's perceptions of the intensity of use of the respective landscapes taking into account resource restrictions, and as indicated by the number of resource users out of the total interviewed which stated that they currently used the respective landscapes, to their actual intensity of use, as indicated by the utilisation/availability ratios. The variables were ranked out of ten (see section 5.2.3 and 5.2.4) so as to compare like units of measurement.

In addition, simple, linear regressions were performed to determine which factors (e.g. density, distance from the village, distance from roads/footpaths, distance from taboo areas and slope) significantly influenced the resource user's active selection, avoidance or indifference towards the intensity of use of a particular harvesting area, as indicated by its utilisation/availability ratio. As an utilisation/availability ratio and not straight count data for use or availability constituted the dependent variable, the data was normally distributed rather than found to exhibit a poisson distribution. Additional assumptions for which the data was tested included:

- 1) Equality of variance (i.e. did a plot of predicted values and residuals show that the points were scattered?), and
- 2) Auto-correlation (i.e. did the Durbin-Watson stat show values  $> 2$  and  $< 1.2$ , which indicate an auto-correlation problem?).

In the case of fuelwood and brushwood users, only the factor, distance from roads/footpaths, satisfied all three assumptions. Hence, a simple linear regression was conducted with distance from the nearest road/footpath as the independent variable, and the utilisation/availability ratios for the respective harvesting areas of resource users across all fuelwood and brushwood landscapes as the dependent variable. Although the utilisation/availability ratios of respective harvesting areas was not measured over time, and the data therefore, not time series data, there was a problem of auto-correlation between the other independent variables of density, distance from the village, distance from taboo areas and slope, and the utilisation/availability ratios for respective harvesting areas. This warrants further investigation.

In the case of kraal post users, simple, linear regression analyses were conducted with density and slope as the independent variables while the utilisation/availability ratios for respective harvesting areas of resource users across all kraal post landscapes constituted the dependent variable. Distance from the village, distance from roads/footpaths and distance from taboo areas were excluded from the regression analyses because of problems with auto-correlation.

A canonical correlation analysis was also performed (Gittins 1985), using the inverse values for average density, distance from the village, distance from roads/footpaths, distance from taboo areas and slope as an input matrix, to determine the relationship between the fuelwood and brushwood landscapes. However, before the analysis could be performed, two assumptions had to be tested on the data:

- 1) Normality
- 2) Redundancy (i.e. did any of the factors exhibit the same effect on the relationship between the landscapes?)

The data set for the factor, distance from the nearest road/footpath, was not normally distributed. Therefore, a square root transformation of the data set, which constituted count data with many near zero values, was performed (StatSoft Incorporated 1999). However, as the transformed data set was still not normally distributed, this factor was excluded from the analysis.

No canonical correlation analysis was conducted for the kraal post landscapes as the data sets for all factors, even after being transformed, violated the assumption of normality. This could be a function of the very small sample size. Few resource users harvested kraal posts, and those that did, did so once every few years (i.e. 15-30 years) to replace old posts and maintain their kraals. In addition, only five resource users were prepared to take the research team along on a collection trip. The combined influence of these factors accounted for the low sample size.

### **5.3 Results**

#### **5.3.1 Landscapes preferred for fuelwood, brushwood and kraal posts**

The resource users identified Makopiyane as the landscape most preferred for fuelwood, followed by Tyip Tyip, Gqumehlo, Mbomboyi, Wani, Qeqe and Ntsunguzi (Table 5.1). However, as the preference ranking attributed to these landscapes was the same as for brushwood, the data for fuelwood and brushwood landscapes was pooled. Tyip Tyip was identified as the most preferred landscape for kraal posts, followed by Mbomboyi, Gqumehlo, Makopiyane, Wani, Ntsunguzi and Qeqe. These landscapes were preferred for fuelwood, brushwood and kraal posts as they were community woodlands, which were associated with a long history of natural resource use.

Table 5.1: Showing people's relative preferences, intensity of use and active selection of landscapes for fuelwood, brushwood and kraal posts

Resource	Landscapes	Stated preference ranking <sup>a</sup>	Intensity of use ranking <sup>b</sup>	Utilisation/availability ratios <sup>c</sup>				
				No. trees used in landscape	U <sub>L1</sub>	No. trees counted in landscape	A <sub>L1</sub>	UI
Fuelwood and brushwood	Makopiyane	2.5	1.0	16	0.03	184	0.08	0.42
	Tyip Tyip	2.1	1.7	170	0.35	724	0.31	1.14
	Gqumehlo	1.8	0.9	28	0.06	180	0.08	0.75
	Mbomboyi	1.4	1.5	40	0.08	120	0.05	1.61
	Wani	1.1	0.4	25	0.05	90	0.04	1.34
	Qeqe	0.7	0.4	10	0.02	60	0.03	0.81
	Ntsunguzi	0.4	0.4	47	0.10	155	0.07	1.47
	Rhenene	0	0.9	42	0.09	273	0.12	0.74
	Jejane	0	0.4	19	0.04	120	0.05	0.77
	Rodi Farm	0	1.0	73	0.15	392	0.17	0.90
	Mount Coke	0	1.4	17	0.03	60	0.03	1.37
Kraal	Tyip Tyip	2.5	3.5	7	0.13	30	0.17	0.75

posts	Mbomboyi	2.1	0.5	18	0.32	30	0.17	1.92
	Gqumehlo	1.8	2.0	n/a	n/a	n/a	n/a	n/a
	Makopiyane	1.4	0	n/a	n/a	n/a	n/a	n/a
	Wani	1.1	0	n/a	n/a	n/a	n/a	n/a
	Ntsunguzi	0.7	0	n/a	n/a	n/a	n/a	n/a
	Qeqe	0.4	0	n/a	n/a	n/a	n/a	n/a
	Rodi Farm	0	3.5	28	0.50	89	0.50	1.01
	Mount Coke	0	0.5	3	0.05	30	0.17	0.32

- a) People's stated landscape preferences, where the highest rank represented the most preferred landscape and the lowest rank represented the least preferred landscape. Zero denoted the landscapes which were not identified by the local people as preferred landscapes (fuelwood and brushwood landscapes n=48; kraal post landscapes n=24)
- b) Intensity of use of the landscapes, where the highest rank represented the most intensively used landscape and the lowest rank represented the least intensively used landscape. Zero denoted the landscapes which were not used by the local people (fuelwood and brushwood landscapes n=48; kraal post landscapes n=24)
- c) Utilisation/availability ratios for the landscapes, where a ratio of greater than one indicated that the landscape was actively selected while a ratio of less than one indicated that the landscape was avoided. However, where utilisation/availability ratios could not be calculated for Gqumehlo, Makopiyane, Wani, Ntsunguzi and Qeqe, n/a represented not applicable (fuelwood and brushwood landscapes n=28; kraal post landscapes n=5)

### 5.3.2 Intensity of use of the landscapes for fuelwood, brushwood and kraal posts, as perceived by the local people

Most people harvested fuelwood or brushwood or both of these resources from Tyip Tyip (18), followed by Mbomboyi (8). Other landscapes used included Mount Coke, Rodi Farm, Rhenene and Jejane, although they were not identified as preferred for fuelwood or brushwood (Figure 5.1). Of the people interviewed for kraal posts, only 58 percent harvested kraal posts (n=14), mostly from Tyip Tyip (n=5) or Rodi Farm (n=5) (Figure 5.2). However, the latter was not identified by the resource users as a preferred landscape.

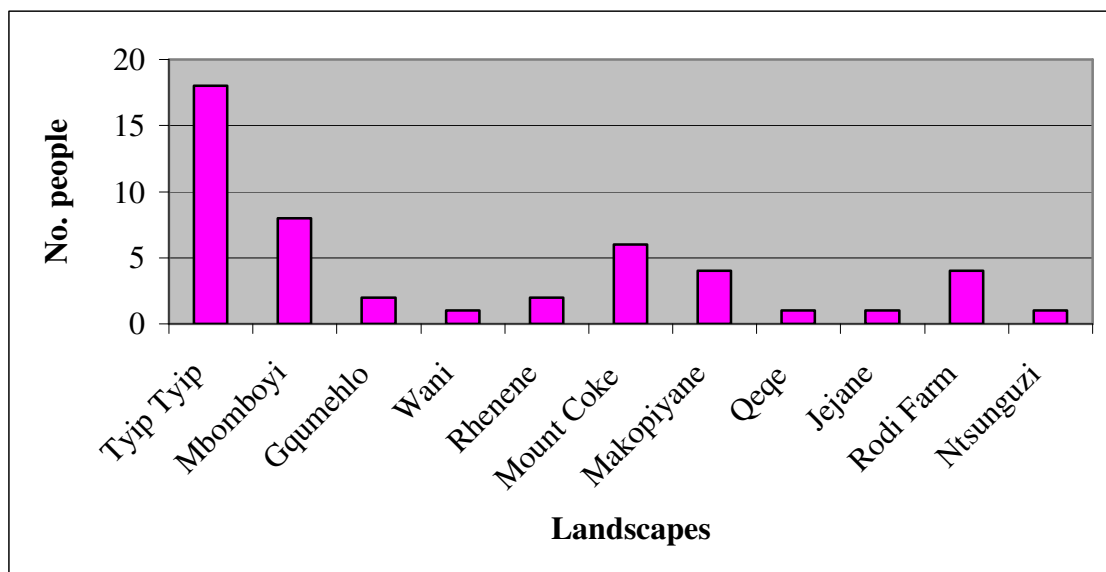


Figure 5.1: Number of people who stated that they harvested fuelwood or brushwood from the respective landscapes during door-to-door interviews (n=48)

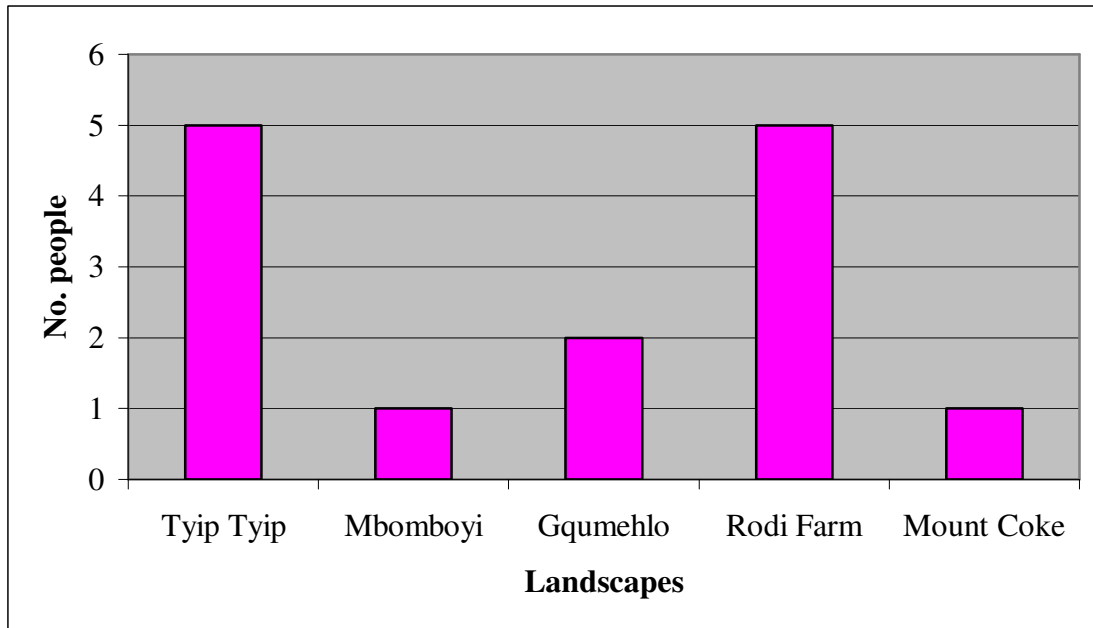


Figure 5.2: Number of people who stated that they harvested kraal posts from the respective landscapes during door-to-door interviews (n=24)

Multiple reasons were cited for differences in the intensity of use of the respective landscapes for fuelwood and brushwood. However, the distance of the landscape from home (n=17) was cited by most people as an important factor in determining which landscape they used, followed by the abundance of fuelwood or brushwood associated with that landscape (n=11). Furthermore, nine people stated that a combination of these two factors influenced their use patterns. This suggested that the local people considered both the distance travelled and the abundance of fuelwood or brushwood on offer when making decisions about using a particular landscape (Figure 5.3).

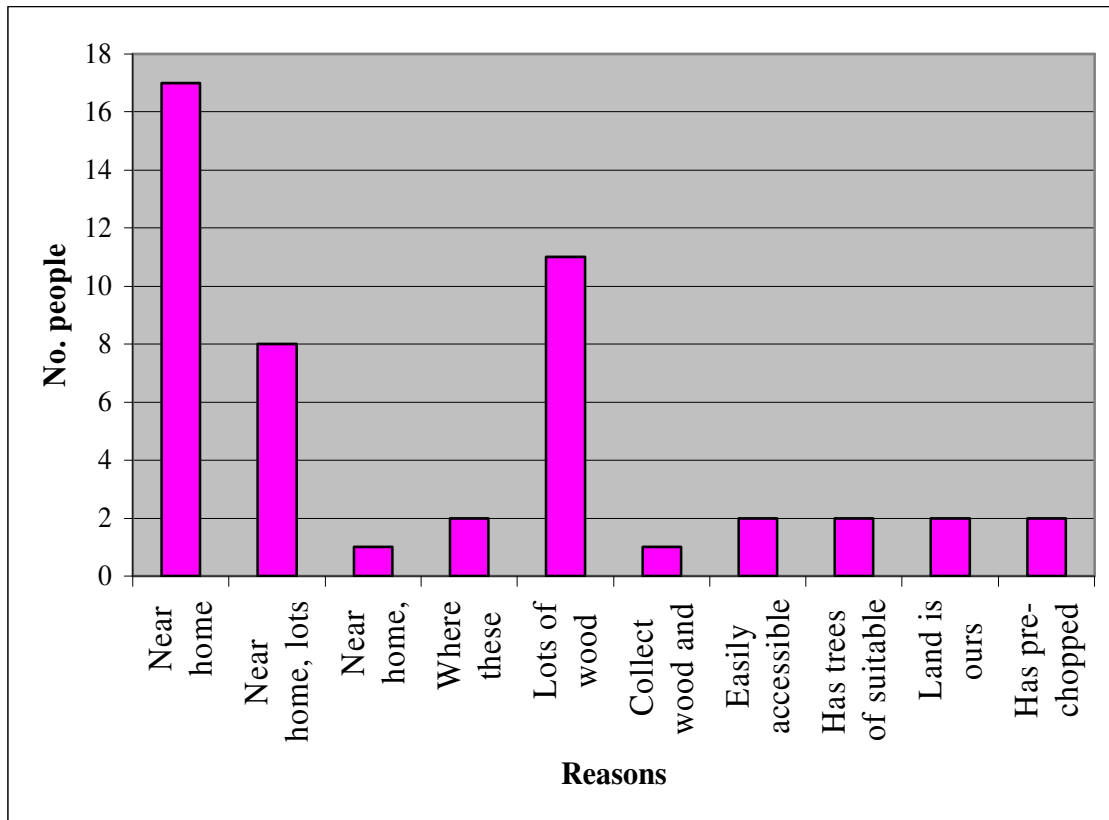


Figure 5.3: Reasons for differences in the intensity of use of the respective landscapes for fuelwood and brushwood (n=48)

Similarly, distance from home and the abundance of kraal posts associated with each landscape was shown to influence people’s use of kraal post landscapes (Figure 5.4). Most people stated that the landscapes used were the only places where the preferred species were available (n=6), with the next most common reason being proximity to the household.

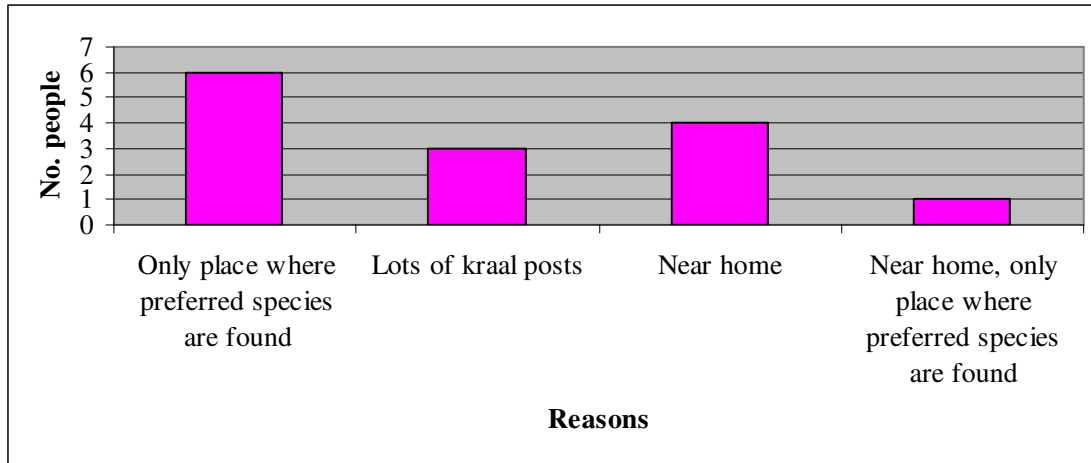


Figure 5.4: Reasons for differences in the intensity of use of the respective landscapes for kraal posts (n=24)

### 5.3.3 Landscapes actively selected for fuelwood, brushwood and kraal posts

Tyip Tyip, Mbomboyi, Wani, Ntsunguzi and Mount Coke were actively selected for their fuelwood and brushwood (i.e. these landscapes exhibited utilisation/availability ratios of greater than one) (Table 5.1). In contrast, Makopiyane, Gqumehlo, Qeqe, Rhenene, Jejane and Rodi Farm exhibited utilisation/availability ratios of less than one, and were avoided by resource users. A comparison of people's perceptions of the intensity of use of the respective landscapes and their actual intensity of use, as indicated by their utilisation/availability ratios, showed no significant correlation (Spearman's rank order correlation;  $n=11$ ;  $R=0.18$ ;  $P=0.59$ ).

Mbomboyi and Rodi Farm were actively selected by the resource users for kraal posts while Tyip Tyip and Mount Coke were avoided (Table 5.1). Utilisation/availability ratios for Gqumehlo, Makopiyane, Wani, Ntsunguzi and Qeqe were not calculated as these landscapes were no longer used for kraal posts by the resource users due to their scarcity in the preferred kraal post species (see chapter six), or in the case of Gqumehlo, as none of the kraal post users were willing to have the research team accompany them on a collection trip to this landscape. Furthermore, there was no correlation between the utilisation/availability ratios for Tyip Tyip, Mbomboyi, Rodi Farm and Mount Coke, and people's perceptions of the intensity of use of these landscapes (Spearman's rank order correlation;  $n=4$ ;  $R=0.01$ ;  $P=1.00$ ).

### 5.3.4 Factors that influenced people's choices for harvesting areas across all landscapes

Distance from roads/footpaths was significantly correlated with people's active selection of harvesting areas across all fuelwood and brushwood landscapes (Regression;  $F=8.04$ ;  $df=1, 27$ ;  $P=0.01^*$ ). The  $R^2$  value showed that 23 percent of the variance in the data set was accounted for in the regression (Figure 5.5).

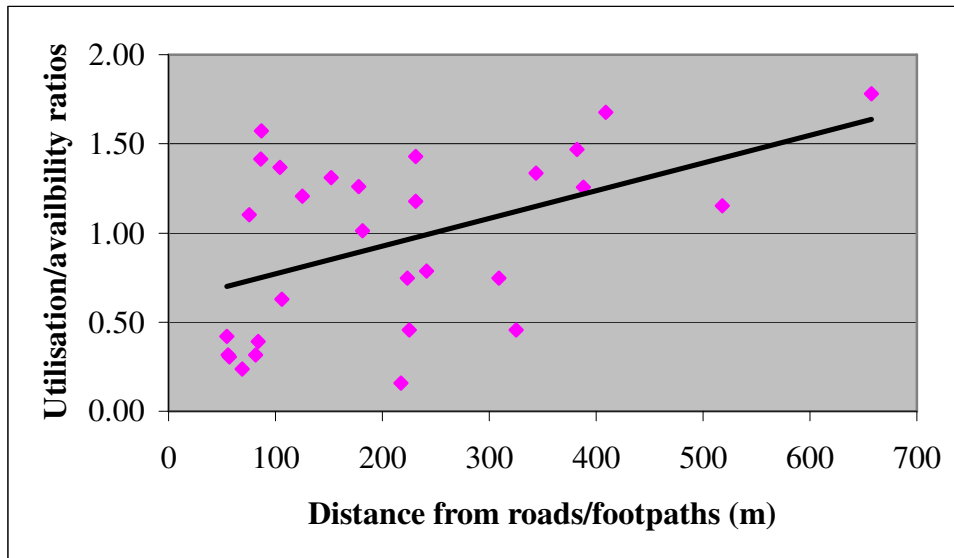


Figure 5.5: Showing the positive correlation between the utilisation/availability ratios for respective harvesting areas of resource users across all fuelwood and brushwood landscapes and their distance from roads/footpaths (n=28)

However, due to a problem with auto-correlation, simple, linear regressions could not be undertaken to examine the influence of density, distance from village, distance from taboo areas and slope on the resource user's active selection, avoidance or indifference towards the intensity of use of a particular harvesting area for fuelwood and brushwood (Table 5.2). Auto-correlation was also encountered in the data sets for factors, distance from village, distance from roads/footpaths and distance from taboo areas, for kraal post landscapes.

Table 5.2: Showing auto-correlation problems with regression analyses for fuelwood and brushwood landscapes, and kraal post landscapes (where Durbin-Watson stat values  $>2$  and  $<1.2$  indicate an auto-correlation problem)

Dependent variable	Independent variable	Durbin-Watson stat	
		Fuelwood and brushwood landscapes	Kraal post landscapes
Utilisation/availability ratios	Density	0.69	1.89
Utilisation/availability ratios	Distance from village	0.85	3.39
Utilisation/availability ratios	Distance from roads/footpaths	1.18	2.13
Utilisation/availability ratios	Distance from taboo areas	0.68	2.61
Utilisation/availability ratios	Slope	0.70	1.86

However, simple, linear regressions did show that kraal post density and slope were not correlated with the utilisation/availability ratios for respective harvesting areas of resource users across all kraal post landscapes (Table 5.3).

Table 5.3: Relationships between the utilisation/availability ratios for harvesting areas across the kraal post landscapes, and their density in kraal post species or slope

Dependent variable	Independent variable	F	df	P	R <sup>2</sup>
Utilisation/availability ratios	Density	5.73	1,4	0.10	0.66
Utilisation/availability ratios	Slope	0.01	1,4	0.94	0.002

### **5.3.5 Relative importance of the landscapes actively selected by the local people for fuelwood, brushwood and kraal posts**

Each landscape was described in terms of its density, distance from the village, distance from taboo areas and slope, using the average values for the harvesting areas

of individual users within each landscape (Table 5.4). Distance of each landscape from roads/footpaths was not taken into account for the analysis, as the data points were not normally distributed, even after the data set was transformed.

Table 5.4: Characteristics of the fuelwood and brushwood landscapes, using average values

Landscapes	Density (trees/Ha) $\pm$ SE	Distance from village (m) $\pm$ SE	Distance from roads (m) $\pm$ SE	Distance from taboo areas (m) $\pm$ SE	Slope ( $^{\circ}$ ) $\pm$ SE
Makopiyane	123 $\pm$ 2	2985 $\pm$ 416	70 $\pm$ 15	313 $\pm$ 120	4 $\pm$ 0
Tyip Tyip	112 $\pm$ 27	2064 $\pm$ 305	332 $\pm$ 57	530 $\pm$ 75	2 $\pm$ 0.5
Gqumehlo	120 $\pm$ 32	1366 $\pm$ 495	137 $\pm$ 41	527 $\pm$ 209	7 $\pm$ 0.7
Mbomboyi	68 $\pm$ 0	2845 $\pm$ 0	87 $\pm$ 0	226 $\pm$ 0	2 $\pm$ 0
Wani	62 $\pm$ 0	1987 $\pm$ 0	152 $\pm$ 0	204 $\pm$ 0	0 $\pm$ 0
Qeqe	30 $\pm$ 0	2058 $\pm$ 0	241 $\pm$ 0	444 $\pm$ 0	12 $\pm$ 0
Ntsunguzi	26 $\pm$ 0	739 $\pm$ 0	231 $\pm$ 0	197 $\pm$ 0	11 $\pm$ 0
Rhenene	78 $\pm$ 6	1293 $\pm$ 122	186 $\pm$ 69	1045 $\pm$ 192	2 $\pm$ 1
Jejane	104 $\pm$ 0	2105 $\pm$ 0	223 $\pm$ 0	2125 $\pm$ 0	4 $\pm$ 0
Mount Coke	177 $\pm$ 0	4226 $\pm$ 0	344 $\pm$ 0	91 $\pm$ 0	0 $\pm$ 0
Rodi Farm	189 $\pm$ 57	3584 $\pm$ 856	99 $\pm$ 21	0 $\pm$ 0	2 $\pm$ 1

A canonical correlation analysis was then performed on the average values in order to determine the relative importance of the different fuelwood and brushwood landscapes, with density and inaccessibility as input variables (Figure 5.6). The latter was calculated separately for each landscape as the sum of its distance from the village, proximity to taboo areas, and the steepness of its slopes. However, as the respective factors did not display an equal influence on the importance of the landscapes, they were multiplied by factor weightings assigned to them by the analysis (Table 5.5).

Table 5.5: Factor weightings for density, distance from the village, distance from taboo areas and slope, as determined by the canonical correlation analysis for fuelwood and brushwood landscapes

Factors	Weighting
Density	-1.0
Distance from village	-0.8
Distance from taboo areas	-0.1
Slope	0.3

Furthermore, as Ntsunguzi and Qeqe dominated the analysis, these landscapes were excluded from the final canonical correlation. Ntsunguzi and Qeqe exhibited considerably lower densities of fuelwood and brushwood than the other landscapes (i.e. Makopiyane, Tyip Tyip, Gqumehlo, Mbomboyi, Wani, Rhenene, Jejane, Mount Coke and Rodi Farm), with the result that there was a clear separation between the former and the latter. However, there was no distinct separation between Makopiyane, Tyip Tyip, Gqumehlo, Mbomboyi, Wani, Rhenene, Jejane, Mount Coke and Rodi Farm.

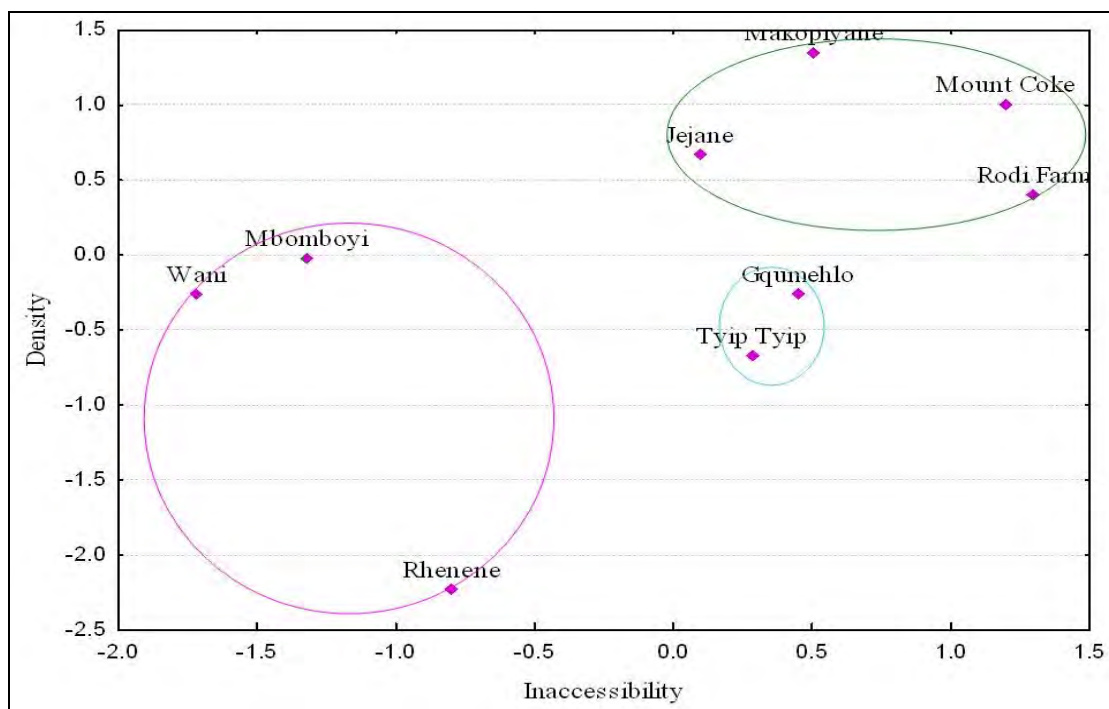


Figure 5.6: Relative importance of the fuelwood and brushwood landscapes, as produced by canonical correlation analysis

On the x-axis, inaccessibility accounted for 25 percent of the variance between the fuelwood and brushwood landscapes. Wani, Mbomboyi and Rhenene were located towards the negative side of the x-axis while Tyip Tyip, Gqumehlo, Jejane, Makopiyane, Mount Coke and Rodi Farm were located towards the positive side of the x-axis.

Density accounted for 72 percent of the variance between the landscapes, and was represented on the y-axis. Landscapes associated with high densities of fuelwood and brushwood of  $> 100 < 200$  trees/Ha (Jejane, Makopiyane, Mount Coke and Rodi Farm) were located towards the positive side of the axis while those associated with low densities ( $< 80$  trees/Ha), Rhenene, were located towards the negative side of the axis. Landscapes that exhibited intermediate densities of fuelwood and brushwood of  $> 60 < 120$  trees/Ha (Wani, Mbomboyi, Tyip Tyip and Gqumehlo) were located towards the centre of the y-axis.

Consequently, the fuelwood and brushwood landscapes were divided into three groups. Wani, Mbomboyi and Rhenene constituted landscapes that were easily accessible but exhibited low to intermediate densities of fuelwood and brushwood. Tyip Tyip and Gqumehlo were less accessible than the former but exhibited intermediate fuelwood and brushwood densities. In turn, Jejane, Makopiyane, Mount Coke and Rodi Farm were even less accessible than Tyip Tyip and Gqumehlo but exhibited intermediate to high densities of fuelwood and brushwood.

Similarly, the kraal post landscapes were described in terms of their density, distance from the village, distance from roads/footpaths, distance from taboo areas and slope, using average values for the harvesting areas of resource users within each landscape (Table 5.6). However, a canonical correlation analysis was not performed for kraal post landscapes as the transformed data sets for the above-mentioned factors were not normally distributed.

Table 5.6: Characteristics of the kraal post landscapes, using average values

Landscapes	Density (trees/Ha) ± SE	Distance from village (m) ± SE	Distance from roads (m) ± SE	Distance from taboo areas (m) ± SE	Slope (°) ± SE
Tyip Tyip	60 ± 0	3378 ± 0	325 ± 0	724 ± 0	1 ± 0
Mbomboyi	61 ± 0	2845 ± 0	87 ± 0	226 ± 0	2 ± 0
Rodi Farm	47 ± 31	4589 ± 2198	117 ± 61	0 ± 0	5 ± 0.5
Mount Coke	199 ± 0	2713 ± 0	83 ± 0	965 ± 0	0 ± 0

## 5.4 Discussion

### 5.4.1 Differences between people's stated preferences and the landscapes they actively selected for fuelwood, brushwood and kraal posts

Makopiyane was identified as the most preferred landscape for fuelwood and brushwood, followed by Tyip Tyip, Gqumehlo, Mbomboyi, Wani, Qeqe and Ntsunguzi. These landscapes constituted community woodlands that were associated with a long history of natural resource use by the local people, which dated back to the establishment of the village between 1958 and 1960 as a result of Betterment Planning (Rhodes University et al 2000; Cundill 2005). Hence, it was through people's past experiences and historical perceptions of these landscapes that they were most desired for their fuelwood and brushwood (Pearce and Turner 1990; Field 2002; Pahl-Wostl in press).

However, not all preferred landscapes were actively selected by the local people, which suggested that their choices were not simply governed by habit (see section 5.4.2). Tyip Tyip, Mbomboyi, Wani and Ntsunguzi were actively selected for fuelwood and brushwood while Makopiyane, Gqumehlo and Qeqe were avoided (Table 5.1).

In addition, although Mount Coke was not identified as a preferred landscape, it was actively selected by the local people (Table 5.1). Consequently, they were prepared to substitute alternatives for the preferred landscapes, when the costs outweighed the benefits (Vermeulen 2001; Pote et al 2006).

Similarly, Tyip Tyip was identified as the most preferred landscape for kraal posts, followed by Mbomboyi, Gqumehlo, Makopiyane, Wani, Ntsunguzi and Qeqe. However, only Mbomboyi was actively selected by the local people (Table 5.1). In response to resource scarcity (see section 5.4.2), the other preferred landscapes were replaced by Rodi Farm, which constituted neighbouring community land, and prompted the illegal harvesting of kraal posts. The illegal harvesting of state forest resources and neighbouring community resources was also documented in Indian (Rao and Pant 2001) and other South African rural communities (Shackleton et al 2004), in reply to increasing resource scarcities.

#### **5.4.2 Factors that shaped people's landscape use patterns**

The local people behaved in a rational manner by weighing up the benefits and costs associated with the different landscape options available to them before actively selecting those landscapes that afforded them the greatest net benefits (Turner et al 1994; Field 2002; Curtis 2004). Consequently, the local people made trade-offs between the returns from harvesting and the accessibility costs associated with the respective options (Shackleton and Mander 2000; Lynam et al 2004; Pote et al 2006). The returns from harvesting were determined by landscape quality, as reflected by people's preferences for the relative options, as well as their density in resources (i.e. fuelwood and brushwood or kraal posts) and diversity of preferred species, in the case of kraal post landscapes. Similarly, Shackleton et al (1994) and Tilman et al (2005) found that resource quality, density and diversity influenced people's natural resource use patterns.

On the flip side, the accessibility costs were determined as a function of the landscapes' distance from the village (Vermeulen 1996; Kirubi et al 2000; Pote et al 2006), proximity to taboo areas (Klubnikin et al 2000; Tabuti et al 2003; Bodin et al 2006) and slope (Rao and Pant 2001; Luoga et al 2002), in the case of fuelwood and brushwood landscapes. However, in addition to the costs associated with accessing the landscapes themselves, the local people incurred accessibility costs associated with the harvesting of resources from these landscapes, particularly in the case of fuelwood and brushwood (Bembridge and Tarlton 1990; Shackleton et al 1994).

In contrast, people's choices were not influenced by the landscapes' accessibility via roads/footpaths, contrary to Luoga et al (2002). Distance from roads/footpaths was positively correlated with utilisation/availability ratios for harvesting areas across all fuelwood and brushwood landscapes (Figure 5.5). However, this was because fuelwood and brushwood were harvested within disturbed areas and on landscape edges, where the canopy structure had been largely 'opened up' due to livestock grazing and the harvesting of natural resources (Scheepers 2001; Pote et al 2006), making it easy for the local people to navigate without the aid of access paths. In the case of kraal post landscapes, the preferred species occurred within the core woodland areas, situated far from any roads/footpaths (see chapter six).

Ultimately, trade-offs between these benefit- and cost factors accounted for the local people's active selection of certain preferred landscapes, and avoidance of others. In addition, optimal choice explained people's use of alternatives instead of the preferred landscapes that were avoided.

For example, only Tyip Tyip, Mbomboyi, Wani and Ntsunguzi of the preferred landscapes were actively selected for fuelwood and brushwood (Table 5.1). This was explained as the local people made trade-offs between the fuelwood and brushwood densities of the respective landscape options and their accessibility costs, measured as a function of their distance from the village, proximity to taboo areas and steepness of slope. Ultimately, the preferred landscapes that exhibited intermediate fuelwood and brushwood densities and low inaccessibility such as Mbomboyi, Wani and Ntsunguzi were selected over those of intermediate to high densities but high inaccessibility such as Gqumehlo and Makopiyane (Figure 5.6). This gradient of decreasing utilisation with increasing accessibility costs was supported by previous studies of fuelwood and timber use by rural communities in Zimbabwe (Grundy et al 1993; Vermeulen 1996), Kenya (Kirubi et al 2000), Mozambique (Lynam et al 2004), Tanzania (Luoga et al 2002) and South Africa (Shackleton et al 1994; Motinyane 2001; Pote et al 2006). Whiting and Greeff (1999) and Hill et al (2001) also documented similar behaviour in lizards and bees, which would travel greater distances in order to select preferred food items.

Tyip Tyip was the only exception as this landscape exhibited a lower fuelwood and brushwood density than Gqumehlo and Makopiyane, and was associated with a more 'open' vegetation canopy. This had a positive spin-off for Tyip Tyip in that it was easier for the local people to navigate through the spiny vegetation preferred for fuelwood and brushwood at intermediate rather than high densities, reducing the accessibility costs associated with the harvesting of resources from this landscape, and ultimately, resulting in people's active selection of Tyip Tyip over Gqumehlo and Makopiyane.

However, the local people were prepared to substitute state-owned Mount Coke for the preferred fuelwood and brushwood landscapes that were avoided as they were permitted to collect bundles of exotic wood from here, which had been cut down by the forestry officials as part of the Department of Water Affairs and Forestry's alien eradication programme. The wood, having been already cut and dried, was easier to collect and drier than indigenous trees from the preferred landscapes (Shackleton et al 1994).

Consequently, reduced costs due to the ease of collection of fuelwood and brushwood from the landscape rather than the accessibility of the landscape itself, and its influence on the cost-benefit ratios for all available options, accounted for people's choices of alternatives to the preferred landscapes. Rhenene, while a better choice for fuelwood and brushwood than Mount Coke in terms of its returns from harvesting versus accessibility costs (Figure 5.6), was avoided by the local people because it was not associated with the added incentive of 'ready to use' fuelwood and brushwood.

People's landscape choices for kraal posts involved a trade-off between the returns from harvesting, determined as a function of the landscape's quality, density and diversity of preferred species (Shackleton et al 1994; Lynam et al 2004; Tilman et al 2005), and its accessibility costs, measured in terms of its distance from the village (Vermeulen 1996; Kirubi et al 2000; Motinyane 2001) and the risk involved with its use (Fox 2005; Bodin et al 2006). The local people explained that due to resource scarcity, and the subsequent disappearance of preferred kraal post species from the preferred landscapes, with the exception of Mbomboyi, they were forced to abandon Tyip Tyip, Gqumehlo, Makopiyane, Wani, Ntsunguzi and Qeqe in favour of

harvesting kraal posts illegally from Rodi Farm at a higher accessibility cost (Table 5.1). This finding was supported by previous research which showed that local people resorted to illegal activities and crime when faced with little or zero options available to them during times of scarcity (Nagothu 2001; Lawes et al 2004).

However, the local people did respond to risk thresholds in making their choice of an alternative to the preferred landscapes (Abbot and Mace 1999; Nagothu 2001). Whereas the preferred landscapes constituted community woodlands to which rights of access and use belonged to the people of Machibi (see chapter two), Rodi Farm constituted neighbouring community land, and was associated with an additional low risk of being caught for illegal harvesting. Weak institutional controls associated with Rodi Farm constituted unrestricted access to outsiders from Machibi, no formal monitoring system of natural resource use and light penalties for illegal harvesting.

In contrast, although Mount Coke was perceived to exhibit the highest density and diversity of kraal post species (Rhodes University et al 2000), this landscape was not actively selected by the local people as it was associated with greater institutional controls than Rodi Farm. Mount Coke was state-owned and managed with controlled access to local communities, forest guards that accompanied resource users on collection trips and monitored their resource use, as well as associated with strong penalties for illegal harvesting.

Similar trade-offs between food quality and quantity and predation risk were documented in the animal kingdom. For example, Olsson et al (2002) and Duriez et al (2005) showed that birds were more inclined to take risks when foraging in poor food patches (i.e. when resources were scarce) than when foraging in rich food patches (i.e. when resources were abundant).

### **5.4.3 Management implications**

As the local people exhibited a different harvesting strategy for fuelwood and brushwood landscapes than kraal post landscapes, multiple management strategies are recommended for Machibi. Furthermore, as people's use and management of these landscapes has aspects in common with the management of common property resources, for example, a lack of exclusivity rights (where the benefit one resource

user derives from using a particular landscape for fuelwood and brushwood detracts from the benefit available for another resource user), the management guidelines provided by this study are often underpinned by Oström's rules for lasting common property institutions (Oström 1990).

Supported by Oström (1990), strategies for the use and management of fuelwood, brushwood and kraal post landscapes at Machibi must be appropriate to local conditions. For example, the local people did not always use the preferred landscapes for fuelwood and brushwood (Shackleton 1993; Scheepers 2004; Pote et al 2006). However, Mbomboyi, Wani, Ntsunguzi and Tyip Tyip were identified as important fuelwood and brushwood landscapes as the local people made trade-offs between the returns from harvesting (Grundy et al 1993) and accessibility costs of using them, as well as the cost of navigating the spiny vegetation preferred for fuelwood and brushwood, particularly in the case of Tyip Tyip (Bembridge and Tarlton 1990; Luoga et al 2002; Tabuti et al 2003). This finding suggests that the management strategies should focus on a select group of important fuelwood and brushwood landscapes, and look to manipulate people's landscape use patterns by influencing the returns from harvesting in terms of fuelwood and brushwood quality and density and the accessibility and harvesting costs associated with using particular landscapes (i.e. by changing the ratio of costs to benefits).

Therefore, a possible management strategy could be to encourage the use of suitable alternatives to the preferred landscapes by providing incentives for the local people to harvest their fuelwood and brushwood from less traditional sources, and thereby reducing the harvesting pressure on Mbomboyi, Wani, Ntsunguzi and Tyip Tyip. These incentives may be in the form of reduced harvesting costs by providing the local people with 'ready to use' fuelwood and brushwood, as is the case of Mount Coke, over the short term, or 'value-adding' opportunities over the medium term (Geldenhuys 1997; Lugo and Helmer 2004; Naughton-Treves et al 2007), as is the case of Rhenene, which constituted an old agricultural field, which upon subsequent colonisation with fast-growing, opportunistic species such as those preferred for fuelwood and brushwood, is currently used by the local people. In the long term, such incentives could be used to promote a rotational use system of Mbomboyi, Wani, Ntsunguzi, Tyip Tyip and new, less traditionally used landscapes for fuelwood and

brushwood, thereby dispersing the harvesting pressure across a wider range of landscapes and allowing time for landscapes to recover when not in use.

In contrast, resource scarcity and a decline in the diversity of preferred species within the landscapes explained people's abandonment of the preferred kraal post landscapes, with the exception of Mbomboyi, in favour of harvesting kraal posts illegally from Rodi Farm (Nagothu 2001; Lawes et al 2004). This suggests that people's use of kraal post landscapes can be manipulated by influencing the returns from harvesting in terms of kraal post density and the range in quality of kraal post species available, and the risk associated with being caught for illegal harvesting.

A possible short term management strategy could be to encourage the sharing of landscapes between neighbouring communities through a collective choice arrangement, where most resource users affected by the operational rules can participate in changing the rules (Oström 1990). An alternative management strategy with a medium to long term perspective, could be to provide the local people of Machibi with additional kraal post landscapes through the establishment of indigenous woodlots as an incentive for them to use their own resources (Geldenhuys 1997; Klooster and Masera 2000; Akinbami et al 2003; Jagger et al 2004) while increasing the risk of resource users being caught for illegal harvesting on neighbouring community land through the deployment of forest guards, and setting of harsh penalties for illegal use (Abbot and Mace 1999), which can be enforced by the establishment of credible and legitimate local institutions such as the participatory forestry committee at Machibi (Oström 1990; Reid and Turner 2004; Fabricius et al 2004a). In the long term, a combination of these strategies, which promotes the joint use of landscapes between neighbouring communities in the short term, and while new landscapes are developed for each community to be able to meet their own needs, may be effective for enhancing kraal post landscapes, and promoting their better use and management.

However, the resource users from Machibi and the neighbouring village need to have clearly defined rights to the use of Rodi Farm, with a capped timeframe on joint use, and the boundaries of the landscape itself need to be defined (Oström 1990). Furthermore, as many tree planting programmes and similar community initiatives

have failed in rural South Africa because of a lack of secure land and tree tenure (Shackleton 1993; Shackleton et al 2004), the establishment of a local monitoring system is critical (Oström 2000; Fabricius et al 2004a; Nott and Jacobsohn 2004).

Supported by Oström (1990), these community-level management strategies should also be embedded in a larger system. Many of these management recommendations will benefit from the support of the existing PFM programme championed by DWAF, and aimed at involving Machibi and the other neighbouring communities of Mount Coke in the management of the state forest, and promoting the wiser use of community resources.

### **5.5 Conclusion**

This chapter showed that the local people behaved in a rational manner by weighing up the returns from harvesting and accessibility costs associated with the respective landscapes available to them, before selecting the option(s) associated with the greatest net benefits. However, the combination of factors involved in making these trade-offs differed between the fuelwood and brushwood landscapes and kraal post landscapes. Consequently, a range of diverse and flexible management options and strategies is recommended for the landscapes wise use and management.

## **6. PEOPLE'S SPECIES PREFERENCES AND USE PATTERNS**

### **Executive summary**

Social and ecological changes have shaped the different ways in which people view natural resources, as well as how they are used and managed. This chapter 1) identifies people's species preferences for fuelwood, brushwood and kraal posts, 2) determines which species are actively selected by the local people for these purposes, and 3) provides a comparison between people's stated preferences and their patterns of use. A combination of participatory and scientific methods was used to tap into people's local knowledge of these species, and measure the level of utilisation, relative to their availability. Results showed that people did not always use what they preferred. However, discrepancies between people's stated preferences and species use patterns were explained by trade-offs between the returns from harvesting, measured in terms of the quality and density of the species, and the accessibility costs of harvesting them, or the costs of commercial alternatives.

### **6.1 Introduction**

Social and ecological systems have co-evolved over many centuries, characterised by people's adaptations to changes, and often crises, in their surrounding environment (Holling et al 1998; Lane and McDonald 2002). These changes have shaped the different ways in which people view natural resources such as fuelwood, brushwood and kraal posts, with implications for how the tree and shrub species that are harvested for these purposes are used and managed (Shackleton and Scholes 2000; Kennedy et al 2001; Lane and McDonald 2002).

Numerous studies worldwide have demonstrated the importance of natural resources to rural livelihoods in terms of income generation (Shackleton and Shackleton 2000b; Twine et al 2003), creating cash-saving opportunities (Bhagavan and Giriappa 1995; Kituyi et al 2001) and performing an important safety net function during times of hardships, often brought about by sudden changes in the economic, social or ecological environment (Vermeulen 2001; Dovie et al 2004; Shackleton and Shackleton 2004). Fuelwood consists of the stems or stout branches of woody trees and shrubs that are harvested predominately on a subsistence basis by the women in the village, and used for cooking and heating purposes (Bembridge and Tarlton 1990;

Dyer 1996; Shackleton 1993; Motinyane 2001). Hence, the specific species that are harvested for this purpose are referred to as fuelwood species (see chapter one).

However, kraalwood can be divided into two categories based on the form and structure of a typical Xhosa kraal; brushwood and kraal posts (Scheepers 2001). Brushwood refers to the branches of woody trees or shrubs that are loosely piled on top of each other or compacted to construct the sides of the kraal. Kraal posts constitute the stems or stout branches of trees that are set vertically at kraal entrances, and used intermittently along the sides of the kraal to reinforce the packing material or brushwood (Scheepers 2001; Pote et al 2006). Consequently, the species that are harvested for these purposes are defined as brushwood and kraal post species, respectively (see chapter one).

However, despite their importance in rural livelihoods, many natural resources such as fuelwood and kraalwood have been unsustainably used and managed (Geist and Lambin 2002; Obiri 2002; International Institute for Sustainable Development 2005), with implications for the well-being of current and future generations (Biggs et al 2004). Therefore, an understanding of the thought processes behind how local people come to arrive at their resource use decisions is critical to managing these systems and knowing how to buffer them against radical, and often irreversible, changes (Ludwig et al 1997; Scheffer and Carpenter 2003).

In this chapter, I examine people's species preferences for fuelwood, brushwood and kraal posts, as reflected in their desires to use particular trees and/or shrubs for these respective purposes, as well as the factors that influence them. For example, previous studies have shown that criteria such as wood density, drying rate and duration of ember production determine the quality of fuelwood species, and ultimately, influence people's preferences (Bembridge and Tarlton 1990; Abbot et al 1997; Madubansi and Shackleton in press). Similarly, criteria such as durability, termite-resistant properties and straightness of stem influence people's species preferences for brushwood and kraal posts (Liengme 1983; Van Eck et al 1997; Twine et al 2003; Pote et al 2006).

I also identify the species that were actively selected for fuelwood, brushwood and kraal posts (i.e. used in greater proportion to their availability), and contrast people's

stated preferences with their patterns of use. An explanation of the factors that influenced the decision-making strategies, and ultimately, species use patterns of the local people is then discussed, borrowing principles and paradigms from resource economics and behavioural ecology.

For example, conventional consumer behaviour theory assumes that an individual's preference for a particular resource is a measure of his/her satisfaction gained from its use (Dusgupta and Pearce 1972), and reflected in their willingness to pay for it (Pearce and Turner 1990). This measure takes into account the benefits obtained from the use of the resource, as well as the costs incurred by the resource users to use it (More et al 1996; Sikhakhane 2001; Field 2002), where the optimal choice is represented by the option that affords them the greatest net benefit.

Similarly, optimal foraging theory assumes that animals make trade-offs between the benefits of improved calorie intake and the cost of energy expenditure before choosing the resource that affords them the greatest net benefit (Hurly and Oseen 1999; Olsson et al 2002; Arcis and Desor 2003), whether measured in terms of the net rate of gain (gain-expenditure/time) or efficiency (gain/expenditure) (Hutchinson and McNamara 2000; Kacelnik and Marsh 2002). Hence, willingness to pay is comparable to optimal foraging.

In the context of this study, it is assumed that the local people of Machibi have preferences for particular species for fuelwood, brushwood and kraal posts, based on their past experiences and historical perceptions (Pearce and Turner 1990; Field 2002; Pahl-Wostl in press), which reflect how much they 'want' to use them (see chapter two). However, as people's use of the preferred species is subject to resource limitations, their species use patterns can be determined by the trade-off between the benefits obtained from the use of particular species, measured in terms of their density and quality as fuelwood, brushwood or kraal posts, and the costs incurred to use them, measured in terms of their physical accessibility and/or monetary costs (Dusgupta and Pearce 1972; Pearce and Turner 1990; Field 2002). For example, previous studies have documented the illegal harvesting of live wood for fuel (Ainslie et al 1997; May et al 1997), increased distances covered by local people in search of fuelwood, timber and kraal posts (Gandar 1984; Shackleton et al 1994; Boudreau et al 2005), changes

in people's species preferences (Shackleton 1993; Kituyi et al 2001; Scheepers 2004; Pote et al 2006) and the supplementation of natural resource use with commercial alternatives (Bhagavan and Giriappa 1995; Mahapatra and Mitchell 1999; Madubansi and Shackleton in press) in response to resource scarcity.

However, while numerous studies are available on people's fuelwood species choices (Bembridge and Tarlton 1990; Dyer 1996; Shackleton 1993; Motinyane 2001), there exists little information on people's kraalwood choices, despite the fact that livestock production is an important part of rural livelihoods. Due to the irregularity of kraal size and shape across studies, kraalwood is often excluded from studies on timber use by rural communities (Liengme 1983). And where not excluded, kraalwood is often lumped together with timber for building fences and building poles for housing as the poles/wood used for these purposes are of similar size, shape and species (Liengme 1983; Luoga et al 2002). In addition, few studies have combined scientific and local knowledge when assessing people's species preferences and use patterns (Abbot et al 1997; Lynam et al 2004).

This chapter addresses these challenges by including brushwood and kraal posts in addition to fuelwood, and comparing and combining local knowledge with science when assessing people's utilisation of these resources, relative to their availability. Ultimately, a better understanding of the trade-offs people make in their species choices for fuelwood, brushwood and kraal posts will ensure wiser use and management of these resources.

## **6.2 Methods**

An assessment of the stated preferences and active selection of species for fuelwood, brushwood and kraal posts was complex as numerous factors could significantly influence the way in which the local people viewed, and ultimately, ranked these species. Hence, a combination of participatory and scientific methods was used to encapsulate people's preferences and patterns of use.

### **6.2.1 Participatory methods**

A number of participatory methods were used, including workshops, ranking exercises, trend-lines, participatory mapping and structured interviews to tap into

people's local knowledge of the trees and shrubs, as well as gather information on cultural practices and traditions regarding species use at Machibi. A series of workshops were conducted between the researchers and separate fuelwood and kraalwood user groups of four to six members each, selected by the local forestry committee for their specialised knowledge of species used for fuelwood, brushwood and kraal posts (Huntington 2000; Cundill 2005). The fuelwood user group consisted predominately of women across all age groups, as well as two men that collected and sold fuelwood in the village. The kraalwood user group was all men, across all age groups. However, where exercises required the collective knowledge of fuelwood and kraalwood, the user groups were combined to form a core group of between eight and ten members. These workshops were facilitated by two independent, Xhosa-English speaking interpreters to ensure that all parties understood each other.

However, the focus group exercises were only used to gain initial insights into the range of species across which individual preferences and use patterns at Machibi may occur. No statistical comparisons were drawn between the preferences and use patterns of the core group or fuelwood and kraalwood user groups, and those of individual resource users.

During the first workshop, the core group was asked to compile a list of the species preferred for fuelwood, brushwood and kraal posts, respectively. Hence, the core group was asked to name the species they most desired to use for fuelwood, brushwood and kraal posts while assuming the hypothetical scenario that a complete range of species was available to them (i.e. given that there were no resource restrictions). These species were initially identified using local knowledge. However, species were later collected in the field (i.e. while on collection trips with resource users), and verified by specialists at the Albany Museum Herbarium in Grahamstown (Martin 1995). Xhosa names for species, based on local knowledge, were also converted to botanical names with the help of relevant publications such as Johnson (1990) and Dold and Cocks (1999). In the case where a local name was used to describe more than one species, field verification and the use of cyclical feedback sessions during workshops for the participants to re-evaluate their previous inputs, and change or add information which they felt was omitted or mis-interpreted, helped to ensure data reliability (Mitchell 1997; Huntington 2000).

During the second workshop, the core group was guided through a series of ranking exercises to determine people's relative preferences for particular species for fuelwood, brushwood and kraal posts, respectively (Theis and Grady 1991; International Institute for Environment and Development 1998). The names of the preferred species were written on cue cards, and the core group asked to arrange them such that the species which people most desired to use was placed on top of the list and allocated the highest rank. The species which people least desired to use was placed at the bottom of the list and allocated the lowest rank. People's relative preferences for the fuelwood species, brushwood species and kraal post species, respectively, were then calculated out of ten by multiplying the rank allocated to each species by ten, and dividing this number by the sum of all species ranks. Zero was allocated to species which were not identified as preferred for fuelwood, brushwood or kraal posts. However, the actual ranking was not as important as the debate generated by the exercise, and the reasons given for the preference ranking of the species (Sithole 2004).

In addition, the core group was guided through a series of trend-line exercises (Chambers 1992) to identify key dates/time periods regarding species use and management for fuelwood, brushwood and kraal posts, respectively, track people's species use patterns and identify trends in the intensity of use of the preferred species over time. Two distinct periods were identified; between 1990 and 1995, leading up to South Africa's first democratic elections, and from 1995 until 2003 when fieldwork ended (i.e. post-elections). The former witnessed the abolition of the chief and headmen system, according to which natural resource management decisions had been made in the village for many years, while the latter was characterised by much confusion and uncertainty over the roles of traditional tribal authorities, local communities and government in natural resource management under the new system of governance (Manona 1992; Rhodes University et al 2000).

Cue cards of the preferred species were once again arranged in order of preference on the floor. The dates/time periods were then written on cue cards and placed in chronological order alongside the species names. The next step required the core group to allocate a number of stones to each preferred species, representing the

intensity of utilisation of that species for a particular period (i.e. where many stones represented high utilisation and few stones represented low utilisation). A total of 100 stones were allocated for the exercise, to be divided up between all preferred species over the two time periods, respectively (Scheepers 2001; Cundill 2005). Thus, the relative intensity of utilisation of the preferred species over time could be recorded. However, as no significant changes in the pattern of species use were observed over these periods, the data was pooled.

Ranking exercises and trend-lines were also conducted with 60 individual resource users from the village (i.e. 30 fuelwood users and 30 kraalwood users) during door-to-door visits to identify trends in the relative intensity of use of all species currently harvested for fuelwood, brushwood and kraal posts, respectively. These households were selected according to three criteria agreed upon by the researcher and key research informants from the core group. The criteria were:

- 1) The fuelwood/kraalwood users from the households possessed good local knowledge of the species they used for fuelwood, brushwood and kraal posts.
- 2) The households were located within close proximity of one or more of the landscapes used for the harvesting of fuelwood, brushwood and kraal post species.
- 3) The fuelwood/kraalwood users were willing to participate in the exercises.

During the third workshop, the core group was guided through a process of compiling a set of participatory resource maps depicting the density and harvesting areas for the preferred species for fuelwood, brushwood and kraal posts, respectively (International Institute for Environment and Development 1998; Cundill 2005). A set of resource density maps showed where the preferred species occurred within the various landscapes used for fuelwood and brushwood or kraal posts, historically (i.e. prior to Betterment Planning in the 1960s) and at present day (i.e. 2002-2003, when fieldwork was conducted), on 1:7500 digital Telkom images of the study area. A harvesting area map showed where the preferred species were currently harvested within the various fuelwood and brushwood landscapes or kraal post landscapes, as well as where taboo areas (e.g. sacred areas or areas associated with dangerous animals) were located within these landscapes.

However, to first familiarise the core group with the mapping process, they were asked to point out important landmarks or distinguishing features in the village. These features were then pointed out to the group on printouts of the images of the study area to illustrate how these maps could be used to navigate from place to place. Once comfortable with the process, the core group was asked to delineate the boundaries of the various landscapes used for fuelwood and brushwood and kraal posts, which were often associated with local stream channels, and bounded by local roads/footpaths. These boundaries were debated amongst the group members, and once consensus was reached, drawn in on the maps. Using a different coloured pen for each species, the core group then indicated on the resource maps, where the preferred species occurred within each landscape, historically and at present, and where resource users harvested them. In addition, on the resource density maps, the core group indicated areas of high, moderate and low densities of the preferred species using symbols (i.e. H=high, M=intermediate and L=low). For example, a high density area was characterised by a large number of trees or shrubs of a particular preferred species that occurred within short distances of each other. Conversely, a low density area was characterised by sparse vegetation and large distances between trees or shrubs of a particular species, with a moderate density area falling between these two categories. These maps were then, for verification purposes, compared to existing resource maps for the village, which were earlier compiled using free-hand mapping on A-zero sized newsprint (Rhodes University et al 2000).

Door-to-door, structured interviews (Mitchell 1997; Huntington 2000) were also conducted with a number of individual fuelwood and kraalwood users from Machibi. A total of 50 households were included in the survey; 25 for fuelwood and 25 for kraalwood (brushwood and kraal posts). However, two households were eventually excluded from the survey due to incomplete questionnaire forms. The households were selected on the same basis as those used for the ranking exercises and trend-lines with individual resource users. Consequently, these results are representative of a select group of people with specialised knowledge of fuelwood, brushwood and kraal post species rather than the community of Machibi as a whole. Each resource user was asked to list the species they preferred for fuelwood, brushwood and kraal posts, as well as those species that they currently used. They were also asked whether they

used any alternatives to the preferred species, and if so, why and at what cost/price to them.

### **6.2.2 Scientific methods**

The resource users included in the door-to-door questionnaire survey were asked whether they would be willing to let the research team accompany them on their next collection trip. Fourteen fuelwood users and 14 kraalwood users agreed, provided the exercise not take longer than two to three hours, as they would have to take time out from other daily activities to participate in the trip.

Once at their harvesting area, the resource user was asked to indicate where, and in which direction, he/she began searching for the species they used for fuelwood, brushwood or kraal posts. As the search continued, a number of G.P.S. points were then recorded at random distances along the path. A minimum of 30 points had to be recorded for short routes so as to ensure that the data was statistically viable (Sutherland 1996). For each G.P.S. recording, the distance from that point to the nearest tree or shrub was measured for fuelwood, brushwood and kraal post species, respectively. Using a variation of the point-quarter method for plotless sampling (Smith 1996), the density of the respective species across all harvesting areas and all landscapes was then determined separately for fuelwood, brushwood and kraal posts. It was also recorded whether the tree or shrub showed any signs of utilisation (e.g. chopped or cut but not 'broken off' branches in the case of fuelwood and brushwood or chopped stems, with or without the presence of coppicing, in the case of kraal posts).

### **6.2.3 Analysis of participatory data**

The participatory maps were digitised on to 1:7500 digital, Telkom images of the village using the geographical information system (G.I.S.), ArcView version 3.5, which is marketed by ESRI. This process was undertaken using the on-screen digitising function of ArcView in order to facilitate the comparison of multiple data layers (e.g. a comparison of the historical and current density maps).

As done for the ranking exercise data for the core group, the species for fuelwood, brushwood and kraal posts, respectively, were ranked in order of preference by

counting the number of resource users out of the total that were interviewed (24 for fuelwood, 24 for kraalwood), which stated that they preferred the respective species. Similarly, the species were ranked in order of their relative intensity of use for fuelwood, brushwood and kraal posts, as measured by the number of stones allocated to each species during the trend-line exercises with individual resource users. In each case, the respective species were allocated a rank out of ten for all species for fuelwood, brushwood and kraal posts, respectively.

The interview data was condensed in the form of:

- 1) Bar charts of the number of resource users that stated they preferred the respective species for fuelwood, brushwood and kraal posts,
- 2) Bar charts of the number of resource users that used alternatives to the preferred species, and
- 3) Tables of the annual cost of these alternatives to the local people.

#### **6.2.4 Analysis of vegetation surveys**

The density of the respective species for fuelwood, brushwood and kraal posts was calculated using the same formulae as for landscapes (see chapter five, section 5.2.4):

$$X_i = 1/(2D)^2,$$

Subject to:  $D = \Sigma d/s$

However,  $X_i$  represented the total density of a particular species for fuelwood, brushwood or kraal posts for all points across all harvesting areas (and all landscapes),  $D$  was the mean point-to-tree distance for all points,  $d$  was the distance to the nearest individual for all points, and  $s$  represented the total number of sampling points.

Furthermore, as it was assumed that resource restrictions influenced the resource user's species choices, utilisation/availability ratios (Neu et al 1974; Shackleton 1993) were calculated for the respective fuelwood, brushwood and kraal post species to determine whether they were used in greater or smaller proportion to their availability (i.e. whether they were actively selected or avoided). Utilisation/availability ratios equal to zero indicated that the species was neither actively selected nor avoided.

For example, the utilisation/availability ratios for the respective fuelwood species were determined using the following formulae (Neu et al 1974; Shackleton 1993; Pote et al 2006):

$$UI_{sp1} = U_{sp1}/A_{sp1}$$

Where:

$U_{sp1}$  = number of trees of that particular species utilised for fuelwood across all harvesting areas, across all landscapes ( $Nu_1$ )/total number of utilised trees of all fuelwood species across all harvesting areas, across all landscapes ( $Nu_{tot}$ ), and

$A_{sp1}$  = number of trees of that particular fuelwood species counted for all sampling points across all harvesting areas and landscapes ( $Na_1$ )/total number of fuelwood trees of all species counted for all sampling points across all harvesting areas and landscapes ( $Na_{tot}$ ). This included both utilised and unutilised trees of the fuelwood species.

The same process was used to determine the utilisation/availability ratios for the respective brushwood and kraal post species.

The respective species for fuelwood, brushwood and kraal posts were then also ranked out of ten, according to their relative intensity of use, as indicated by their utilisation/availability ratios.

### **6.2.5 Statistical analysis**

All statistical analyses were performed using the statistical software package, STATISTICA, marketed by StatSoft Incorporated (1999). Spearman's rank order correlations were conducted to compare people's perceptions of the intensity of use of the respective preferred species for fuelwood, brushwood and kraal posts, taking into account resource restrictions, and as indicated by the number of stones allocated to each species during the trend-line exercises with individual resource users, to their actual intensity of use, as indicated by the utilisation/availability ratios. In addition, regression analyses were performed to determine whether species density influenced people's patterns of use, subject to the assumptions of normality, equality of variance and auto-correlation (see chapter five, section 5.2.5).

## **6.3 Results**

### **6.3.1a Species preferred for fuelwood**

The core group identified the preferred fuelwood species as *Acacia karroo*, followed by *Scutia myrtina*, *Acacia caffra*, *Eucalyptus grandis*, *Acacia mearnsii* and *Gymnosporia arenicola*. These species preferences were then confirmed during interviews with individual users (n=24), with the exception of *Diospyros lycioides*, which was stated as an additional species preferred for fuelwood (Figure 6.1). The reasons for people's preference of *A. karroo* over other species included that a) this species was considered environmentally detrimental to the grazing areas, b) there was too much of it in the landscapes, c) that it produced the longest lasting coals and d) that the resource users did not have to walk far from their homes in order to harvest it.

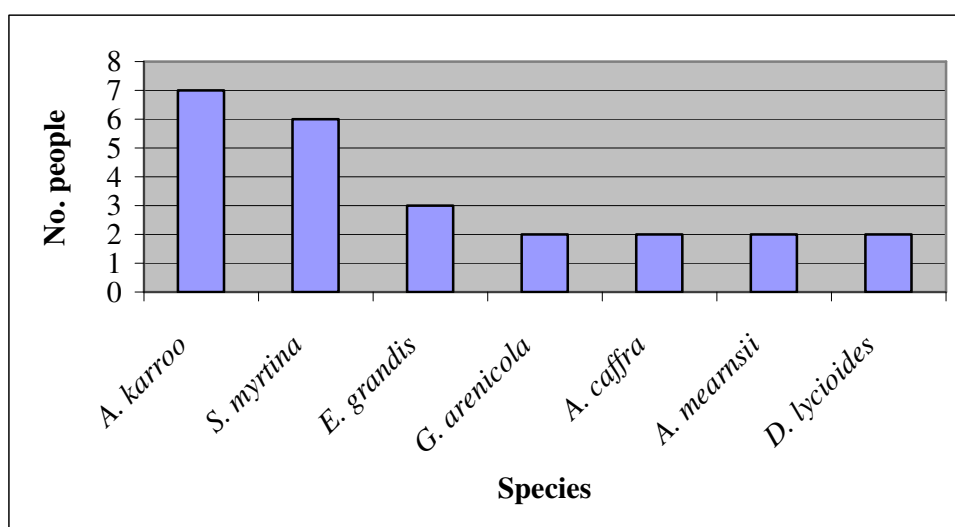


Figure 6.1: Number of people who stated that they preferred the respective fuelwood species during door-to-door interviews (n=24)

### **6.3.1b Intensity of use of the preferred fuelwood species, as perceived by the local people**

*A. karroo* was perceived by the core group as the most intensively used species for fuelwood, followed by *S. myrtina*, *A. caffra*, *E. grandis*, *A. mearnsii* and *G. arenicola*. With the exception of *A. mearnsii*, which was not identified as currently used for fuelwood by individual resource users, the high intensity of use of these species was then confirmed during ranking exercises with individual fuelwood users (n=30). However, a wide variety of species other than the stated preferred species was also used for fuelwood over the period from 1990 to 2003 (Table 6.1).

Table 6.1: Number of stones allocated to each fuelwood species that represented their intensity of use over the period from 1990 to 2003, as perceived by the local people (n=30)

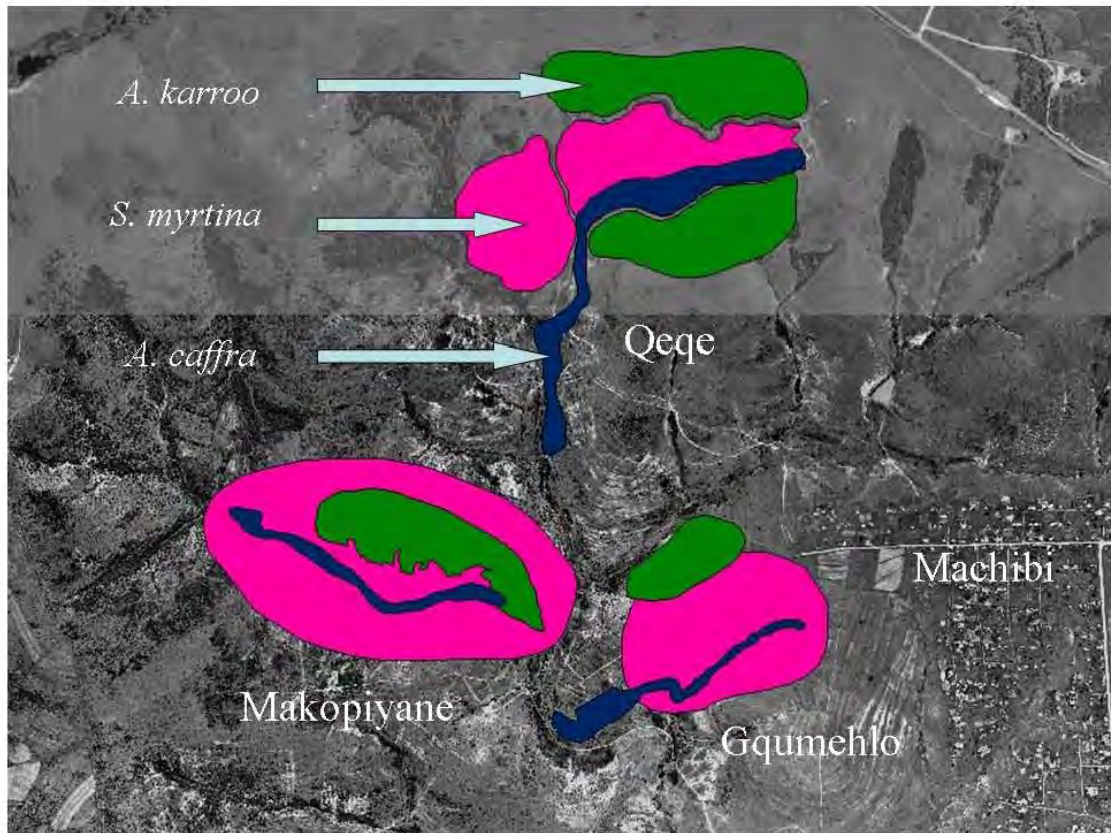
Species	Total	Maximum	Minimum	Mean	Standard error
<i>A. karroo</i>	2551	92	10	43	2.5
<i>S. myrtina</i>	832	37	1	16	1.0
<i>D. lycioides</i>	609	46	3	12	1.1
<i>G. arenicola</i>	406	42	3	11	1.0
<i>A. caffra</i>	397	28	4	11	0.9
<i>Sideroxylon inerme</i>	247	16	2	8	0.7
<i>Ptaeroxylon obliquum</i>	234	32	2	8	1.4
<i>Podocarpus falcatus</i>	181	12	2	6	0.5
<i>E. grandis</i>	177	100	7	30	14.3
<i>Olea europaea subsp. africana</i>	172	70	10	43	15.8
<i>Ficus natalensis</i>	128	9	2	5	0.4
<i>Schotia latifolia</i>	43	26	17	22	4.5
<i>Buddleja salviifolia</i>	23	12	11	12	0.5

### **6.3.1c Abundance of the preferred fuelwood species, as perceived by the local people**

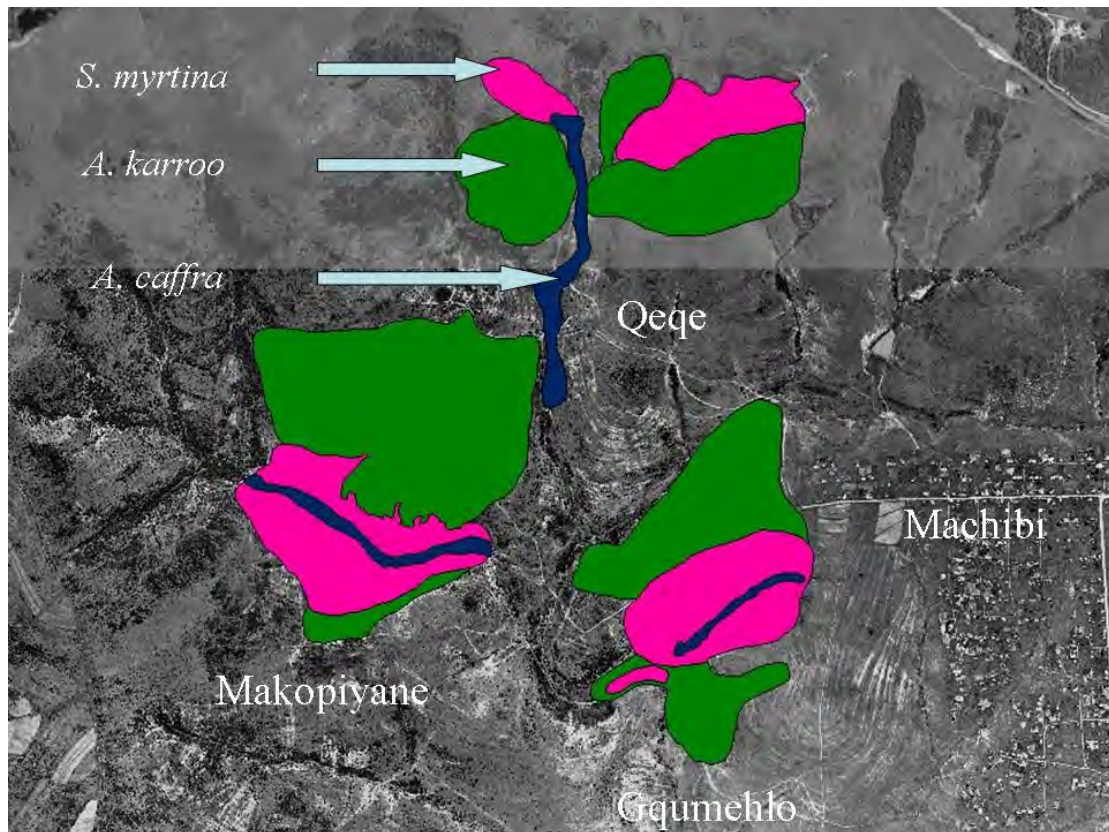
The local users perceived an increase in the abundance of fast-growing, spiny species such as *A. karroo* and *S. myrtina* across all fuelwood and brushwood landscapes (e.g. Qeqe, Makopiyane and Gqumehlo) over the period from 1960 until 2003. However, the same trend was not observed for all preferred species, as the local users perceived a decline in the abundance of *A. caffra* during this period (Figure 6.2).

However, as these changes in species abundance have gradually occurred over the period from 1960 to 2003, the local people do not seem to make the link between increasing degradation of the community woodlands, associated with the removal of

the tall, woody component from the vegetation, opening it up to fast-growing, opportunistic species and increasing grass cover, and possibly more frequent fires.



a)



b)

Figure 6.2: Showing an increase in the abundance of *A. karroo* and *S. myrtina*, and decline in *A. caffra*, within the fuelwood landscapes, Qeqe, Makopiyane and Gqumehlo, over the period from 1960 (a) until 2003 (b), according to resource users (where pink=*S. myrtina*, green=*A. karroo* and dark blue= *A. caffra*)

### 6.3.1d Species actively selected for fuelwood

*A. caffra*, *A. karroo* and *A. mearnsii* exhibited utilisation/availability ratios of greater than one, and were thus, actively selected by the local people for fuelwood (Table 6.2). However, *E. grandis*, *G. arenicola*, *D. lycioides* and *S. myrtina* constituted avoided species as they exhibited utilisation/availability ratios of less than one. A comparison of people's perceptions of the intensity of use of the preferred species versus their actual intensity of use, as indicated by their utilisation/availability ratios, showed no significant correlation (Spearman's rank order correlation;  $n=7$ ;  $R=-0.29$ ;  $P=0.49$ ).

Table 6.2: Species actively selected by the local people for fuelwood

Species	Stated preference ranking <sup>a</sup>	Intensity of use ranking <sup>b</sup>	Density (trees/Ha) <sup>c</sup>	Utilisation/availability ratios <sup>d</sup>				
				Nu <sub>1</sub>	U <sub>sp1</sub>	Na <sub>1</sub>	A <sub>sp1</sub>	UI
<i>A. karroo</i>	3.1	2.9	138	138	0.43	362	0.29	1.48
<i>S. myrtina</i>	2.3	2.4	61	59	0.18	332	0.27	0.69
<i>A. caffra</i>	0.8	1.0	20	26	0.08	61	0.05	1.65
<i>E. grandis</i>	1.5	0.5	37	6	0.02	30	0.02	0.78
<i>A. mearnsii</i>	0.8	0.0	40	17	0.05	60	0.05	1.10
<i>G. arenicola</i>	0.8	1.4	34	22	0.07	121	0.10	0.71
<i>D. lycioides</i>	0.8	1.9	84	51	0.16	272	0.22	0.73

a) The preferred species, as indicated by the number of resource users that stated they preferred the respective species.

The highest rank represented the most preferred species and the lowest rank represented the least preferred species (n=24)

b) Intensity of use of the species, as indicated by the number of stones allocated to each species by the individual resource users. The highest rank represented the most intensively used species and the lowest rank represented the least intensively used species. Zero denoted the species which were not used (n=30)

c) Density of the respective species across all harvesting areas, across all landscapes. However, where density could not be calculated for a species, n/a represented not applicable (n=14)

d) Utilisation/availability ratios for the species, where a ratio of greater than one indicated that the species was actively selected while a ratio of less than one indicated that the species was avoided. However, where utilisation/availability ratios could not be calculated for the species, n/a represented not applicable (n=14)

### 6.3.1e Commercial alternatives

Seventy five percent of the fuelwood users (i.e. 18 out of 24) used commercial alternatives such as paraffin and electricity in addition to fuelwood for cooking and heating purposes (Figure 6.3). Reasons cited for the use of these alternatives included a) wet weather that resulted in fuelwood that would not burn, b) paraffin and electric stoves cooked food faster than fuelwood fires and c) they functioned as a safety net if there was no fuelwood to be harvested.

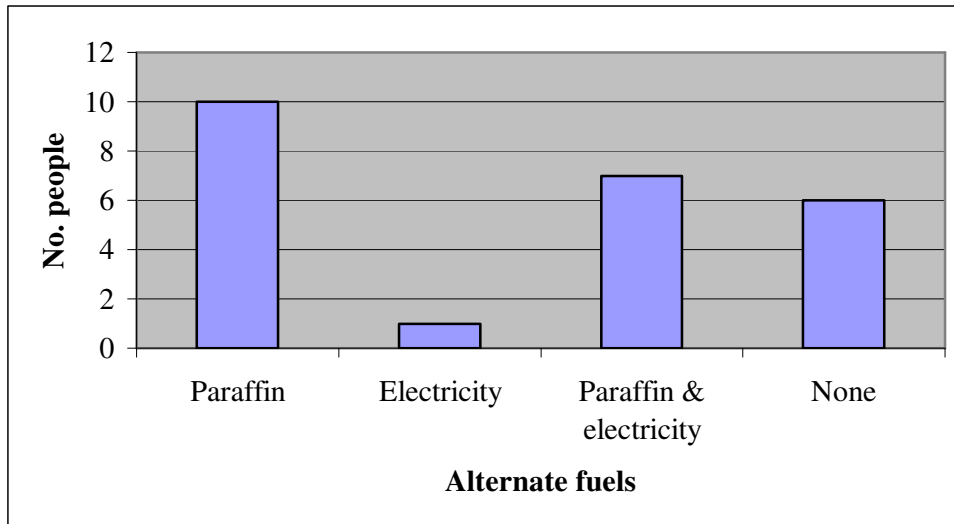


Figure 6.3: Number of people who used commercial alternatives in addition to the preferred fuelwood species (n=24)

The average annual cost of paraffin per household was R350±77. This price accounted for an average volume of 107±21 litres per household per annum. However, there was a wide range in the amounts paid for paraffin by different households in Machibi (Table 6.3). The average annual cost of electricity per household was R360±87 but there was also wide variation between households.

Table 6.3: The annual cost per household for the use of alternatives (n=18)

Alternatives	Average annual cost (S.A. Rand)	Maximum (S.A. Rand)	Minimum (S.A. Rand)	Standard error
Paraffin	350	1050	72	77
Electricity	360	600	120	87

### 6.3.2a Species preferred for brushwood

The core group identified *Coddia rudis* as the most preferred species for brushwood, followed by *S. myrtina*. They stated that these species were preferred for a) their durability, b) robust and sharp branches, c) the presence of thorns in the case of *S. myrtina* which served as a deterrent to livestock wanting to escape the kraal, and d) were traditionally used for brushwood for generations.

Interviews with individual users (n=24) confirmed people's relative preferences for these species. However, *A. karroo*, *O. africana* and *G. arenicola* were also stated as preferred brushwood species (Figure 6.4).

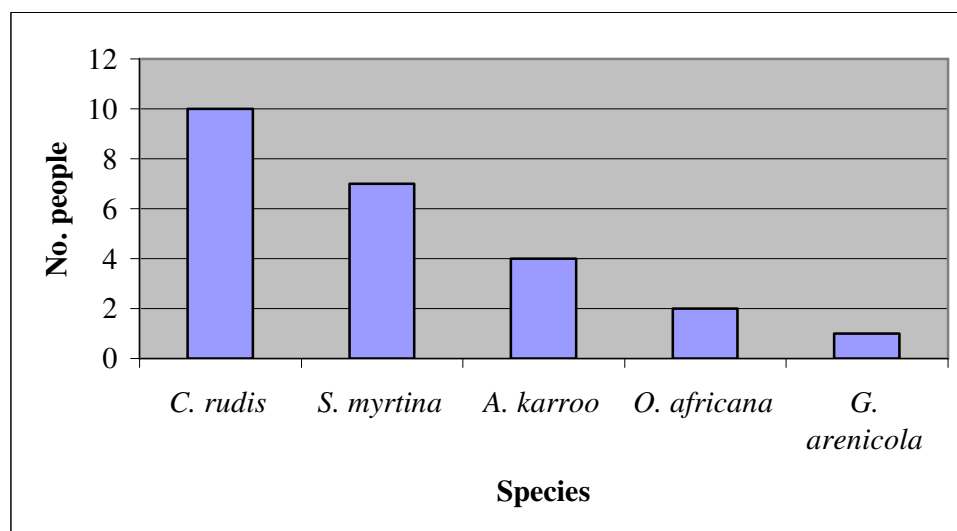


Figure 6.4: Number of people who stated that they preferred the respective brushwood species during door-to-door interviews (n=24)

### 6.3.2b Intensity of use of the preferred brushwood species, as perceived by the local people

*C. rudis* was perceived by the core group as the most intensively used species for brushwood, followed by *S. myrtina*. The high intensity of use of these species was then confirmed during ranking exercises with individual kraalwood users (n=30). However, a wide variety of brushwood species was used over the period from 1990 to 2003, including *A. karroo* (ranked third in Table 6.4), *O. africana* (ranked fourth in Table 6.4) and *G. arenicola* (ranked ninth in Table 6.4).

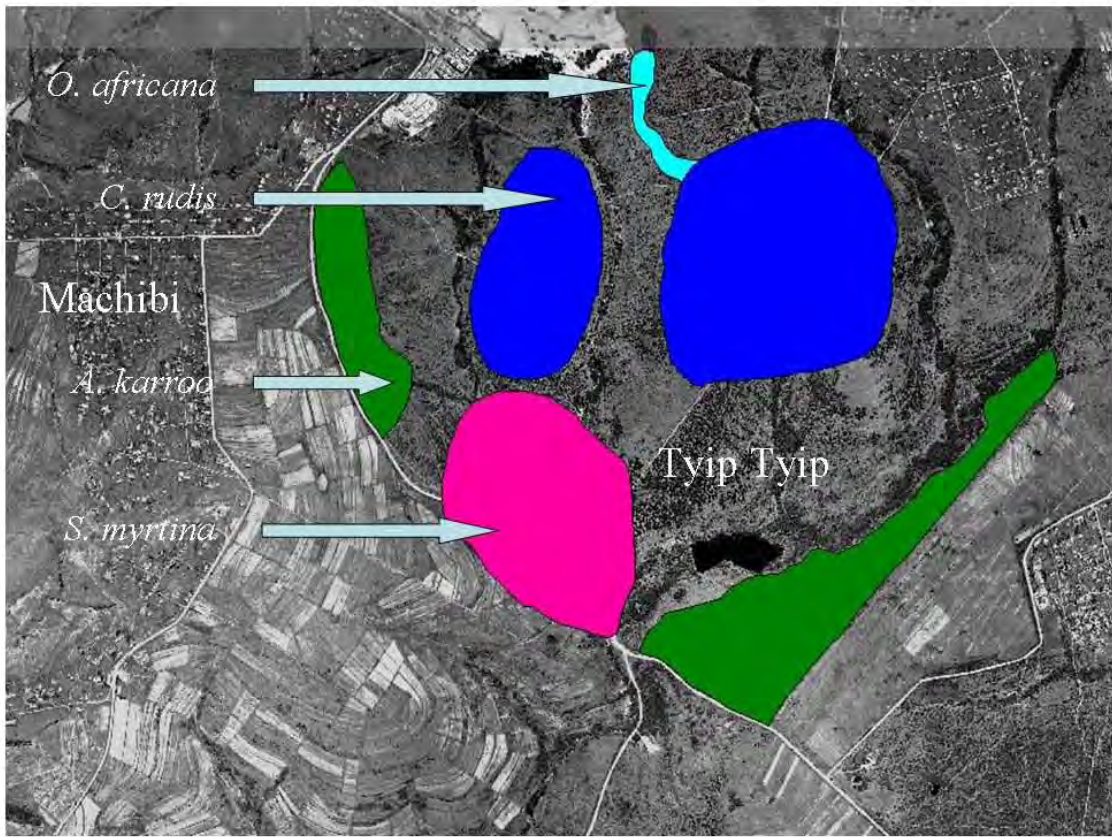
Table 6.4: Number of stones allocated to each brushwood species that represented their intensity of use over the period from 1990 to 2003, as perceived by the local people (n=30)

Species	Total	Maximum	Minimum	Mean	Standard error
<i>C. rudis</i>	2565	100	15	44	2.9
<i>S. myrtina</i>	1597	70	4	30	2.3
<i>A. karroo</i>	695	61	4	25	3.4

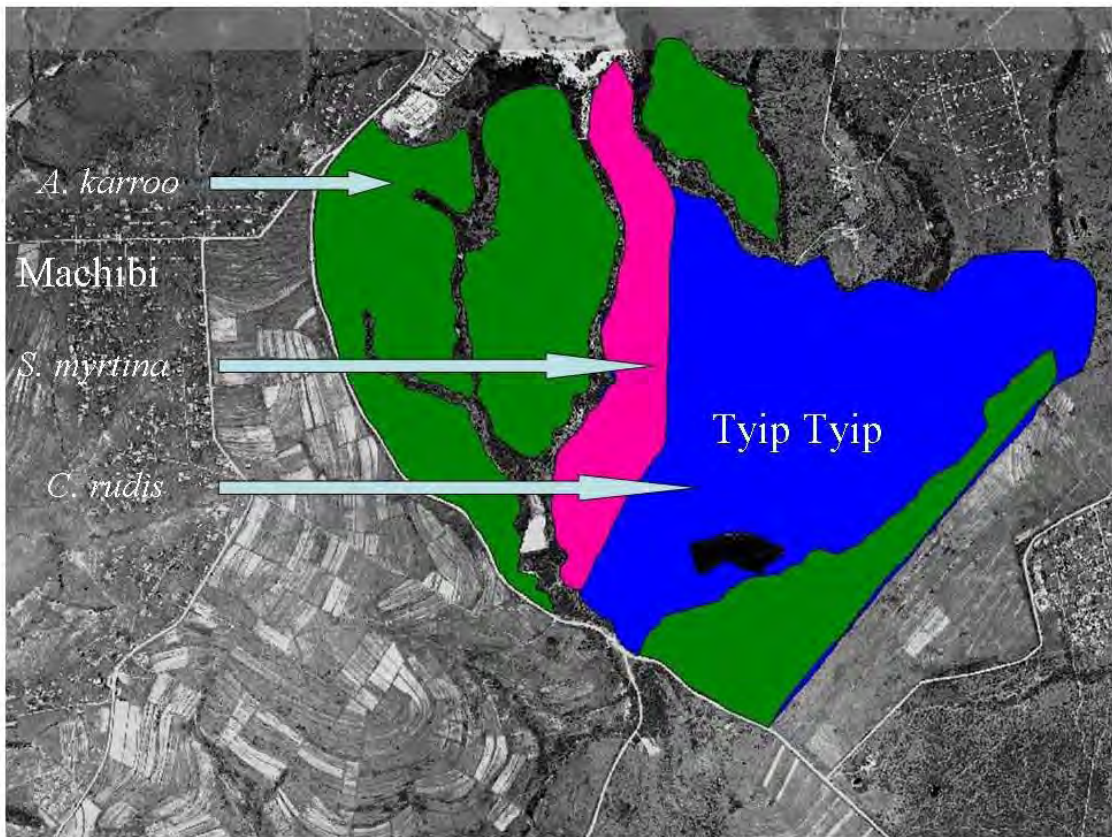
<i>O. africana</i>	537	67	4	19	2.5
<i>A. caffra</i>	127	40	7	16	3.7
<i>Rhus lucida</i>	113	39	10	28	6.5
<i>D. lycioides</i>	97	19	2	11	1.8
<i>P. obliquum</i>	67	21	13	17	1.8
<i>G. arenicola</i>	48	12	4	8	1.5
<i>Rhus incisa</i> var. <i>effuse</i>	45	24	4	11	4.8
<i>Ehretia rigida</i>	34	25	9	17	8.0
<i>Cassine</i> <i>aethiopica</i>	23	17	6	12	5.5
<i>Zanthoxylum</i> <i>capense</i>	22	13	9	11	2.0
<i>S. inerme</i>	18	10	8	9	1.0
<i>P. falcatus</i>	6	3	3	3	0.0
<i>F. natalensis</i>	6	3	3	3	0.0

### 6.3.2c Abundance of the preferred brushwood species, as perceived by the local people

The local people perceived an increase in the abundance of fast-growing, spiny species such as *C. rudis* and *S. myrtina* across all fuelwood and brushwood landscapes (e.g. Tyip Tyip) over the period from 1960 until 2003 (Figure 6.5). In contrast, there was a perceived decline in the abundance of slow-growing, smooth species such as *O. africana*, which was stated by local users (n=24) as preferred for brushwood.



a)



b)

Figure 6.5: Showing an increase in the abundance of *C. rudis* and *S. myrtina*, and decline in *O. africana* within the brushwood landscapes such as Tyip Tyip, over the period from 1960 (a) until 2003 (b), according to resource users (where blue=*C. rudis*, pink=*S. myrtina*, green=*A. karroo* and light blue=*O. africana*)

### 6.3.2d Species actively selected for brushwood

*O. africana*, *G. arenicola* and *S. myrtina* were actively selected for brushwood while *A. karroo* and *C. rudis* were avoided species (Table 6.5). A comparison of people's perceptions of the intensity of use of the preferred species versus their actual intensity of use, as indicated by their utilisation/availability ratios, showed no significant correlation (Spearman's rank order correlation;  $n=5$ ;  $R=-0.80$ ;  $P=0.13$ ).

Table 6.5: Species actively selected by the local people for brushwood

Species	Stated preference ranking <sup>a</sup>	Intensity of use ranking <sup>b</sup>	Density (trees/Ha) <sup>c</sup>	Utilisation/availability ratios <sup>d</sup>				
				Nu <sub>1</sub>	U <sub>sp1</sub>	Na <sub>1</sub>	A <sub>sp1</sub>	UI
<i>C. rudis</i>	3.3	3.3	109	44	0.28	454	0.43	0.66
<i>S. myrtina</i>	2.7	2.7	70	70	0.45	393	0.37	1.21
<i>A. karroo</i>	2.0	2.0	79	12	0.08	93	0.09	0.88
<i>O. africana</i>	1.3	1.3	51	24	0.15	90	0.08	1.81
<i>G. arenicola</i>	0.7	0.7	33	6	0.04	30	0.03	1.36

a) The preferred species, as indicated by the number of resource users that stated they preferred the respective species.

The highest rank represented the most preferred species and the lowest rank represented the least preferred species (n=24)

b) Intensity of use of the species, as indicated by the number of stones allocated to each species by the individual resource users. The highest rank represented the most intensively used species and the lowest rank represented the least intensively used species. Zero denoted the species which were not used (n=30)

c) Density of the respective species across all harvesting areas, across all landscapes. However, where density could not be calculated for a species, n/a represented not applicable (n=14)

d) Utilisation/availability ratios for the species, where a ratio of greater than one indicated that the species was actively selected while a ratio of less than one indicated that the species was avoided. However, where utilisation/availability ratios could not be calculated for the species, n/a represented not applicable (n=14)

### 6.3.2e Commercial alternatives

Twenty one percent of the local users (i.e. 5 out of 24) purchased wagonloads of brushwood from sellers in the village rather than harvest their own brushwood. The average annual cost per household for brushwood was R264±90 but there was wide variation between households (Table 6.6). This accounted for an average of two wagonloads of brushwood per household per annum.

Table 6.6: Annual cost per household of brushwood

	Total	Maximum	Minimum	Mean	Standard error
Number of wagonloads	12	6	1	2	0.9
Cost (S.A. Rand)	1320	600	120	264	90

### 6.3.3a Species preferred for kraal posts

The core group identified *Ptaeroxylon obliquum*, *O. africana*, *A. caffra* and *Schotia latifolia* as equally preferred for kraal posts. They stated that these species were preferred for a) their durability and b) termite-resistant properties in the case of *P. obliquum*. *O. africana* and *P. obliquum* also had significant cultural value as the branches of these species were used to plate the meat during traditional feasts and rituals centred on the kraal.

Interviews with individual users (n=24) also identified the same four species as preferred for kraal posts (Figure 6.6). However, only 58 percent (n=14) of the local users harvested kraal post species. The local users also explained that because the preferred species (i.e. *P. obliquum*, *O. africana*, *A. caffra* and *S. latifolia*) had become increasingly scarce due to their over-utilisation, they were forced to use *S. inerme*, *E. grandis* and *A. mearnsii*. Consequently, these species were also stated as preferred for kraal posts (Figure 6.6). The remaining 42 percent of the local users explained that they had not replaced old posts in their kraals because of this scarcity.

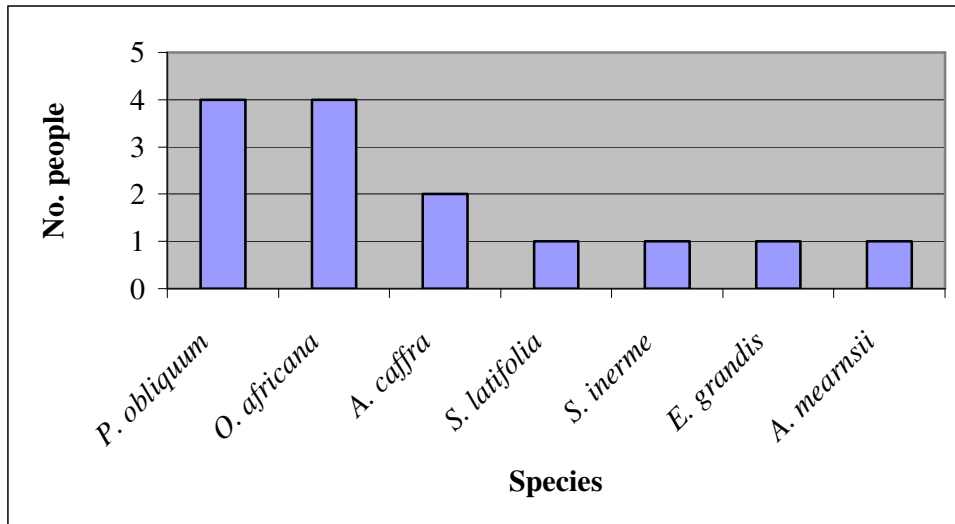


Figure 6.6: Number of people who stated that they preferred the respective kraal post species during door-to-door interviews (n=14)

### 6.3.3b Intensity of use of the preferred kraal post species, as perceived by the local people

The core group perceived *P. obliquum* and *O. africana* as equally the most intensively used species for kraal posts, followed by *A. caffra*. However, although *S. latifolia* was identified as preferred for kraal posts, this species was not perceived as used by individual resource users. A range of other species, including *E. grandis* and *S. inerme*, was also perceived as currently used for kraal posts (Table 6.7).

Table 6.7: Number of stones allocated to each kraal post species that represented their intensity of use over the period from 1990 to 2003, as perceived by the local people (n=30)

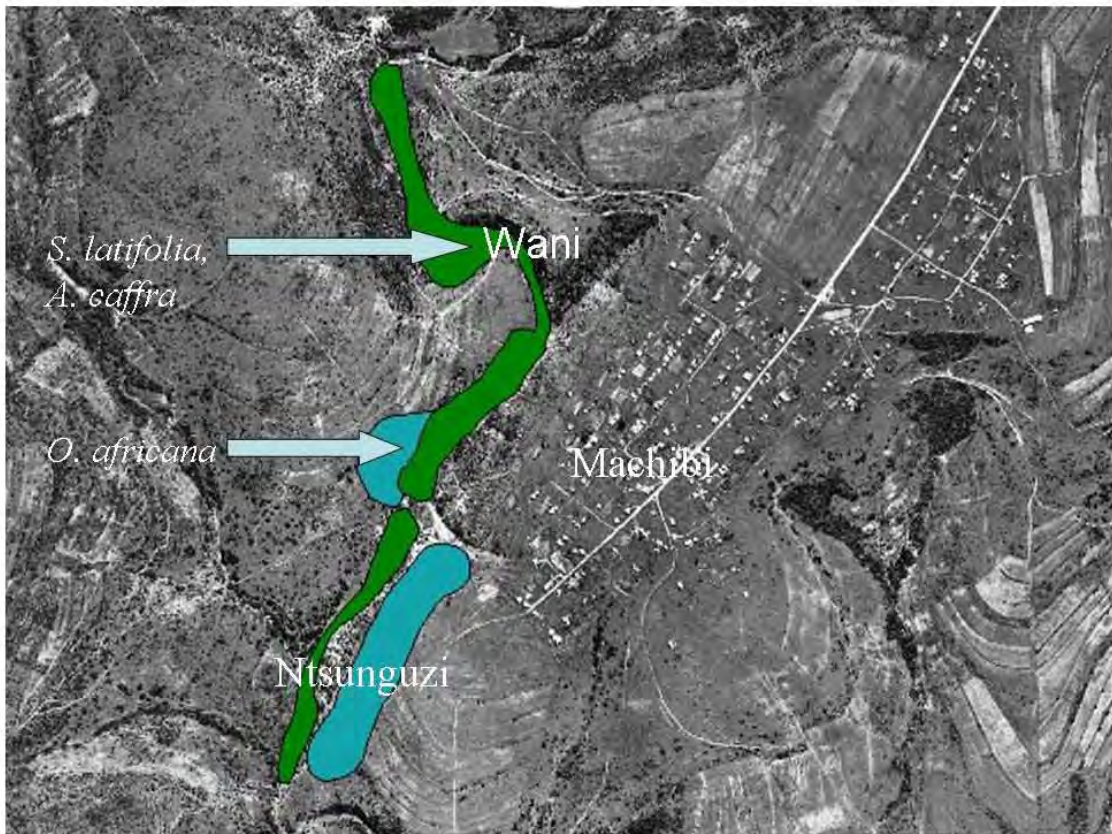
Species	Total	Maximum	Minimum	Mean	Standard error
<i>P. obliquum</i>	2303	100	14	44	2.4
<i>O. africana</i>	2207	80	15	43	2.5
<i>E. grandis</i>	415	100	1	32	8.1
<i>S. inerme</i>	301	76	22	50	10.1
<i>A. caffra</i>	144	32	20	24	2.3
<i>Combretum erythrophyllum</i>	110	34	24	28	2.2

<i>R. lucida</i>	100	50	50	50	0.0
<i>D. lycioides</i>	90	20	5	15	3.2
<i>Salix capensis</i>	49	26	23	25	1.5
<i>Z. capense</i>	39	11	8	10	0.6
<i>A. mearnsii</i>	38	19	19	19	0.0
<i>F. natalensis</i>	36	36	36	36	0.0
<i>B. salviifolia</i>	32	17	15	16	1.0
<i>Hippobromus pauciflorus</i>	20	10	10	10	0.0
<i>Olea woodiana</i>	8	5	3	4	1.0
<i>Apodytes dimidiata</i>	8	4	4	4	0.0

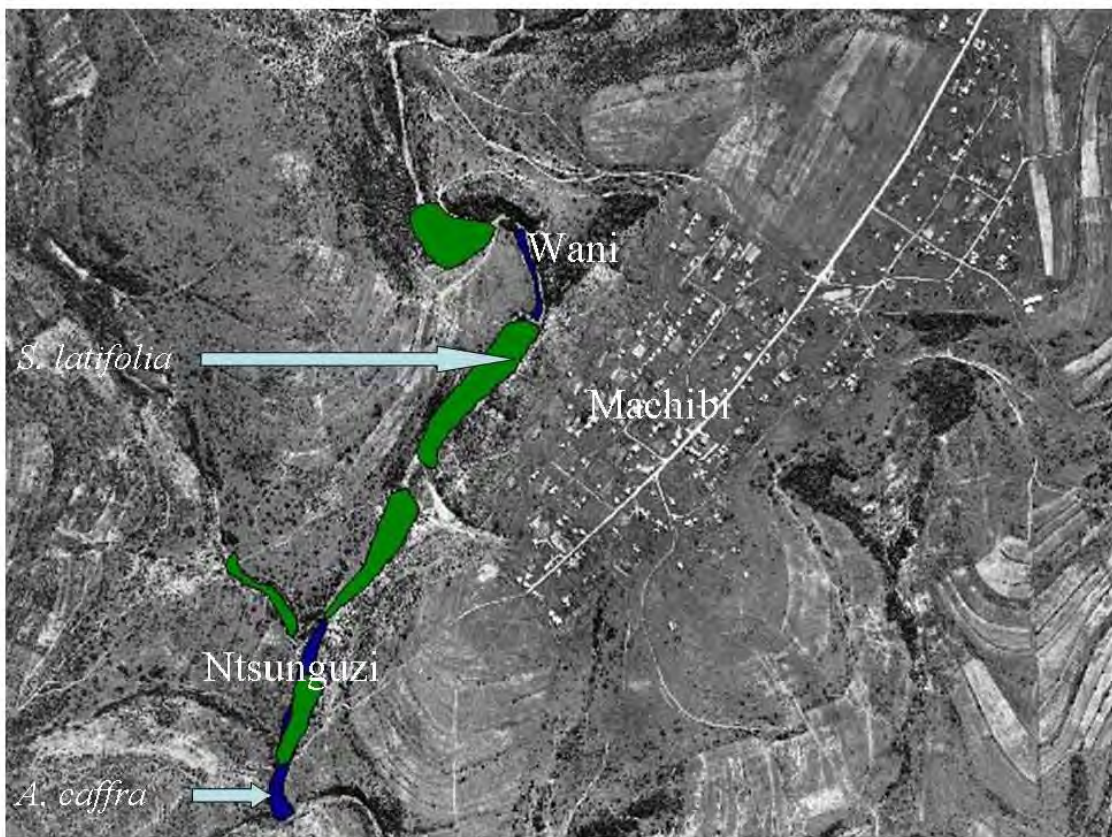
### 6.3.3c Abundance of the preferred kraal post species, as perceived by the local people

The local people perceived a decline in the abundance of the preferred species such as *A. caffra*, *S. latifolia* and *O. africana* across all kraal post landscapes (e.g. Wani and Ntsunguzi) over the period from 1960 and 2003 (Figure 6.7). *P. obliquum* had not historically occurred within Wani and Ntsunguzi. However, a decline in the abundance of this species was also noted in kraal post landscapes such as Tyip Tyip.

The decline in abundance was attributed to the over-utilisation of the preferred species. And although certain species such as *P. obliquum* have been known to produce coppice shoots when cut, there was little sign of coppicing at Machibi.



a)



b)

Figure 6.7: Showing a decline in the abundance of the preferred species for kraal posts within the landscapes, Wani and Ntsunguzi, over the period from 1960 (a) until 2003 (b), according to resource users (where green=*S. latifolia*, light blue=*O. africana* and dark blue=*A. caffra*)

### 6.3.3d Species actively selected for kraal posts

*A. caffra* and *P. obliquum* were actively selected by the local people for kraal posts while *O. africana*, *S. inerme* and *E. grandis* were avoided (Table 6.8). Utilisation/availability ratios for *S. latifolia* and *A. mearnsii* could not be calculated as none of the local users accompanied on collection trips harvested these species. A comparison of people's perceptions of the intensity of use of the preferred species versus their actual intensity of use, as indicated by their utilisation/availability ratios, showed no significant correlation (Spearman's rank order correlation;  $n=5$ ;  $R=-0.10$ ;  $P=0.95$ ).

Table 6.8: Species actively selected by the local people for kraal posts

Species	Stated preference ranking <sup>a</sup>	Intensity of use ranking <sup>b</sup>	Density (trees/Ha) <sup>c</sup>	Utilisation/availability ratios <sup>d</sup>				
				Nu <sub>1</sub>	U <sub>sp1</sub>	Na <sub>1</sub>	A <sub>sp1</sub>	UI
<i>A. caffra</i>	1.7	1.0	20.0	26	0.35	61	0.25	1.38
<i>P. obliquum</i>	2.5	2.9	10.0	11	0.15	29	0.12	1.23
<i>O. africana</i>	2.5	2.4	51.0	24	0.32	90	0.38	0.86
<i>S. latifolia</i>	0.8	0.0	n/a	n/a	n/a	n/a	n/a	n/a
<i>S. inerme</i>	0.8	1.4	61.0	7	0.09	30	0.13	0.76
<i>E. grandis</i>	0.8	1.9	191.0	6	0.08	30	0.13	0.65
<i>A. mearnsii</i>	0.8	0.5	n/a	n/a	n/a	n/a	n/a	n/a

a) The preferred species, as indicated by the number of resource users that stated they preferred the respective species.

The highest rank represented the most preferred species and the lowest rank represented the least preferred species (n=24)

b) Intensity of use of the species, as indicated by the number of stones allocated to each species by the individual resource users. The highest rank represented the most intensively used species and the lowest rank represented the least intensively used species. Zero denoted the species which were not used (n=30)

- c) Density of the respective species across all harvesting areas, across all landscapes. However, where density could not be calculated for a species, n/a represented not applicable (n=5)
- d) Utilisation/availability ratios for the species, where a ratio of greater than one indicated that the species was actively selected while a ratio of less than one indicated that the species was avoided. However, where utilisation/availability ratios could not be calculated for the species, n/a represented not applicable (n=5)

### 6.3.3e Commercial alternatives

Only one of the local users stated that he purchased *E. grandis* posts from Mount Coke for approximately R 5 per post. This amounted to R 130 per annum for the 24 posts needed to reinforce an average size kraal.

### 6.3.4 Influence of density on people's species use patterns

There was no correlation between people's active selection of a particular species and its density across all harvesting areas, across all landscapes. This relationship was documented for fuelwood, brushwood and kraal post species, respectively (Table 6.9).

Table 6.9: Relationships between the utilisation/availability ratios for fuelwood, brushwood and kraal post species, and their densities across all harvesting areas, across all landscapes

Resource	Dependent variable	Independent variable	F	df	P	R <sup>2</sup>
Fuelwood species	Utilisation/availability ratios	Density	0.13	1,6	0.73	0.02
Brushwood species	Utilisation/availability ratios	Density	5.79	1,4	0.10	0.66
Kraal post species	Utilisation/availability ratios	Density	4.52	1,4	0.12	0.60

## 6.4 Discussion

### 6.4.1 Differences between people's stated preferences and the species they actively selected for fuelwood, brushwood and kraal posts

*A. caffra*, *A. karroo* and *A. mearnsii* were stated as preferred species (Figure 6.1), and were used in greater proportion to their availability (Table 6.2). Supported by

previous studies such as Bembridge and Tarlton (1990), Abbot et al (1997) and Pote et al (2006), the reasons included that hardwood species like *acacia* species produced the longest lasting coals, and yielded more heat and less smoke than other species.

In addition, the local users stated that *A. mearnsii* was actively selected for fuelwood because of its ease of collection (Bembridge and Tarlton 1990). This exotic species only occurred within Mount Coke, where it had been originally grown for commercial use but was now removed by forestry officials as part of the Department of Water Affairs and Forestry's programme to eradicate alien species from South Africa's indigenous forests. Consequently, local communities were permitted to collect bundles of pre-cut and dried wood of this species from the state forest.

However, the preferred species were not always actively selected by the local users. For example, *S. myrtina* was identified as an avoided species (Table 6.2) despite its characteristics as a hardwood species that produced good quality coals (Bembridge and Tarlton 1990; Pote et al 2006). This could be explained as this species was so abundant that it was sampled at too fine a scale to accurately determine its utilisation/availability ratio (Shackleton et al 1994).

On the other hand, softwood species such as *E. grandis*, *D. lycioides* and *G. arenicola* were avoided because they produced poor quality coals (Shackleton et al 2004). It was possible that the core group and individual local users identified these species, which were currently used for fuelwood, as preferred species due to a failure in their understanding of a 'preference' as defined in the context of this study, and caused by the language barrier between the researchers and local users.

For brushwood, *S. myrtina*, *O. africana* and *G. arenicola* were identified as preferred species (Figure 6.4) and actively selected by the local users (Table 6.5). Supported by Scheepers (2001) and Pote et al (2006), these species were selected because of their durability, robust and strong branches, as well as the presence of sharp thorns in the case of *S. myrtina* and *G. arenicola*, which served as a deterrent to cattle trying to flee the kraal.

In addition, *O. africana* was of cultural significance in the kraal. Local users stated that branches from this species were used as plates to hold the meat after a cow or goat was slaughtered during a ritual feast in honour of their ancestors (Che and Lent 2004). These rituals were centred on the kraal as this was where the slaughtering of the animal took place.

In contrast, although *C. rudis* and *A. karroo* were stated as preferred brushwood species (Figure 6.4), they were not actively selected (Table 6.5). However, this was explained as these species were characterised by durable, robust and strong branches and/or the presence of thorns, in the case of *A. karroo*, which made navigating the vegetation more difficult for the local users at the high densities at which these species occurred across all fuelwood and brushwood landscapes, relative to *S. myrtina*, *O. africana* and *G. arenicola*.

*P. obliquum*, *O. africana*, *A. caffra* and *S. latifolia* were stated as preferred for kraal posts (Figure 6.6). However, only *P. obliquum* and *A. caffra* were actively selected (Table 6.8) for their durability and termite-resistant properties, as well as cultural value in the case of *P. obliquum* (Van Eck et al 1997; Ham and Theron 2001; Shackleton et al 2004; Pote et al 2006). Supported by Scheepers (2004), local users stated that *S. latifolia* was not actively selected because this species had become so scarce within the kraal post landscapes due to its over-utilisation (Figure 6.7). On the other hand, *O. africana* was more abundant than expected due to people's illegal harvesting of this species from Rodi Farm, which occurred on neighbouring community land. Hence, it was possible that this species was so abundant that it was sampled at too fine a scale to accurately record its utilisation/availability ratio. Consistent with this finding, Scheepers (2004) showed that *O. africana* was the second most abundant species in the kraals, after *E. grandis*.

However, the local users explained that *E. grandis*, as well as *S. inerme* and *A. mearnsii*, were only used to supplement their supply of the preferred species (i.e. *P. obliquum*, *O. africana*, *A. caffra* and *S. latifolia*), which had become increasingly scarce across all kraal post landscapes due to their over-utilisation. As was the case for fuelwood species, the core group and individual local users had mistakenly

identified *E. grandis*, *S. inerme* and *A. mearnsii*, which were currently used for kraal posts (Table 6.7), as preferred species.

In addition, utilisation/availability ratios for *E. grandis* and *S. inerme* showed that these species exhibited little signs of utilisation, relative to their availability across all kraal post landscapes (Table 6.8). However, no utilisation/availability ratio could be calculated for *A. mearnsii* as none of the local users accompanied by the research team on collection trips harvested this species. Although *E. grandis* and *S. inerme* were more abundant than the preferred species (Table 6.8), the former constituted commercial posts that were sold at Mount Coke for upwards of R2 per post (depending on their size) (Rhodes University et al 2000) while the preferred species could be harvested for free, and the latter was of inferior quality to *P. obliquum*, *O. africana*, *A. caffra* and *S. latifolia*.

#### **6.4.2 Factors that shaped people's species use patterns**

The local people behaved in a rational manner by weighing up the benefits and costs associated with the different species options available to them for fuelwood, brushwood and kraal posts, respectively, before actively selecting those species that afforded them the greatest net benefits (Turner et al 1994; Field 2002; Curtis 2004). Consequently, the local people made trade-offs between the returns from harvesting, measured in terms of the quality and density of the species (Abbot et al 1997; Kituyi et al 2001; Boudreau et al 2005), and the accessibility costs associated with harvesting them, as well as the costs of commercial alternatives (Shackleton and Mander 2000; Pote et al 2006).

##### **i) Species quality and density versus their accessibility**

Although density was not found to significantly influence people's species use patterns on its own (Table 6.9), the quality and density of species probably had a synergistic effect on people's species choices for fuelwood, brushwood and kraal posts. For example, the local people actively selected the most abundant, hardwood species in *A. karroo* for fuelwood (Bembridge and Tarlton 1990; Pote et al 2006), which was preferred as it produced better quality coals than inferior, softwood alternatives such as *E. grandis*, *D. lycioides* and *G. arenicola*, which occurred at relatively lower densities across all fuelwood and brushwood landscapes. However,

when the preferred fuelwood species were less abundant, people's active selection of these species was contingent upon a reduction in their accessibility costs, which in the case of *A. mearnsii*, took the form of a greater ease of collection of this species in bundles of pre-cut and dried wood (Madubansi and Shackleton in press).

The opposite was true of people's species use patterns for kraal posts, as they were prepared to incur higher accessibility costs in order to obtain the preferred species during times of scarcity, even if this meant harvesting these species illegally from neighbouring community lands (see chapter five). Whiting and Greeff (1999) and Hill et al (2001) also documented similar behaviour in lizards and bees, which would travel greater distances in order to select preferred food items.

However, contrary to studies such as Grundy et al (1997) and Boudreau et al (2005), the most abundant species such as *A. karroo* and *C. rudis* were avoided for brushwood while *O. africana*, *G. arenicola* and *S. myrtina*, which occurred at relatively lower densities, were actively selected by the local people. This was explained as the local people made trade-offs between the density of the species and the accessibility costs, as related to the ease with which they could navigate the often spiny vegetation. At high densities, as measured for *A. karroo* and *C. rudis* (Table 6.5), the vegetation was too difficult for local people to navigate without being scratched, or their clothes damaged, by the species' sharp branches or thorns. Hence, *O. africana*, *G. arenicola* and *S. myrtina*, which occurred at densities  $\leq 70$  trees/Ha, were actively selected for brushwood (Table 6.5). Studies such as Olsson et al (2002) and Arcis and Desor (2003) showed that animals make similar trade-offs between the density of food items and vegetation cover, which served as camouflage and protection from predators by obstructing their attacks, when deciding which resource patches to exploit and which to avoid.

#### ii) Density versus the cost of alternatives

This trade-off took on different forms for fuelwood, brushwood and kraal post species. In response to an increasing scarcity of the preferred fuelwood species such as *A. caffra* (Figure 6.2), the local people harvested smaller quantities of this species (Shackleton et al 2004), and switched from using only fuelwood to using commercial alternatives such as paraffin and electricity in addition to fuelwood (Masera and Navia

1997; Mahapatra and Mitchell 1999). An additional function of these alternatives was to act as a buffer against ecological and social factors over which the local people had no control. For example, most local users stated that when it rained they were unable to harvest fuelwood so would use paraffin or electric stoves instead. Some also stated that they used paraffin or electric stoves to prepare speciality foods that required long cooking times (Masera and Navia 1997).

However, these alternatives lacked the ability to replace fuelwood completely, as an open fire had significant cultural value as a gathering place for people to talk and celebrate during special occasions, in addition to providing light and heat for cooking, and warmth during the cold winter nights (Masera and Navia 1997; Shackleton et al 2004). Fuelwood was also free whereas the use of paraffin and electricity were associated with monetary costs (Bhagavan and Giriappa 1995; Kituyi et al 2001) (Table 6.3).

In contrast, the local people switched from harvesting the preferred brushwood species such as *A. karroo* and *C. rudis* themselves to purchasing their brushwood, as these species became too abundant, and navigating the vegetation became impossible without getting scratched, or your clothes being damaged by the thorns and/or sharp branches. However, only twenty one percent of the local users interviewed during this study (i.e. 5 out of 24) purchased wagonloads of brushwood from sellers in the village rather than harvest *O. africana*, *G. arenicola* and *S. myrtina* for brushwood, which occurred at relatively lower densities across the fuelwood and brushwood landscapes than *A. karroo* and *C. rudis*.

People's kraal post species choices did not respond to increasing scarcity with a shift towards the use of commercial posts. Instead, the local people continued to heavily utilise the already scarce, preferred species such as *A. caffra* and *P. obliquum*, which could be harvested for free, or continued to use old posts in their kraals (Scheepers 2004) rather than purchase *E. grandis* posts from Mount Coke, which for upwards of R2 per post (depending on their size) (Rhodes University et al 2000), were too expensive.

#### **6.4.3 Management implications**

This chapter showed that the local people did not always use the preferred species for fuelwood, brushwood and kraal posts (Shackleton 1993; Pote et al 2006). Discrepancies between people's stated preferences and species use patterns were explained by trade-offs between the returns from harvesting, measured in terms of the quality and density of the species (Abbot et al 1997; Kituyi et al 2001; Boudreau et al 2005), and the accessibility costs of harvesting them (Bembridge and Tarlton 1990), or the costs of commercial alternatives (Vermeulen 2001; Madubansi and Shackleton in press). However, as the trade-offs differed across fuelwood, brushwood and kraal post species, multiple management strategies are recommended for Machibi.

For example, an increase in the abundance of certain preferred fuelwood and brushwood species across all landscapes over the period from 1960 until 2003 had different management implications for fuelwood species (Table 6.2) than brushwood species (Table 6.5). An increase in *A. karroo* for fuelwood contributed towards people's preference for the species, and their active selection of it in the landscapes, as *A. karroo* was considered environmentally detrimental to the grazing areas, and people stated that there was too much of it in the landscapes. The harvesting costs associated with trying to harvest this thorny species without getting injured were also superceded by the benefits it provided to the local people as a high quality fuelwood species. Hence, this trade-off can be used to promote heavy utilisation and clearing of *A. karroo* from the landscapes.

For brushwood, an increase in *A. karroo* across all landscapes had a negative effect on people's species use patterns, even though its thorns were a known deterrent to errand cattle wanting to escape the kraal, and was a preferred quality trait, as high densities of this species made it impossible for local users to navigate the vegetation without getting injured or their clothes ruined. Consequently, some users switched from harvesting the preferred brushwood species themselves to purchasing brushwood from local sellers, where a change in price meant that more or less of a particular species was sold or harvested.

Hence, as the same species were often used for fuelwood and brushwood but influenced differently by changes in the system (i.e. by trade-offs in the costs and benefits), multi-resource management strategies which examine the interactions

between these trade-offs need to be employed for fuelwood and brushwood species. For example, an increase in the price of *A. karroo* for brushwood could result in an increase in its overall harvesting by resource users (for fuelwood and brushwood), and if depleted, a scarcity in fuelwood.

In contrast, there was a decline in the abundance of other preferred species for fuelwood such as *A. caffra* across the fuelwood and brushwood landscapes (Table 6.2). In response to increasing scarcity, the local people harvested smaller quantities of this species, and switched from using only fuelwood, that could be harvested for free from the preferred landscapes (see chapter five), to using commercial alternatives such as paraffin and electricity in addition to fuelwood (Masera and Navia 1997; Mahapatra and Mitchell 1999). Yet, in order for these alternatives to completely replace fuelwood in people's homes for cooking and heating purposes, they need to be provided to the local people at more affordable prices, for example, by government subsidising the use of electricity (Bhagavan and Giriappa 1995; Madubansi and Shackleton in press). The feasibility of cheaper forms of energy such as solar power and wind power for household fuel needs should also be investigated for Machibi (Masera and Navia 1997).

Similarly, there was a decline in the preferred species for kraal posts across all landscapes over the period from 1960 until 2003, as perceived by the local users (Figure 6.7). However, the local people continued to heavily utilise the already scarce, preferred species such as *A. caffra* and *P. obliquum*, obtained for free from certain preferred landscapes (see chapter five) rather than switch to the use of commercial alternatives such as *E. grandis* posts, which were more expensive. Some users also harvested the preferred species such as *O. africana* from neighbouring community lands illegally (Nagothu 2001; Lawes et al 2004).

Consequently, management of the preferred kraal post species requires that they be made less attractive to the local people, for example, by instituting a permit system for the harvesting of these species. However, as recommended in chapter five, a local monitoring system for these species (Fabricius et al 2004a; Nott and Jacobsohn 2004) should focus beyond the borders of Machibi, and focus on shared efforts between neighbouring communities to curb illegal harvesting. In addition, the provision of

cheaper alternatives to the preferred species (Van Eck et al 1997; Madubansi and Shackleton in press) could encourage people to stop exhausting scarce resources and to use commercial alternatives instead. This can be achieved by reducing the cost of *E. grandis* posts. However, the feasibility of other cheap alternatives such as plastic posts should also be investigated for Machibi.

## **6.5 Conclusion**

This chapter showed that people's species choices were governed by trade-offs between the returns from harvesting, measured in terms of the quality and density of the species, and the accessibility costs of harvesting them, or the costs of commercial alternatives. However, as the form taken by the trade-offs differed across fuelwood, brushwood and kraal post species, multiple management strategies are recommended for Machibi.

## **7. REVISED CONCEPTUAL MODEL: HARVESTING STRATEGIES OF FUELWOOD AND KRAALWOOD USERS AT MACHIBI, AND THE FACTORS THAT INFLUENCE THEM**

### **Executive summary**

Natural resource management problems are complex given that they are often driven by multiple factors, non-linear in nature, cross-cutting in space and time, and contain an element of unpredictability. However, using an iterative modelling process to develop conceptual models to help researchers, policy-makers and natural resource users understand such complex problems enables the optimal use of existing information given the cost and time constraints of research studies. This chapter revisits the conceptual model of the harvesting strategies of fuelwood and kraalwood users at Machibi, presented in chapter two, in order to 1) compare its assumptions with the empirical findings of the study, 2) provide new insights into the factors that shaped people's landscape and species choices for fuelwood, brushwood and kraal posts, and 3) develop a second generation model. Supported by conceptual model (version I), people's landscape and species choices for fuelwood, brushwood and kraal posts were determined by the trade-off between the returns from harvesting, measured in terms of resource quality and density, and the accessibility costs. At the landscape level, the accessibility costs included their distance from the village, proximity to taboo areas and steepness of slope, in the case of fuelwood and brushwood landscapes. However, people's landscape choices were not influenced by their distance from roads/footpaths, contrary to conceptual model (version I). In addition, the costs were not only associated with accessing the landscapes themselves but with the costs of harvesting these resources from the landscapes. The harvesting costs considered the ease with which local people could navigate the landscapes and the ease of collection of these resources (i.e. whether the wood was pre-cut and dried). At the species level, the costs of obtaining particular species for fuelwood, brushwood or kraal posts related only to the act of harvesting them. These accessibility costs related to the harvesting of resources were not considered in conceptual model (version I) but were included in the second generation model.

## 7.1 Introduction

Natural resource management problems are complex given that they are often driven by multiple factors, non-linear in nature, cross-cutting in space and time, and contain an element of unpredictability (Gunderson et al 1995; Berkes and Folke 1998; Gunderson and Holling 2002). People also differ in their capacity to adapt to ecosystem changes, which has implications for the management of complex systems (Brooks et al 2005; Lebel et al 2006; Metzger et al 2006). Thus, an understanding of the thought processes underpinning local people's resource use decisions is critical to managing complex systems and knowing how to buffer them against radical, and often irreversible, changes (Walker 1993; Ludwig et al 1997; Anderies et al 2002; Scheffer and Carpenter 2003).

Starfield et al (1990), Starfield and Bleloch (1991) and Lynam et al (2002) showed that the development of a conceptual model is a useful tool to help ecologists, scientists, policy-makers and natural resource users identify cause and effect connections between people's behavioural actions and resource dynamics. However, this process is also helpful for defining and describing the context of the research (i.e. for providing a framework for the research hypotheses), and for organising the baseline data (Starfield et al 1990; Hutchinson and McNamara 2000).

Consequently, chapter two provided a conceptual model of the harvesting strategies of fuelwood and kraalwood users at Machibi, which showed the linkages and feedbacks between the social and ecological systems, and how these relationships may have influenced the local people's harvesting strategies and natural resource use decisions in terms of the trade-offs they made between the landscapes and species they actively selected for fuelwood, brushwood and kraal posts, and those they did not select (Rose and Chapman 2003; Biggs et al 2004; Wei and Hoganson 2005). Ultimately, the local users' ability to adapt to changes in the ecosystem influenced their resource use decisions (Brooks et al 2005; Lebel et al 2006; Metzger et al 2006), and had consequences for the management of these landscapes and species.

Empirical manipulations of the model parameters then allowed the stakeholders to test the validity of the relationships between system components, and their sensitivity to change (Scheffer et al 2001; Lynam et al 2002). In turn, a sound understanding of

these relationships improved decision maker adaptability by facilitating the screening of management options or strategies to eliminate those that were unfeasible (see chapter five and chapter six). Biggs and Rogers (2003) and Lynam et al (2002) showed that in this way, models enable scientific research to be adapted to local management objectives, and facilitate flexibility to changes in the needs of local users and managers.

This chapter revisits the conceptual model presented in chapter two in order to refine it, based on empirical findings of the trade-offs people made, and the factors that influenced their landscape and species choices for fuelwood, brushwood and kraal posts. Consequently, this chapter highlights the model's assumptions that were verified by empirical findings, as well as those assumptions that were unfounded. New insights into the factors that influenced people's resource use decisions are also presented.

## **7.2 Initial model (version I)**

The local people of Machibi exhibited close ties with their surrounding natural environment, which included a number of woodland patches, referred to as landscapes, and the species associated with them, which were used for fuelwood, brushwood and kraal posts. Consequently, the harvesting model for Machibi adopted an integrated approach that focused on the linkages and feedbacks between the social and ecological system (Berkes and Folke 1998; Pierotti and Wildcat 2000; Lynam et al 2002) to show how these relationships influenced people's harvesting strategies for fuelwood, brushwood and kraals, and ultimately, their natural resource use patterns (see chapter two).

Borrowing principles and paradigms from cost-benefit analysis (Pearce and Turner 1990; Field 2002) and optimal foraging theory (Hutchinson and McNamara 2000; Kacelnik and Marsh 2002), the model also relied on the concept of optimisation to explain people's landscape and species choices (i.e. their natural resource use patterns), and why they sometimes differed from people's preferences (Shackleton 1993; Scheepers 2004; Pote et al 2006). Consistent with the economic definition (Dasgupta and Pearce 1972), a resource user's 'preference' for a particular landscape or species was defined as a measure of his/her desires to use that resource. Supported

by Pearce and Turner (1990) and Field (2002), this definition also allowed that people's experiences with nature, and natural resources, often encoded in their systems of knowledge and belief, culture, traditions, customs and ethics could influence these preferences (Sullivan 1999; Klubnikin et al 2000; Turner et al 2000). However, whereas people's preferences were based on their past experiences and historical perceptions of the landscapes and species for fuelwood, brushwood and kraal posts rather than facts regarding resource abundance and accessibility (Pahl-Wostl in press), their natural resource use patterns were ultimately influenced by such resource limitations (see chapter one and two).

Consequently, as resources were often limited in reality, the model assumed that the local people were forced to exercise choice over the landscapes and species they used for fuelwood, brushwood and kraal posts. Supported by consumer behaviour theory (Sikhakhane 2001; Field 2002; Turner et al 2003) and optimal foraging theory (Whiting and Greeff 1999; Hill et al 2001), it was assumed that this choice was made in a rational manner by weighing up the costs and benefits associated with the different options available to the local users in order to determine their optimal choice, which was represented by the option that afforded them the greatest net benefit (see chapter one and two). Thus, the 'actual use' of a particular landscape or species by a local user was reflected in what he/she was willing and able to sacrifice in order to use it (i.e. his/her 'willingness to pay') (Pearce and Turner 1990).

A number of social and ecological factors were assumed to influence the trade-offs people made in their landscape and species choices. Supported by previous studies (Campbell and Du Toit 1988; Grundy et al 1993; Lynam et al 2004), the benefit or returns from harvesting fuelwood, brushwood or kraal posts from a particular landscape or species was determined as a function of resource density and quality, as reflected by people's relative preferences for the different options available to them.

However, the active selection of a particular landscape or species was influenced by the 'cost' of its accessibility to the local users, determined as a function of its distance from the village (i.e. travel cost) (Grundy et al 1993; Vermeulen 1996; Kirubi et al 2000), distance from roads/footpaths (Luoga et al 2002) and slope (Rao and Pant 2001), which constituted its physical accessibility, as well as people's rights of access

(i.e. legal accessibility) (Nagothu 2001; Lawes et al 2004). Consequently, the model assumed that the distance of a landscape or species from the nearest taboo area, including sacred areas protected by local taboos (Klubnikin et al 2000; Turner et al 2000), and state or neighbouring communities' resources, protected by formal laws (Nagothu 2001), was a proxy for the risk people were prepared to take in order to access these resources. In addition, the model considered the influence of the availability and cost of alternatives on people's active selection of particular landscapes and species (Bhagavan and Giriappa 1995; Shackleton and Mander 2000).

Thus, supported by the assumptions of conventional consumer behaviour theory (Turner et al 1994; Ward and Beal 2000; Field 2002) and optimal foraging theory (Hutchinson and McNamara 2000; Kacelnik and Marsh 2002), the model assumed that local users behaved in such a manner so as to maximise their benefits from harvesting while minimising the associated costs and risks. This meant targeting the landscapes and species of the highest density and quality, which could be obtained at the lowest accessibility costs, and with the lowest risk.

### **7.3 Trade-offs affecting people's landscape and species use patterns**

The local people's landscape and species choices for fuelwood, brushwood and kraal posts were determined by the trade-off between the returns from harvesting and the accessibility costs of the respective options available to them (Pearce and Turner 1990; Field 2002). These trade-offs, manifest in people's active selection or avoidance of landscapes and species, could be illustrated using decision trees, developed by working back from the reasons people gave for currently using particular landscapes and species, and in the case of landscapes, from the factors influencing the relationships between landscapes, to explain their choices. These trade-offs are explained separately for landscapes and species.

#### **7.3.1 Fuelwood and brushwood landscapes**

Based on people's past experiences and historical perceptions (Pearce and Turner 1990; Field 2002; Pahl-Wostl in press), people believed Makopiyane was the most preferred landscape for fuelwood and brushwood, followed by Tyip Tyip, Gqumehlo, Mbomboyi, Wani, Qeqe and Ntsunguzi (see chapter five). These landscapes constituted community woodlands that were associated with a long history of

fuelwood and brushwood usage by the local people, which dated back to the establishment of the village between 1958 and 1960 as a result of Betterment Planning (Rhodes University et al 2000; Cundill 2005). Consequently, these landscapes were regarded as the highest quality for their fuelwood and brushwood.

However, people's landscape use patterns showed that only Tyip Tyip, Mbomboyi, Wani and Ntsunguzi of the preferred landscapes were actively selected for fuelwood and brushwood (see chapter five). This was explained as people made trade-offs between the returns from harvesting, measured in terms of the fuelwood and brushwood densities of the respective landscape options (Grundy et al 1993; Lynam et al 2004), and their accessibility costs, measured as a function of their distance from the village (Vermeulen 1996; Kirubi et al 2000; Pote et al 2006), proximity to taboo areas (Tabuti et al 2003; Bodin et al 2006) and steepness of slope (Luoga et al 2002). Ultimately, the preferred landscapes that exhibited intermediate fuelwood and brushwood densities and high accessibility such as Mbomboyi, Wani and Ntsunguzi were selected over those of intermediate to high densities but high inaccessibility such as Gqumehlo and Makopiyane (see chapter five).

Tyip Tyip was the only exception (see chapter five) as this landscape exhibited a lower fuelwood and brushwood density than Gqumehlo and Makopiyane, and was associated with a more 'open' vegetation canopy. This had a positive spin-off for people, as it was easier for them to navigate through the spiny vegetation preferred for fuelwood and brushwood at intermediate rather than high densities, reducing the accessibility costs associated with the harvesting of resources from this landscape, and ultimately, resulting in people's active selection of Tyip Tyip over Gqumehlo and Makopiyane.

The local people also made trade-offs between the landscape quality, as reflected by people's stated preferences for landscapes belonging to the community (i.e. community woodlands) that exhibited a long history of fuelwood and brushwood usage by the local people, and the ease of collection of these resources from the landscape (Van Eck et al 1997; Shackleton et al 2004). Although not identified as a preferred landscape, state-owned Mount Coke was actively selected for fuelwood and brushwood because the local people were permitted to collect bundles of exotic wood from here, which had been cut down by the forestry officials as part of the

Department of Water Affairs and Forestry's alien eradication programme, and left out to dry. This facilitated a greater ease of collection of wood resources from Mount Coke than had the local users to harvest indigenous trees from the preferred landscapes (Madubansi and Shackleton in press).

Figure 7.1 shows the trade-offs the local people made in their choice of fuelwood and brushwood landscapes, with the exception of Ntsunguzi and Qeqe. These landscapes were excluded from the final canonical correlation as they dominated the analysis (see chapter five).

The landscapes which constituted community woodlands belonging to the village of Machibi, and that were associated with a long history of natural resource use by the local people, were regarded as of higher quality than alternatives owned by the state or neighbouring communities (e.g. Rodi Farm), as well as local alternatives such as Jejane and Rhenene, which had only recently come into use for fuelwood and brushwood. Consequently, the former were actively selected over the latter. The only exception was Mount Coke, which despite being state-owned and managed, was actively selected for fuelwood and brushwood because it was easier for the local people to collect bundles of pre-cut and dried exotic wood from this landscape than to harvest indigenous species from the preferred landscapes.

However, all high quality landscapes were not actively selected by the local people. Mbomboyi and Wani, which exhibited intermediate fuelwood and brushwood densities and high accessibility, were actively selected over Gqumehlo and Makopiyane, which were characterised by intermediate to high densities but high inaccessibility. Tyip Tyip was the only exception because despite its high fuelwood and brushwood density, this landscape was associated with an 'open' vegetation canopy structure, which made it easy for local people to navigate, and reduced the accessibility costs associated with its use.

Actively selected landscapes

Avoided landscapes

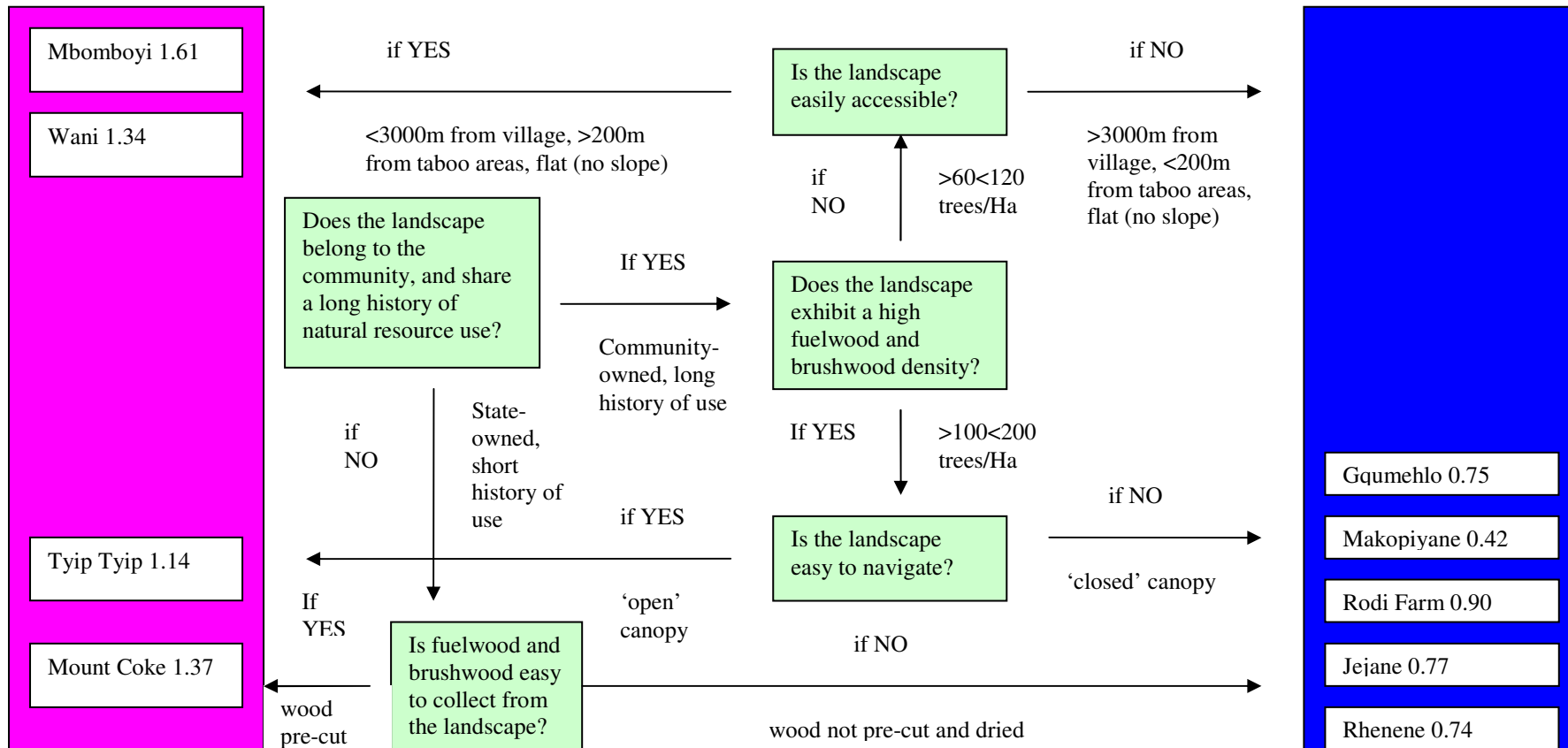


Figure 7.1: Decision tree, showing the trade-offs people made, and the factors that influenced their fuelwood and brushwood landscape choices (where the pink box represents the landscapes that were actively selected and the blue box represents the avoided landscapes, and their utilisation/availability ratios)

### 7.3.2 Kraal post landscapes

Although no multivariate analysis could be performed on the data for kraal post landscapes (see chapter five), people's choices involved a trade-off between the returns from harvesting, determined as a function of the landscape's quality, density and diversity of preferred species (Shackleton et al 1994; Lynam et al 2004; Tilman et al 2005), and its accessibility costs, measured in terms of its distance from the village (Vermeulen 1996; Kirubi et al 2000; Motinyane 2001) and the risk involved with its use (Fox 2005; Bodin et al 2006).

Based on people's past experiences and historical perceptions (Pearce and Turner 1990; Field 2002; Pahl-Wostl in press), Tyip Tyip was identified as the most preferred landscape for kraal posts, followed by Mbomboyi, Gqumehlo, Makopiyane, Wani, Ntsunguzi and Qeqe. However, only Mbomboyi of the preferred landscapes was actively selected (see chapter five). The local people explained that due to resource scarcity, and the subsequent disappearance of preferred kraal post species from the preferred landscapes (i.e. a decline in the landscapes' diversity of preferred species), with the exception of Mbomboyi, they were forced to abandon Tyip Tyip, Gqumehlo, Makopiyane, Wani, Ntsunguzi and Qeqe in favour of harvesting kraal posts illegally from Rodi Farm at a higher accessibility cost. Similarly, Nagothu (2001) and Lawes et al (2004) documented the illegal harvesting of natural resources from state forests and neighbouring community lands by local communities in response to increasing scarcity.

Whereas the preferred landscapes constituted community woodlands to which rights of access and use belonged to the people of Machibi (see chapter two), Rodi Farm constituted neighbouring community land, and was associated with an additional low risk of being caught for illegal harvesting. Weak institutional controls associated with Rodi Farm constituted unrestricted access to outsiders from Machibi, no formal monitoring system of natural resource use and light penalties for illegal harvesting.

In contrast, although Mount Coke was perceived to exhibit the highest density and diversity of kraal post species (Rhodes University et al 2000), this landscape was not actively selected by the local people as it was associated with greater institutional controls than Rodi Farm. Mount Coke was state-owned and managed with controlled

access to local communities, forest guards that accompanied resource users on collection trips and monitored their resource use, as well as associated with strong penalties for illegal harvesting. Hence, the risk of being caught for the illegal use of landscape resources was higher for Mount Coke than Rodi Farm.

Figure 7.2 shows the trade-offs the local people made in their choice of kraal post landscapes. However, the preferred landscapes, Gqumehlo, Makopiyane, Wani, Ntsunguzi and Qeqe were not included in the decision tree as none of the resource users accompanied on collection trips by the research team harvested kraal posts from any of these landscapes (see chapter five).

Landscapes such as Mbomboyi, which exhibited good returns from harvesting in terms of their high density and diversity of the preferred kraal post species, low accessibility costs and no risk of being caught for illegal harvesting as they belonged to the people of Machibi, were actively selected over alternatives such as Mount Coke, which was owned by the state, or neighbouring community lands, which offered lower returns at higher costs. The only exception was neighbouring community land, Rodi Farm, which despite being located further from Machibi, and associated with a greater risk of being caught for illegal harvesting than the community woodlands such as Tyip Tyip, was actively selected because it exhibited a greater diversity of the preferred kraal post species.



### 7.3.3 Fuelwood species

The local people's fuelwood species choices were determined by the trade-off between the returns from harvesting, measured in terms of their quality and density (Abbot et al 1997; Kituyi et al 2001; Boudreau et al 2005), and the accessibility costs, related to their ease of collection (Bembridge and Tarlton 1990), or the costs of commercial alternatives such as paraffin and electricity (Vermeulen 2001; Madubansi and Shackleton in press). Consequently, the local people actively selected the most abundant, hardwood species in *Acacia karroo* for fuelwood (Bembridge and Tarlton 1990; Pote et al 2006), which was preferred as it produced better quality coals than inferior, softwood alternatives such as *Eucalyptus grandis*, *Diospyros lycioides* and *Gymnosporia arenicola*, which occurred at relatively lower densities across all fuelwood and brushwood landscapes.

However, *Acacia mearnsii* was an exception. Despite its relatively low density when compared to that of *A. karroo*, this species was actively selected by the local people because of its ease of collection (Bembridge and Tarlton 1990; Madubansi and Shackleton in press). This exotic species occurred only within Mount Coke, where it had been originally grown for commercial use but was now removed by forestry officials as part of the Department of Water Affairs and Forestry's programme to eradicate alien species from South Africa's indigenous forests. Consequently, local communities were permitted to collect bundles of pre-cut and dried wood of this species from the state forest.

*Acacia caffra* was also actively selected for fuelwood, despite its low density across all fuelwood and brushwood landscapes (see chapter six). However, the local people harvested smaller quantities of this species as it became increasingly scarce (Shackleton et al 2004), and switched from using only fuelwood to using commercial alternatives such as paraffin and electricity in addition to fuelwood when they could no longer obtain branches of adequate size for use as fuelwood (Masera and Navia 1997; Mahapatra and Mitchell 1999).

In addition, as *Scutia myrtina* was an abundant, hardwood species known to produce good quality coals (Bembridge and Tarlton 1990; Pote et al 2006), it was surprising that this species was not actively selected for fuelwood. However, a possible

explanation was that this species was so abundant that it was sampled at too fine a scale to accurately determine its utilisation/availability ratio (Shackleton et al 1994).

Figure 7.3 shows the trade-offs the local people made in their choice of fuelwood species. The most abundant, hardwoods such as *A. karroo* were actively selected over inferior, softwood alternatives such as *E. grandis*, *D. lycioides* and *G. arenicola*, which occurred at relatively lower densities. The local people also continued to actively select the hardwood species, *A. caffra*, despite its increasing scarcity within the fuelwood and brushwood landscapes rather than harvest alternatives of inferior quality. However, the active selection of this species was supplemented by the use of commercial alternatives such as paraffin and electricity.

In addition, the local people made trade-offs between the density of a particular species and its ease of collection. Thus, despite not being the most abundant species, *A. mearnsii* was actively selected by the local people because it was easier to collect pre-cut and dried bundles of this exotic wood from Mount Coke than to harvest indigenous species from the preferred fuelwood and brushwood landscapes.

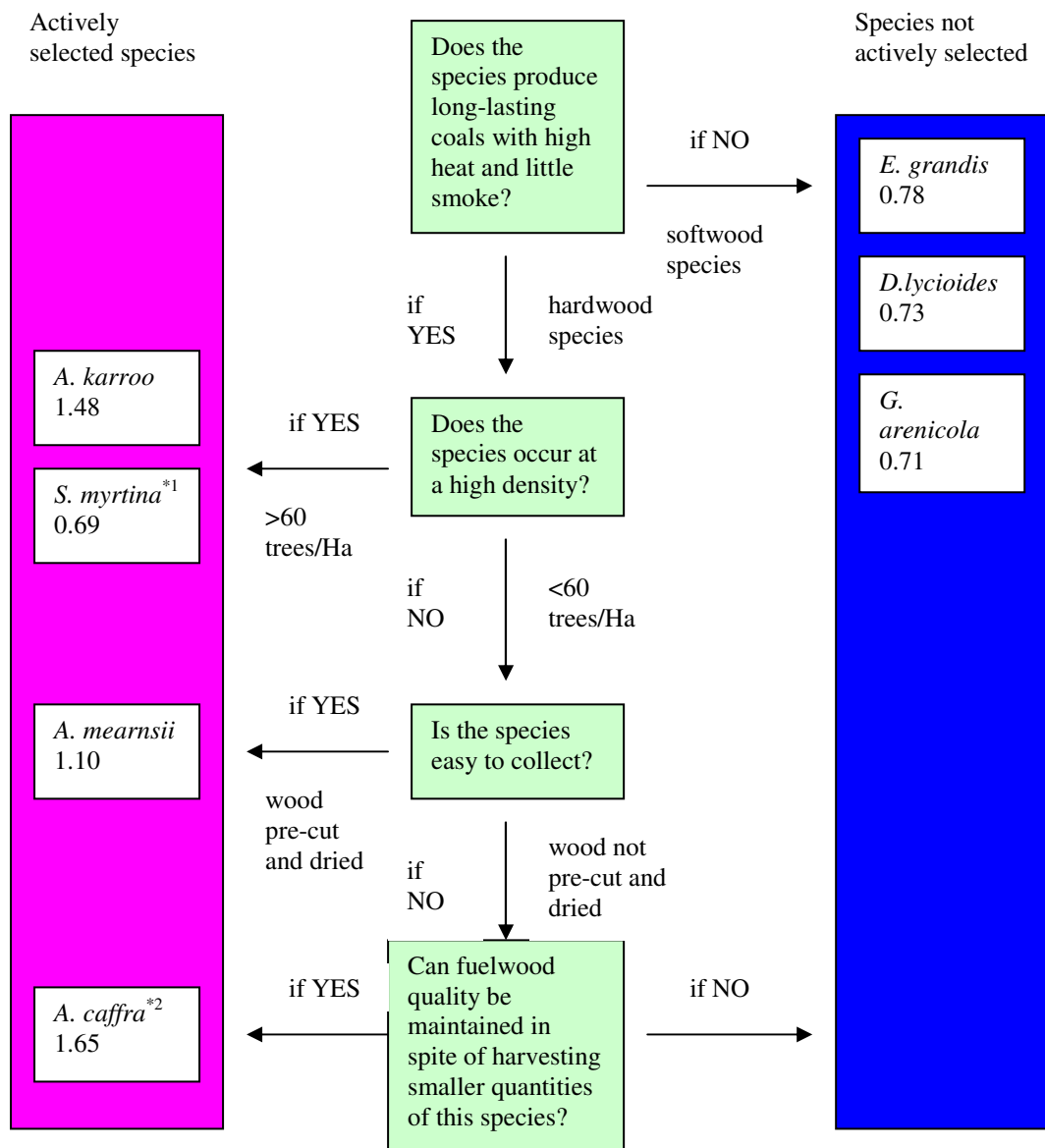


Figure 7.3: Decision tree, showing the trade-offs people made, and the factors that influenced their fuelwood species choices (where the pink box represents the species that were actively selected and the blue box represents the avoided species, and their utilisation/availability ratios). *S. myrtina*<sup>\*1</sup> had a utilisation/availability ratio of less than one, but this value was considered to be an artefact of sampling. The species was extremely abundant, and the scale of sampling probably did not record the utilisation levels. Seventy five percent of the local users interviewed during this study purchased commercial alternatives such as paraffin and electricity in addition to their continued harvesting of *A. caffra*<sup>\*2</sup> (see chapter six).

#### 7.3.4 Brushwood species

People's brushwood species choices were determined by the trade-off between the returns from harvesting, measured in terms of their quality and density (Abbot et al 1997; Kituyi et al 2001; Boudreau et al 2005), and the accessibility costs, related to the ease with which people could navigate the often spiny vegetation to harvest these species, and the costs of commercial alternatives (Shackleton and Mander 2000; Pote et al 2006). However, contrary to the findings of Grundy et al (1997) and Boudreau et al (2005), the most abundant species such as *A. karroo* and *Coddia rudis*, although frequently used, were not actively selected, while *Olea europaea subsp. africana*, *G. arenicola* and *S. myrtina*, which occurred at relatively lower densities, were actively selected for brushwood (see chapter six). This was explained as the above-mentioned brushwood species were characterised by durable, robust and strong branches and the presence of thorns, in the case of *A. karroo*, *G. arenicola* and *S. myrtina*, which made for a good deterrent to cattle trying to flee the kraal (Scheepers 2001; Pote et al 2006). However, at the relatively higher densities of *A. karroo* and *C. rudis* than *O. africana*, *G. arenicola* and *S. myrtina*, people's movements were greatly hindered by sharp branches and thorns, which scratched them and caused damage to their clothes.

This negative spin-off of high densities of the brushwood species could also account for some users electing to purchase brushwood instead of harvesting it for free. *A. karroo* and *C. rudis* were available for sale. These species were perceived by the local people to have increased in abundance within the brushwood landscapes over the period from 1960 until 2003 (see chapter six).

Hence, Figure 7.4 shows the trade-offs the local people made in choosing between good quality brushwood species. *O. africana*, *G. arenicola* and *S. myrtina*, which were not the most abundant species, were actively selected over *A. karroo* and *C. rudis*, which were more abundant but less easy to navigate as they occurred within a 'closed' vegetation canopy structure. However, only those species harvested by the local users accompanied on collection trips by the research team were included in the decision tree.

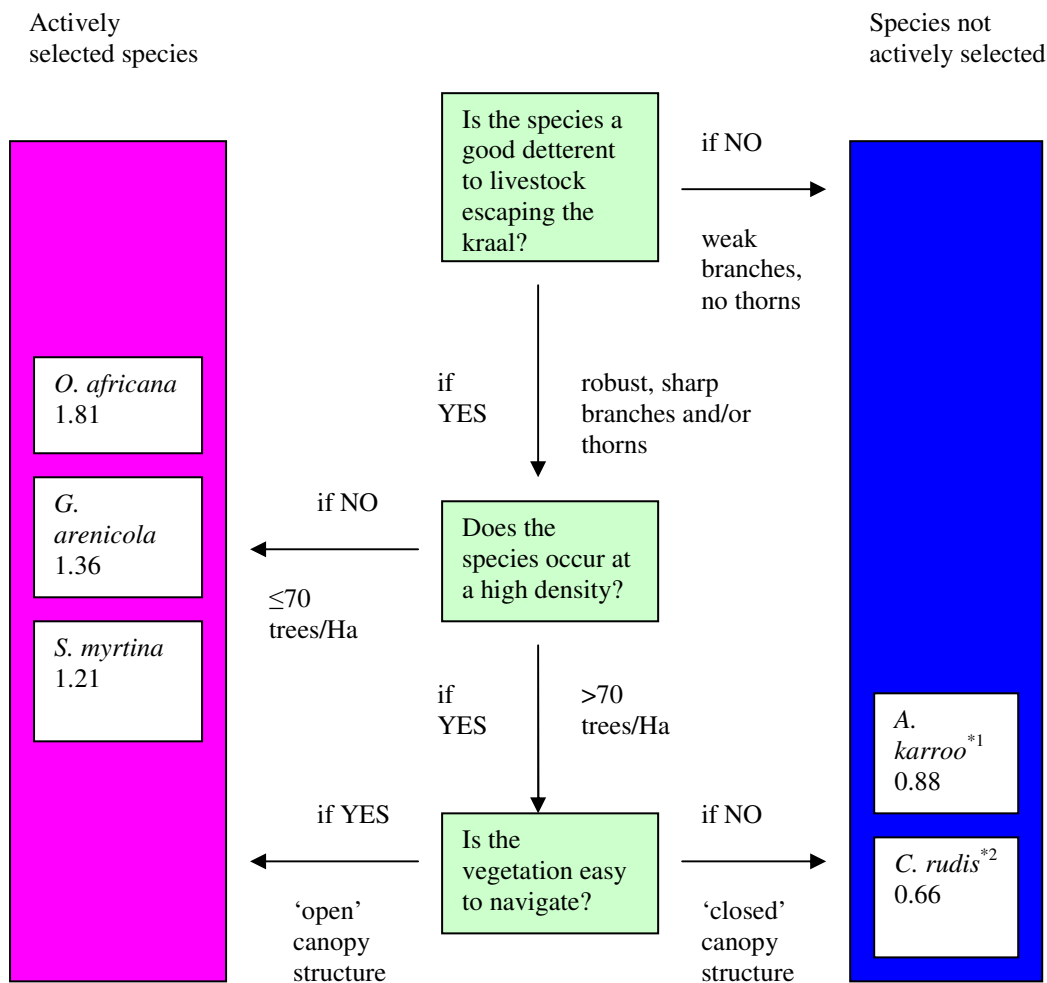


Figure 7.4: Decision tree, showing the trade-offs people made, and the factors that influenced their brushwood species choices (where the pink box represents the species that were actively selected and the blue box represents the avoided species, and their utilisation/availability ratios). However, twenty one percent of the local users interviewed during this study purchased *A. karroo*<sup>\*1</sup> and *C. rudis*<sup>\*2</sup> from local sellers (see chapter six).

### 7.3.5 Kraal post species

The local people's choices for kraal post species were determined by the trade-off between the returns from harvesting, measured in terms of their quality and density, and the cost of commercial alternatives (Shackleton and Mander 2000; Twine et al 2003; Pote et al 2006). Despite their occurrence at low densities, the local people actively selected *A. caffra* and *Ptaeroxylon obliquum*, which were preferred for kraal posts because of their durability, as well as termite-resistant properties and cultural

value in the case of *P. obliquum* (Van Eck et al 1997; Ham and Theron 2001), rather than harvest inferior alternatives such as *Sideroxylon inerme*, which were more abundant (Pote et al 2006). In addition, as *A. caffra* and *P. obliquum* could be harvested for free from the kraal post landscapes, the preferred species were actively selected by the local people while more abundant, commercially available alternatives such as *E. grandis* were not actively selected as they were too expensive (Shackleton and Mander 2000; Shackleton et al 2004).

In contrast, *O. africana* was not actively selected for kraal posts by the local people despite its great durability (Scheepers 2004; Pote et al 2006). However, this was explained as in response to a growing scarcity of this species within the preferred landscapes (see chapter five), the local people identified a new, abundant source of *O. africana* in the form of Rodi Farm, which constituted harvesting kraal posts illegally from neighbouring community land. It was possible that this species was so abundant that it was sampled at too fine a scale to accurately record its utilisation/availability ratio (Shackleton et al 1994).

Figure 7.5 shows the trade-offs the local people made in their choice of kraal post species. For example, they made trade-offs between the quality and density of particular kraal post species. *A. caffra* and *P. obliquum*, despite their occurrence at low densities, were actively selected for kraal posts over inferior alternatives such as *S. inerme*, which were more abundant.

In addition, the local people made trade-offs between the density of the kraal post species and the cost of commercial alternatives. Thus, although *A. caffra* and *P. obliquum* were scarce, the local people continued to harvest these species for free from the preferred kraal post landscapes rather than purchase more abundant, commercially available alternatives such as *E. grandis*, which were too expensive. *S. latifolia* and *A. mearnsii* were excluded from the decision tree as none of the local users accompanied on collection trips harvested these species.

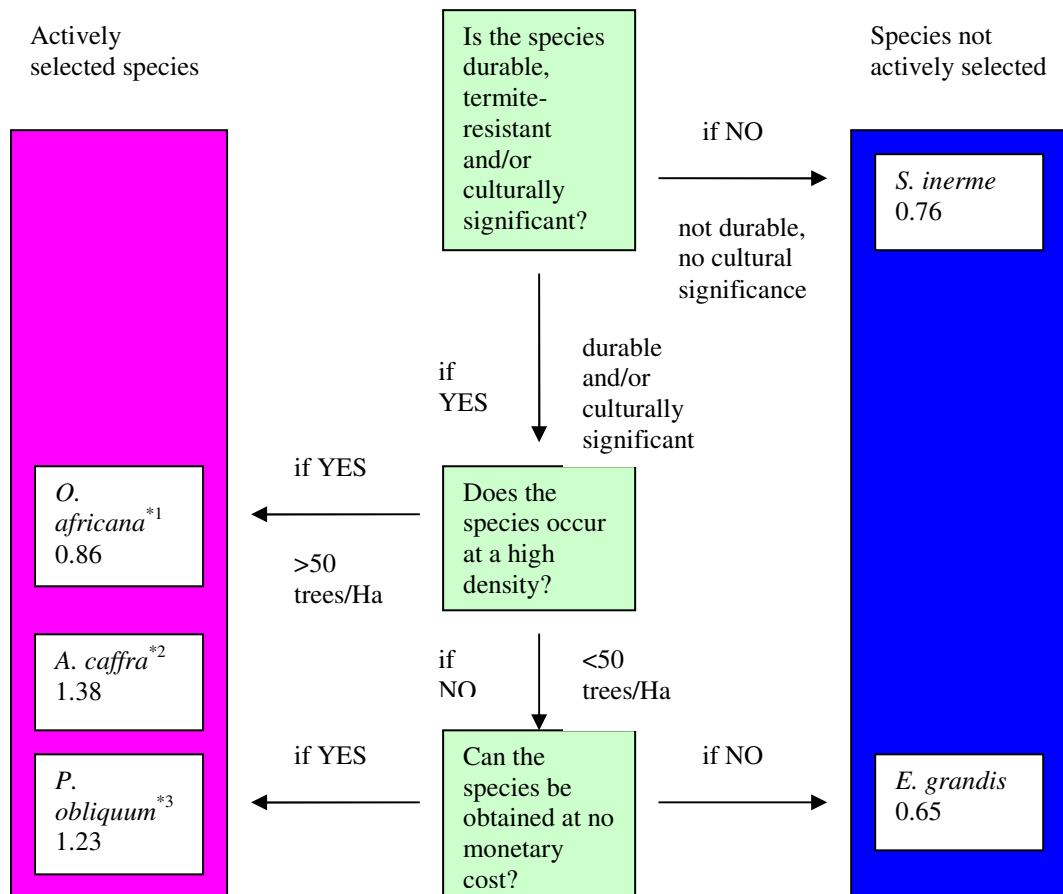


Figure 7.5: Decision tree, showing the trade-offs people made, and the factors that influenced their kraal post species choices (where the pink box represents the species that were actively selected and the blue box represents the avoided species, and their utilisation/availability ratios). *O. africana*<sup>\*1</sup> was more abundant than expected, and possibly sampled at too fine a scale to accurately determine its utilisation/availability ratio. Although *A. caffra*<sup>\*2</sup> and *P. obliquum*<sup>\*3</sup> were scarce, local people continued to harvest these species rather than purchase commercial *E. grandis* posts, which were too expensive.

### 7.3.6 Cross-scale linkages

Supported by Senft et al (1987), there were also cross-scale linkages between the factors that influenced people's landscape and species use patterns. For example, when the preferred species for kraal posts (e.g. *O. africana*) were only found in certain landscapes such as Rodi Farm, species selection for a diversity of the preferred species interacted with people's landscape use choices, such that this landscape was

actively selected by the local users, despite not being stated as preferred for kraal posts.

#### **7.4 Conceptual model (version II)**

In support of the original conceptual model, empirical data showed that the local people's landscape and species choices for fuelwood, brushwood and kraal posts were determined by the trade-off between the returns from harvesting and the accessibility costs of the respective options available to them (Pearce and Turner 1990; Field 2002). However, there were differences in the factors (i.e. benefits and costs) involved in these trade-offs at the landscape and species levels, as well as between the landscapes and species for fuelwood, brushwood and kraal posts, respectively. The factors that influenced people's choices are summarised in Table 7.1.

At the landscape level, the returns from harvesting were determined by landscape quality, as reflected by people's preferences, and density in fuelwood and brushwood or kraal posts (Shackleton et al 1994; Lynam et al 2004). This finding was consistent with the assumptions of the original conceptual model. However, in addition to these factors, the diversity of the preferred species associated with the respective landscape options available to the local people, influenced their choices, particularly with regard to kraal post landscapes (Tilman et al 2005), and was included in conceptual model (version II) (Figure 7.6).

Supported by the original conceptual model, the costs incurred by the local people to access the respective landscapes were determined as a function of their distance from the village (Vermeulen 1996; Kirubi et al 2000; Pote et al 2006), proximity to taboo areas (e.g. sacred areas, neighbouring community land or state forest), associated with the risk of being caught for illegal harvesting (Tabuti et al 2003; Bodin et al 2006), and the steepness of their slopes (Luoga et al 2002), in the case of fuelwood and brushwood landscapes. In contrast, people's landscape choices for fuelwood and brushwood, or kraal posts, were not influenced by their distance from roads/footpaths.

However, in addition to the costs associated with accessing the landscapes themselves, there were accessibility costs associated with the harvesting of fuelwood and brushwood, or kraal posts, from these landscapes, that influenced people's

choices. The additional costs considered the ease with which local people could navigate the respective landscapes, particularly as it related to their densities of fuelwood and brushwood species, which were characterised by sharp branches and/or thorns that hampered people's movements, as well as the ease of collection of these resources (i.e. whether people harvested the wood from trees themselves or collected bundles of pre-cut and dried wood that was ready for use) (Bembridge and Tarlton 1990; Madubansi and Shackleton in press). Consequently, these harvesting costs were included in conceptual model (version II) (Figure 7.6).

Table 7.1: Comparison of this study's findings of the factors that influenced people's harvesting strategies with regard to the landscapes and species they actively selected for fuelwood, brushwood and kraal posts, with the assumptions of conceptual model (version I)

Conceptual model assumptions	Findings supported (Yes/No)	Deviations	Reasons for deviations
People active select the highest quality landscapes and species for fuelwood, brushwood and kraal posts.	Yes, however there were some exceptions at the landscape and species levels.	<p>At the landscape level:</p> <ol style="list-style-type: none"> <li>1) Although not recognised as a high quality landscape for fuelwood and brushwood, Mount Coke was actively selected by the local people.</li> <li>2) Similarly, Rodi Farm was actively selected for kraal posts.</li> </ol> <p>At the species level:</p> <ol style="list-style-type: none"> <li>1) <i>S. latifolia</i> was not actively selected by the local people, although</li> </ol>	<p>At the landscape level, people made trade-offs between the quality of the landscape, and:</p> <ol style="list-style-type: none"> <li>1) The ease of collection of fuelwood and brushwood from the landscape, or</li> <li>2) The risk involved with harvesting kraal posts from the landscape illegally.</li> </ol> <p>At the species level, people made trade-offs between quality, and:</p> <ol style="list-style-type: none"> <li>1) Density of the species (i.e. scarcity).</li> </ol>

		recognised as a high quality kraal post species.	
People actively select the landscapes and species of the highest density for fuelwood, brushwood and kraal posts.	Yes, however there were some exceptions at the landscape and species levels.	<p>At the landscape level:</p> <ol style="list-style-type: none"> <li>1) People actively selected landscapes of intermediate densities for fuelwood and brushwood (e.g. Mbomboyi, Wani, Tyip Tyip).</li> <li>2) Despite the occurrence of landscapes with higher kraal post densities (e.g. Tyip Tyip), people actively selected Rodi Farm.</li> </ol> <p>At the species level:</p> <ol style="list-style-type: none"> <li>1) Local people actively</li> </ol>	<p>At the landscape level, people made trade-offs between the landscapes' density in resources, and:</p> <ol style="list-style-type: none"> <li>1) Accessibility, measured in terms of their distance from the village, proximity to taboo areas and slope, in the case of fuelwood and brushwood landscapes, and</li> <li>2) The ease with which local people could navigate the thorny vegetation preferred for fuelwood and brushwood, or</li> <li>3) Diversity of preferred</li> </ol>

		<p>selected <i>A. caffra</i> for fuelwood, despite it not being the most abundant species.</p> <p>2) Similarly, <i>A. mearnsii</i> was actively selected for fuelwood, but only in Mount Coke.</p> <p>3) <i>O. africana</i>, <i>G. arenicola</i> and <i>S. myrtina</i> were actively selected for brushwood rather than more abundant species such as <i>A. karroo</i> and <i>C. rudis</i>.</p> <p>4) People continued to utilise increasingly scarce populations of <i>A. caffra</i> and <i>P. obliquum</i> for kraal posts.</p>	<p>species for kraal posts.</p> <p>At the species level, people made trade-offs between the density of the species, and:</p> <ol style="list-style-type: none"> <li>1) The cost of commercial alternatives such as paraffin and electricity for fuelwood, commercial brushwood species and exotic kraal post species (e.g. <i>E. grandis</i> posts),</li> <li>2) The ease of collection of fuelwood species, and</li> <li>3) The ease of navigation of brushwood species, characterised by sharp branches and/or thorns.</li> </ol>
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<p>People actively select the landscapes that are nearest the village for fuelwood, brushwood and kraal posts <sup>a</sup>.</p>	<p>Yes, however there were exceptions.</p>	<ol style="list-style-type: none"> <li>1) Despite being situated the furthest from the village, Mount Coke was actively selected as a fuelwood and brushwood landscape.</li> <li>2) Similarly, Rodi Farm was actively selected as a kraal post landscape.</li> </ol>	<p>People made trade-offs between the distance of landscapes from the village, and:</p> <ol style="list-style-type: none"> <li>1) The ease of collection of fuelwood and brushwood from the landscapes, or</li> <li>2) The landscapes' diversity of preferred kraal post species.</li> </ol>
<p>People actively select landscapes that are nearest roads/footpaths for fuelwood, brushwood and kraal posts <sup>b</sup>.</p>	<p>No.</p>	<ol style="list-style-type: none"> <li>1) Distance from roads/footpaths was negatively correlated with the utilisation/availability ratios for harvesting areas of individual users across all fuelwood and brushwood landscapes.</li> <li>2) There was probably no</li> </ol>	<ol style="list-style-type: none"> <li>1) Fuelwood and brushwood were harvested within disturbed areas and on the landscape edges, which were associated with an 'open' canopy vegetation structure. This made it easy for local users to navigate the landscapes</li> </ol>

		<p>correlation between distance from roads/footpaths and the utilisation/availability ratios for harvesting areas of individual users across all kraal post landscapes.</p>	<p>without the aid of access paths.</p> <p>2) Kraal post species occurred within the core woodland areas, far from roads/footpaths.</p>
<p>People actively select landscapes that are associated with the lowest risks for fuelwood, brushwood and kraal posts (e.g. the risk of being caught for illegal harvesting) <sup>c</sup>.</p>	<p>Yes, however there were exceptions.</p>	<p>Despite the risk of being caught for the illegal harvesting of kraal posts from neighbouring community land, people actively selected Rodi Farm rather than landscapes such as Tyip Tyip, which belonged to Machibi.</p>	<p>People made trade-offs between the landscapes' density in kraal posts and the risks involved with harvesting from these landscapes.</p>
<p>People actively select landscapes that are situated on the most gradual slopes for fuelwood, brushwood and kraal posts <sup>d</sup>.</p>	<p>Yes, however there were exceptions.</p>	<p>Ntsunguzi was actively selected for fuelwood and brushwood despite its steep slope, relative to the other</p>	<p>People made trade-offs between the landscapes' accessibility in terms of the steepness of their slopes and</p>

		landscapes.	density in fuelwood and brushwood, where in the case of Ntsunguzi, a relatively low density and 'open' vegetation canopy structure, made it easier for local people to navigate this landscape rather than others.
The cost of alternatives influences people's landscape and species choices.	<p>Yes.</p> <p>At the landscape level:</p> <ol style="list-style-type: none"> <li>1) Mount Coke was actively selected for fuelwood and brushwood over preferred landscapes, Gqumehlo and Makopiyane, because it was easier for local people to collect 'ready to use' exotic wood from the former than to harvest indigenous species from</li> </ol>		

	<p>the latter.</p> <p>2) Despite being situated further from the village, and associated with a greater risk of being caught for illegal harvesting, Rodi Farm was actively selected for kraal posts over preferred landscape, Tyip Tyip, because it exhibited a greater diversity of the preferred kraal post species.</p> <p>At the species level:</p> <p>1) Although expensive, commercial alternatives such as paraffin and electricity supplemented</p>		
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	<p>people's active selection of preferred species, <i>A. caffra</i>, which had become increasingly scarce within the fuelwood and brushwood landscapes.</p> <p>2) Some users elected to purchase preferred brushwood species, <i>A. karroo</i> and <i>C. rudis</i>, rather than harvest them for free from the fuelwood and brushwood landscapes because at high densities, the sharp-branched and spiny vegetation was too difficult to navigate.</p> <p>3) Despite their increasing scarcity, the local people continued to actively</p>		
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	<p>select preferred kraal post species, <i>A. caffra</i> and <i>P. obliquum</i>, which could be harvested for free from the kraal post landscapes rather than use more abundant, commercially available alternatives such as <i>E. grandis</i>, which were too expensive.</p>		
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a-d These factors operated at the landscape level rather than that of the individual species for fuelwood, brushwood and kraal posts.

At the species level, the returns from harvesting were determined by the quality and density of the species (Abbot et al 1997; Kituyi et al 2001; Boudreau et al 2005), which was consistent with the assumptions of the original conceptual model. However, unlike the accessibility costs at the landscape level, the costs of obtaining particular species for fuelwood, brushwood or kraal posts related only to the act of harvesting them. These costs included the ease of collection, in the case of fuelwood species, and the ease with which local people could navigate the 'harsh' vegetation, in the case of the brushwood species (Bembridge and Tarlton 1990; Madubansi and Shackleton in press).

Hence, conceptual model (version II) showed that the trade-offs which governed people's landscape and species choices were more complex than proposed by the initial conceptual model. Improved clarity as to the differences in the benefits and costs involved in these trade-offs at the landscape and species levels, as provided by conceptual model (version II), also allowed for the development of management strategies that were more sensitive to the needs of the local people at these different scales. In turn, the ability to assess people's sensitivity to changes at the landscape and species levels enabled the identification of the landscape as the scale best suited to the management of these natural resources (i.e. fuelwood, brushwood and kraal posts) (see chapter eight).

#### **7.4.1 Linkages and feedbacks in conceptual model (version II)**

Conceptual model (version II) showed that numerous linkages and feedbacks existed between the various components of the socio-ecological system. Supported by Bembridge and Tarlton (1990), Van Eck et al (1997) and Shackleton and Mander (2000), people's preferences for particular landscapes and species (Figure 7.6; Box 1.3) influenced their harvesting strategies (Figure 7.6; Box 2) in terms of identifying the most desired options. However, people's willingness to pay to use the preferred landscapes and species was determined by the trade-off between the benefits obtained from their use, and the costs and risks incurred to do so, where a number of social and ecological factors placed restrictions on people's desires (Figure 7.6; Box 2). Consequently, differences between people's preferences and actual use patterns were not uncommon (Blin and Dodson 1980; Shackleton 1993; Scheepers 2004).

In turn, people's landscape and species choices (reflected by their willingness to pay) influenced their use patterns (Figure 7.6; Box 1.4), and ultimately, impacted on the natural resource base (Figure 7.6; Box 1.1). Supported by previous studies such as Lykke (2000), Shackleton (2000b) and Luoga et al (2003), the local people's previous landscape and species use patterns influenced the future availability of fuelwood, brushwood and kraal post resources.

However, changes in the natural resource base (Figure 7.6; Box 1.1) also interacted with people's patterns of use (Figure 7.6; Box 1.4) and harvesting strategies (Figure 7.6; Box 2) by influencing the ratio of benefits to costs associated with the different landscape and species options. For example, while some users continued to harvest the preferred resources (e.g. *A. caffra* and *P. obliquum* for kraal posts) despite their increasing scarcity, others were prepared to substitute alternatives for the preferred resources (e.g. some users harvested kraal posts illegally from Rodi Farm in response to a decline in the density and diversity of the preferred species within the preferred kraal post landscapes).

Supported by Pearce and Turner (1990) and Field (2002), changes in the natural resource base may also influence people's landscape and species preferences by altering their experiences or perceptions. However, a more long-term study will be required to assess these changes, if any, at Machibi.

In addition, the model recognised that external factors could influence the functioning of the socio-ecological system. Ecological events or surprises such as droughts, floods or biological invasions (Figure 7.6; Box 3) could affect people's natural assets and, in turn, their preferences and use patterns (Biggs et al 2004; Fox 2005). Similarly, socio-economic events and surprises (Figure 7.6; Box 4) such as institutional changes (e.g. in forest laws) or economic changes (e.g. increased wages/incomes) could affect people's social assets and thus, the interactions between people's harvesting strategies and the socio-ecological system (Cundill 2005; Madubansi and Shackleton in press).

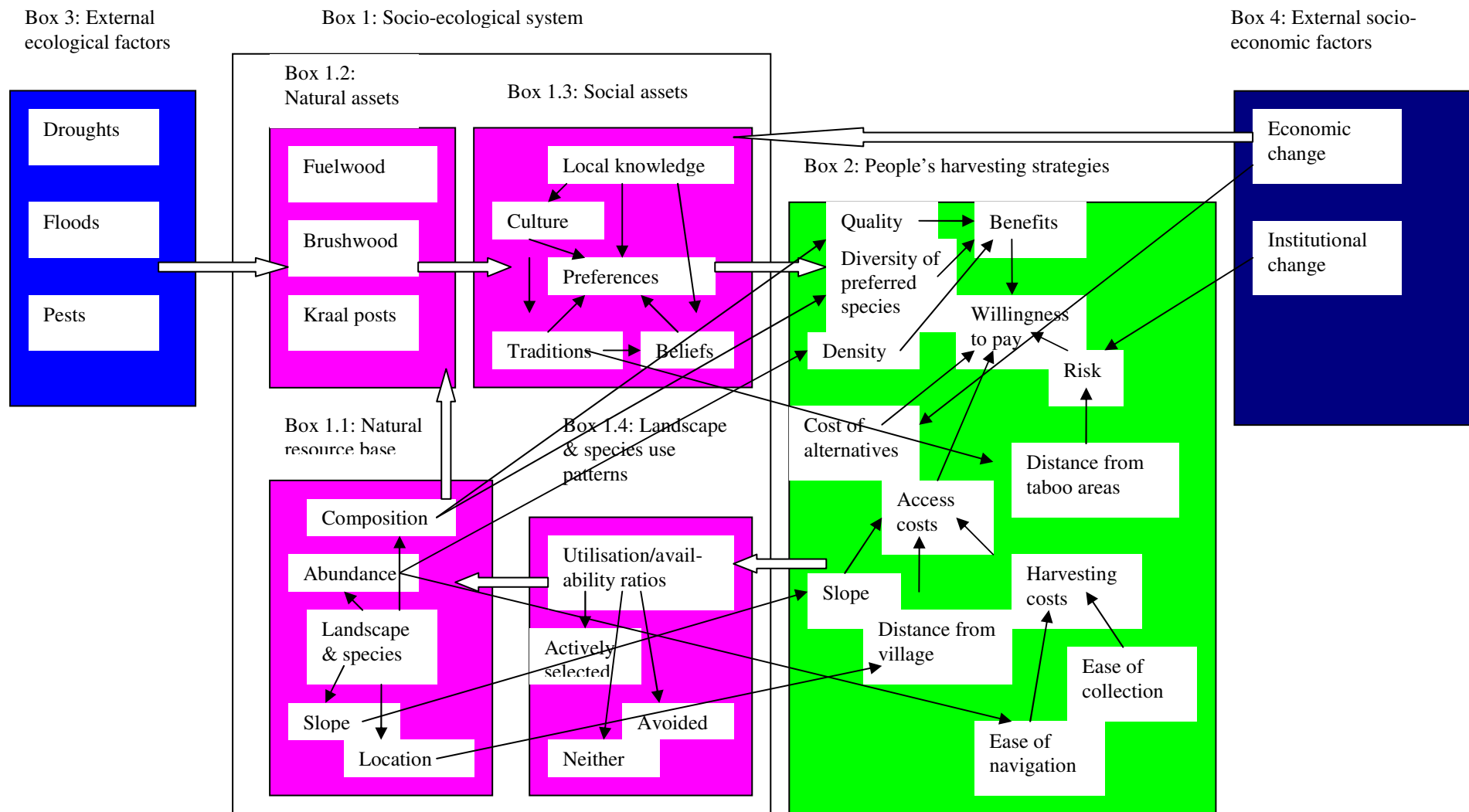


Figure 7.6: Conceptual model (version II), showing how social and ecological factors interact to influence people's harvesting strategies and natural resource use patterns in terms of the landscapes and species they use for fuelwood, brushwood and kraal posts

## **7.5 Conclusion**

This chapter showed that iterative modelling is a useful technique to guide the development of complex system models. The development of a first and second generation model of the harvesting strategies of fuelwood and kraalwood users at Machibi helped to separate the relevant from the irrelevant data, as well as identify new insights into the trade-offs people made, and the factors that influenced their landscape and species choices for fuelwood, brushwood and kraal posts.

## **8. DISCUSSION**

### **Executive summary**

Forests and woodlands provide a variety of natural resources such as fuelwood, timber and fencing to local communities. However, many forests and woodlands worldwide have been unsustainably used and managed. Hence, there is a need for the development of management strategies for these ecosystems. These strategies need to be guided by a sound understanding of how local people determine forest and woodland ecosystems to be of use to them, particularly in terms of the natural resources they provide, and what ‘usefulness’ means to different groups of resources users. To this end, this study aimed to identify which factors influenced people’s landscape and species preferences and patterns of natural resource use at Machibi, Eastern Cape, with a view towards their better use and management. This chapter summarises the trade-offs people made in their landscape and species choices, and discusses the management implications. The strengths and weaknesses of the research approach adopted by this study are also highlighted. Results showed that the development of a conceptual model that integrated social and ecological systems, borrowed paradigms and principles from other fields of study and incorporated different types of knowledge was useful to improve our understanding of the cause and effect connections between people’s preferences, harvesting strategies and resource dynamics, and in turn, inform management recommendations.

### **8.1 Introduction**

Forests and woodlands provide a variety of natural resources such as fuelwood, timber and fencing to local communities (Twine et al 2003; Shackleton and Shackleton 2004; International Institute for Sustainable Development 2005), as well as possess important cultural and spiritual value (Klubnikin et al 2000; Salmon 2000; Bodin et al 2000). However, many forests and woodlands worldwide have been used and managed in a manner which is unsustainable in the long term (Ainslie et al 1997; Lane and McDonald 2002). Consequently, previous studies on the use of natural resources by local communities have documented an increasing scarcity of resources (Ainslie et al 1997; May et al 1997), increased distances covered in search of resources (Gandar 1984; Kirubi et al 2000; Luoga et al 2002), changes in people’s preferences (Shackleton 1993; Scheepers 2004; Pote et al 2006) and the

supplementation of fuelwood and kraalwood resources with commercial alternatives (Mahapatra and Mitchell 1999; Lawes et al 2004; Madubansi and Shackleton in press). Hence, there is a need for the development of strategies for the better use and management of these ecosystems. These strategies need to be guided by a sound understanding of how local people determine forest and woodland ecosystems to be of use to them, particularly in terms of the natural resources they provide, and what 'usefulness' means to different groups of resources users (Chipeta and Kowero 2004).

Therefore, this study aimed to identify which factors influenced people's landscape and species preferences and patterns of natural resource use at Machibi, Eastern Cape. However, in so doing, the study distinguished between those landscapes and species that people most desired to use (i.e. people's preferences), and those that they actually did use (i.e. people's natural resource use patterns) for fuelwood, brushwood and kraal posts, respectively.

A conceptual model of the harvesting strategies of fuelwood and kraalwood users at Machibi was also developed, which emphasized the linkages and feedbacks between the social and ecological systems (Berkes and Folke 1998; Gunderson and Holling 2002; Sendzimir et al in press), and incorporated local and scientific knowledge (Huntington 2000; Lynam et al 2004). This model relied on the concept of an optimal harvesting strategy to explain people's landscape and species choices. Consequently, the model borrowed paradigms and principles from other fields of study such as resource economics, behavioural ecological and wildlife management (see chapter two).

A resource user's 'preference' for a particular landscape or species was defined as the measure of his/her desire to use that resource. This was synonymous with the concept of a 'preference' in the economic sense, as a measure of satisfaction, because it reflected how much he/she 'wanted' to use that resource (Dasgupta and Pearce 1972). Supported by Pearce and Turner (1990) and Field (2002), this definition also allowed that people's experiences with nature, and natural resources, often encoded in their systems of knowledge and belief, culture, traditions, customs and ethics could influence these preferences (Sullivan 1999; Klubnikin et al 2000; Turner et al 2000). However, it differed from the economic definition in that it did not assume a local

user's 'preference' for a particular landscape or species to be constrained by resource limitations (see chapter two).

In reality, this is seldom the case as resources are limited, and people are forced to exercise choice over the landscapes and species they use for fuelwood, brushwood and kraal posts. This choice was determined by the trade-off between the benefits obtained from the use of a particular landscape or species, and the costs incurred to use it (Dusgupta and Pearce 1972; Pearce and Turner 1990; Field 2002). It was in this sense that a 'preference,' in terms of the economic definition, was synonymous with a local user's pattern of natural resource use at Machibi.

However, the level of utilisation or 'active selection' of each landscape or species, as referred to in this study, was determined by its proportional utilisation relative to its availability (Neu et al 1974; Shackleton et al 1994). For example, when a landscape was scarce in a particular resource such as kraal posts, and yet exhibited signs of high utilisation, it was then referred to as 'actively selected'. Conversely, if a particular species was abundant, and could be harvested at a low cost to the resource user, and yet displayed little signs of utilisation, it was regarded as 'avoided' by the local people (see chapter one and chapter two).

By comparing people's preferences with their patterns of landscape and species use, the study then aimed to identify the factors that influenced people's harvesting strategies for fuelwood, brushwood and kraal posts. On the basis of this knowledge, recommendations for the better use and management of these landscapes and species for fuelwood, brushwood and kraal posts were provided.

This chapter summarises the trade-offs people made, and the factors that influenced their landscape and species choices. The management implications of these choices are then discussed, with an emphasis on the differences at landscape and species level. This chapter also highlights the strengths and weaknesses of the research approach adopted by this study with regard to 1) integrating social and ecological systems, 2) the use of 'optimal choice' as a conceptual basis for the harvesting model, and 3) the use of different types of knowledge.

## **8.2 Factors that influenced people's landscape and species choices**

Results showed that people did not always use the landscapes they preferred (see chapter five). For example, Makopiyane was identified as the most preferred landscape for fuelwood and brushwood, followed by Tyip Tyip, Gqumehlo, Mbomboyi, Wani, Qeqe and Ntsunguzi. However, only Mbomboyi, Wani, Ntsunguzi and Tyip Tyip were actively selected by the local people (i.e. their fuelwood and brushwood were used in greater proportion to their availability). This was explained as the local people made trade-offs between the fuelwood and brushwood densities of the respective landscapes (Grundy et al 1993; Lynam et al 2004), and their accessibility, measured in terms of the distance from the village (Vermeulen 1996; Kirubi et al 2000; Pote et al 2006), proximity to taboo areas (Klubnikin et al 2000; Tabuti et al 2003; Bodin et al 2006) and the steepness of their slopes (Rao and Pant 2001; Luoga et al 2002), as well as the accessibility costs as related to people's navigation of the spiny vegetation in order to harvest these resources from the landscapes, in the case of Tyip Tyip.

However, although not identified as a preferred landscape, Mount Coke was also actively selected for fuelwood and brushwood because the local people were permitted to collect bundles of exotic wood from here, which had been cut down by the forestry officials as part of the Department of Water Affairs and Forestry's alien eradication programme, and left out to dry. This facilitated a greater ease of collection of fuelwood from Mount Coke than had the local users to harvest indigenous trees from the preferred landscapes (Madubansi and Shackleton in press).

Tyip Tyip was identified as the most preferred landscape for kraal posts, followed by Mbomboyi, Gqumehlo, Makopiyane, Wani, Ntsunguzi and Qeqe. However, only Mbomboyi was actively selected by the local people. Trade-offs between resource scarcity and institutional controls governed people's kraal post landscape choices such that a decline in the preferred species, and their subsequent disappearance from the preferred landscapes, with the exception of Mbomboyi, explained people's abandonment of these landscapes, in favour of harvesting kraal posts illegally from Rodi Farm (Nagothu 2001; Lawes et al 2004).

Similarly, results showed that people did not always use the species they preferred (see chapter six). However, discrepancies between people's stated preferences and species use patterns were explained by trade-offs between the returns from harvesting, measured in terms of the quality and density of the species (Abbot et al 1997; Kituyi et al 2001; Boudreau et al 2005), and the accessibility costs of harvesting them (Bembridge and Tarlton 1990), or the costs of commercial alternatives (Vermeulen 2001; Madubansi and Shackleton in press). In the case of the fuelwood species, the most abundant, hardwood species in *Acacia karroo* was actively selected for fuelwood (Bembridge and Tarlton 1990; Van Eck et al 1997; Pote et al 2006). *A. karroo* was preferred for fuelwood because this species produced long lasting coals, with more heat and less smoke than softwood species (Abbot et al 1997). However, when the preferred species such as *Acacia caffra* were scarce, the local people harvested smaller quantities (Shackleton et al 2004), and switched from using only fuelwood to using commercial alternatives such as paraffin and electricity in addition to fuelwood (Masera and Navia 1997; Mahapatra and Mitchell 1999; Madubansi and Shackleton in press).

In contrast, the local people purchased the most abundant brushwood species commercially rather than harvesting these species themselves, as it was difficult to navigate the spiny vegetation at high densities without getting scratched or your clothes damaged. However, *Olea europaea subsp. africana*, *Gymnosporia arenicola* and *Scutia myrtina*, which were relatively less dense, were actively selected for brushwood.

In the case of kraal post species, the local people continued to heavily utilise the scarce, preferred species such as *A. caffra* and *Ptaeroxylon obliquum*, obtained for free from certain preferred landscapes (see chapter five) rather than switch to the use of commercial alternatives such as *Eucalyptus grandis* posts, which were more expensive. Some users also harvested the preferred species such as *O. africana* from neighbouring community lands illegally (Nagothu 2001; Lawes et al 2004).

### **8.3 Management implications at the landscape and species levels**

The local people did not always use what they preferred (Shackleton 1993; Scheepers 2004; Pote et al 2006) but were prepared to substitute alternatives when the

accessibility costs of using the preferred landscapes or species became too high (Kirubi et al 2000; Luoga et al 2002), or they were forced to do so due to resource scarcity (Ainslie et al 1997; Madubansi and Shackleton in press). However, there were differences in the management implications at landscape and species level, as the shift from the preferred landscapes and species towards the use of alternatives happened more freely in the case of the former than that of the latter.

This was explained as a wider range of incentives could be employed at the landscape level than the species level. In addition, the incentives at the landscape level could be easily aligned with existing research projects or programmes in the area while those at the species level required future research and feasibility testing before they could be implemented.

The incentives at the landscape level could include a reduction in the accessibility costs associated with the harvesting of resources from the landscapes, for example, by providing pre-cut and dried wood for collection, as in the case of Mount Coke. This incentive could be easily aligned with the existing alien eradication programme of the Department of Water Affairs and Forestry (DWAF) to remove alien species from South Africa's indigenous forests. Another incentive could include promoting the sharing of landscapes and resources between neighbouring communities, as part of the existing participatory forestry monitoring programme already instituted at Machibi between 2001/2002 by DWAF. This incentive could help reduce illegal harvesting and boost the number of landscapes available to all communities during times of scarcity.

At the species level, the local people resorted to the use of commercial alternatives such as paraffin and electricity in addition to their collection of fuelwood when preferred fuelwood species became scarce (Bhagavan and Giriappa 1995; Vermeulen 2001; Madubansi and Shackleton in press). However, these alternatives never completely replaced fuelwood as the primary source of fuel, as they were too expensive. Similarly, most local people avoided the use of commercial alternatives despite an increasing scarcity of the preferred kraal post species over the period from 1960 until 2003, because they were too expensive.

In contrast, some people purchased the most abundant brushwood species commercially rather than harvesting these species themselves, as it was difficult to navigate the spiny vegetation at high densities without getting scratched or your clothes damaged. However, they were in the minority as it was cheaper for people to harvest *O. africana*, *G. arenicola* and *S. myrtina*, which were relatively less dense, than pay for brushwood (see chapter six).

Consequently, monetary incentives in the form of cheaper alternatives to the preferred species were required to influence people's species use patterns. However, the implementation of these incentives will be contingent on future research being done into the feasibility of the use of cheaper forms of energy (e.g. solar power) or timber (e.g. plastic kraal posts) at Machibi.

#### **8.4 Strengths and weaknesses of the research approach**

The conceptual model of the harvesting strategies of fuelwood and kraalwood users at Machibi successfully demonstrated the linkages and feedbacks between the social and ecological systems, and how these relationships influenced people's preferences and natural resource use patterns. The concept of an optimal harvesting strategy also proved helpful in explaining people's landscape and species choices for fuelwood, brushwood and kraal posts.

Furthermore, this study showed why a combination of local and scientific knowledge was better able to capture the dynamic relationships between the local people and their environment than either type of knowledge would have been on its own, as the former could make up for shortcomings in the latter and vice versa. This optimum use of different types of knowledge was particularly useful in the iterative modelling process to identify the factors that influenced people's decisions, and separate the relevant data from the irrelevant data, when scientific measures alone were not adequate.

##### **8.4.1 Integrating social and ecological systems**

People's past experiences and historical perceptions (Pahl-Wostl in press), often encoded in their systems of knowledge and belief, culture and traditions, influenced their landscape and species preferences for fuelwood, brushwood and kraal posts in

terms of what they most desired to use (Dasgupta and Pearce 1972; Pearce and Turner 1990; Field 2002). Thus, landscapes such as Makopiyane, Tyip Tyip, Gqumehlo, Mbomboyi, Wani, Qeqe and Ntsunguzi, which constituted community woodlands that were associated with a long history of natural resource use by the local people, which dated back to the establishment of the village between 1958 and 1960, as a result of Betterment Planning (Rhodes University et al 2000; Cundill 2005), were preferred for fuelwood, brushwood and kraal posts. Similarly, people's local knowledge of the wood-burning properties (Abbot et al 1997; Shackleton et al 2004), or strength and durability of trees and shrubs (Van Eck et al 1997; Shackleton and Shackleton 2000a; Ham and Theron 2001), accumulated over many generations, influenced their preferences for fuelwood, brushwood and kraal post species.

These preferences influenced people's harvesting strategies, and ultimately, their natural resource use patterns. Consequently, the preferred landscapes such as Mbomboyi, Wani, Ntsunguzi and Tyip Tyip were actively selected for fuelwood and brushwood unless people were otherwise persuaded by incentives such as pre-cut and dried wood, as in the case of Mount Coke (see chapter five). At the species level, people continued to actively select the preferred species such as *A. caffra* for fuelwood despite its perceived decline in the fuelwood and brushwood landscapes over the period from 1960 until 2003 (see chapter six), and supplemented their fuelwood supply with commercial alternatives (Vermeulen 2001; Madubansi and Shackleton in press). Fuelwood was not completely replaced as an open fire had significant cultural value as a gathering place for people to talk and celebrate during special occasions, in addition to providing light and heat for cooking, and warmth during the cold winter nights (Masera and Navia 1997; Shackleton et al 2004).

In turn, people's natural resource use patterns impacted positively or negatively on the natural resource base, which had implications for the future availability of fuelwood, brushwood and kraal posts. For example, fast-growing species such as *A. karroo* and *S. myrtina* that were characterised by good seedling recruitment were probably positively affected by increasing disturbance intensity (Obiri et al 2002). This would explain the increase in their abundance across all fuelwood and brushwood landscapes over the period from 1960 until 2003, as perceived by the local people (see chapter six).

In contrast, slow-growing species such as *Schotia latifolia* and *O. africana* that were characterised by poor seedling recruitment were probably negatively affected by increasing disturbance intensity (Obiri et al 2002). Consequently, people perceived a decline in these species across all kraal post landscapes over this period (see chapter six).

However, the natural resource base also interacted with people's patterns of use such that a decline in the preferred species, and their subsequent disappearance from the preferred landscapes, with the exception of Mbomboyi, explained people's abandonment of these landscapes, in favour of harvesting kraal posts illegally from Rodi Farm (Nagothu 2001; Lawes et al 2004). At the species level, an increase in the abundance of *A. karroo* and *Coddia rudis* lead people to purchase rather than harvest these brushwood species themselves, and get injured by their sharp branches and/or thorns.

#### **8.4.2 'Optimal choice' as a conceptual basis for the harvesting model**

The local people behaved in a rational manner by weighing up the returns from harvesting, and the costs and risks associated with the use of the respective landscape and species options available to them, before choosing the option(s) that afforded them the greatest net benefits (Pearce and Turner 1990; Field 2002; Curtis 2004). Consequently, the local people actively selected the preferred landscapes of intermediate fuelwood and brushwood densities and low inaccessibility over the preferred landscapes of high fuelwood and brushwood densities but high inaccessibility (Lynam et al 2004; Tabuti et al 2003; Pote et al 2006). However, in the case of people's active selection of Mount Coke, it was easier to collect fuelwood and brushwood from this landscape than the preferred landscapes such as Gqumehlo or Makopiyane, as the wood had been pre-cut by forestry officials, and left out to dry (see section 8.2). In their choice of kraal post landscapes, the local people were prepared to incur greater travel costs in terms of the distance from the village (Shackleton et al 1994; Motinyane 2001; Pote et al 2006), and take greater risks, associated with the illegal harvesting of resources from Rodi Farm (Nagothu 2001; Lawes et al 2004), in order to obtain a greater diversity of the preferred kraal post species than that which occurred within the preferred landscapes, with the exception of Mbomboyi (Tilman et al 2005).

At the species level, the local people made trade-offs between the returns from harvesting, measured in terms of the quality and density of the species (Abbot et al 1997; Kituyi et al 2001; Boudreau et al 2005), and the accessibility costs of harvesting them (Bembridge and Tarlton 1990), or the costs of commercial alternatives (Van Eck et al 1997; Vermeulen 2001; Madubansi and Shackleton in press). Consequently, the most abundant, hardwood species in the form of *A. karroo*, which produced good quality coals, was actively selected for fuelwood while less abundant, softwood species were avoided by the local people (Abbot et al 1997; Shackleton et al 2004). Thus, when some hardwood species such as *A. caffra* had become increasingly scarce, the local people switched from harvesting only fuelwood to a multi-fuel strategy, thereby optimising their use of different fuels (Masera and Navia 1997; Mahapatra and Mitchell 1999). However, when the commercial alternatives were too expensive, as in the case of kraal post species, the local people continued to actively select the already scarce, preferred species such as *A. caffra* and *P. obliquum*, which could be harvested for free from the kraal post landscapes (Shackleton and Mander 2000; Shackleton et al 2004).

In contrast, the local people purchased the most abundant brushwood species commercially rather than harvesting these species themselves, as it was difficult to navigate the spiny vegetation at high densities without getting scratched or your clothes damaged. *O. africana*, *G. arenicola* and *S. myrtina*, which were relatively less dense, were actively selected for brushwood (see chapter six).

### **8.4.3 Using different types of knowledge**

This study showed that the use of local knowledge to complement scientific knowledge added credibility to the research (Huntington 2000; Lynam et al 2002; Moller et al 2004). Scientific knowledge was developed under a mechanistic view of the natural world, where scientists believed that complex phenomena could be studied and controlled by reducing them to their basic components (Holling et al 1998; Berkes et al 2000). Thus, scientific knowledge was detailed, quantitative and focused on answering very specific research questions.

Local knowledge, on the other hand, focused on the linkages and feedbacks between the local people and the natural environment because of its development under a

holistic worldview, and its reliance on history and comparisons between the past and the present (Mitchell 1997; Pierotti and Wildcat 2000; Kennedy et al 2001). However, because local knowledge was often encoded in a wide variety of everyday social, cultural and belief practices (Nabhan 1997; Berkes et al 2000; Che and Lent 2004), this type of knowledge was less structured and more qualitative than scientific knowledge.

Thus, while scientific knowledge was used to answer specific questions pertaining to the natural resource base (e.g. to calculate utilisation/availability ratios for the landscapes and species for fuelwood, brushwood and kraal posts), people's local knowledge identified linkages and feedbacks between people's preferences, harvesting strategies and natural resource use patterns, which were critical to understanding the system, and making recommendations as to its wise use and management. Consequently, when the utilisation/availability ratios for certain species were brought into question because these species were more abundant than expected, local knowledge, triangulated across multiple sources including ranking exercises, trend-lines and door-to-door interviews with local users, helped shed light on people's patterns of use. Similarly, when scientific measures of the accessibility of the respective landscapes from the village, alone, could not account for discrepancies between people's stated preferences and patterns of use, people's local knowledge regarding the ease of collection of fuelwood and brushwood from these landscapes, and the difficulties associated with trying to navigate the spiny vegetation, helped to make sense of people's choices.

## **8.5 Conclusion**

This chapter reaffirmed that natural resource management problems are complex. For example, people's natural resource use decisions at the landscape and species levels had different management implications. Therefore, the development of conceptual models that integrate social and ecological systems, borrow paradigms and principles from other fields of study and incorporate different types of knowledge are useful to improve our understanding of the cause and effect connections between people's preferences, harvesting strategies and resource dynamics.

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## **Glossary of terms**

**Active selection** refers to the level of utilisation of a particular resource, and is determined by its proportional utilisation relative to its availability (Neu et al 1974; Shackleton et al 1994). *Also see utilisation/availability ratios*

**Albany Thicket Biome** is a dense, woody, semi-succulent and thorny vegetation type with an average height of two to three metres that is relatively impenetrable in its pristine state (Acocks 1953; Everard 1987; Thompson et al 2001).

**Benefit** refers to the gain or satisfaction obtained by the resource user from using a particular resource or good (Dasgupta and Pearce 1972; Pearce and Turner 1990; Field 2002).

**Bounded rationality** refers to a stable set of rules (i.e. rules of thumb) by which consumers, acting with incomplete knowledge, can satisfactorily make decisions towards meeting a specific target (near but not necessarily the optimal choice) (Gans 1996; Sent 2004).

**Brushwood** refers to the branches of woody tree or shrub species that are loosely piled on top of each other or compacted to construct the sides of the kraal (Scheepers 2001; Pote et al 2006).

**Buffels Thicket** is characterised by short, dense and tangled thicket stands which can reach up to 10 m, and occurs along the slopes of river valleys within highly dissected, hilly parts of the former Transkei (Mucina and Rutherford 2006).

**Conventional consumer behaviour theory** assumes that consumers will choose the option that affords them the highest benefits (after cost deductions) when faced with trade-offs between choices (Turner et al 1994; Ward and Beal 2000; Field 2002). *Also see rational choice*

**Cost** refers to the price or penalty incurred by the resource user to use a particular resource or good, and can be monetary, the opportunity cost of their time or a travel cost (Dasgupta and Pearce 1972; Pearce and Turner 1990; Field 2002).

**Forest (vegetation)** is a multi-layered vegetation unit, dominated by trees (largely evergreen or semi-deciduous) and possessing a canopy cover of greater than 75 percent, where graminoids in the herbaceous stratum (if present) are generally rare. Stand height ranges from high forest (i.e. over 30 m) to scrub forest (i.e. over 3 m) (Mucina and Rutherford 2006).

**Formal knowledge** is knowledge accumulated through applied learning and education within formal institutions such as schools and universities (Colley et al 2002).

**FOz 5 Scarp Forest** forms part of the Transkei Coastal Belt and typically occurs as a series of scattered, small to very small forest patches (i.e. less than 10 ha), embedded within a broader landscape dominated by another vegetation type e.g. thicket or grassland. **FOz 5 Scarp Forest** makes up small forest patches confined to steep river valleys along the Transkei Coast, including parts of Mount Coke State Forest (Mucina and Rutherford 2006). *Also see Transkei Coastal Belt*

**Fuelwood** consists of the stems or stout branches of woody tree and shrub species that are used as fuel for cooking and heating purposes (Bembridge and Tarlton 1990; Dyer 1996; Shackleton 1993; Motinyane 2001).

**Informal knowledge** is knowledge accumulated through informal processes and practical experiences outside of a formal learning setting (Colley et al 2002).

**Knowledge** is defined as as 1) the fact or condition of knowing something with familiarity gained through experience or association, 2) acquaintance with or understanding of a science, art, or technique, 3) the range of one's information or understanding and 4) the sum of what is known: the body of truth, information, and principles acquired by humankind (Merriam-Websters dictionary 2006). Knowledge can also be referred to as a construction of a group's perceived reality, which the group members use to guide behaviour toward each other and the world around them (Ericksen and Woodley 2004).

**Kraal** is synonymous with livestock corral (Stevenson 2006).

**Kraal posts** constitute the stems or stout branches of trees that are set vertically at kraal entrances, and used intermittently along the sides of the kraal to reinforce the packing material or brushwood (Scheepers 2001; Pote et al 2006).

**Kraalwood** refers to the wood used in the construction and maintenance of livestock corrals or 'kraals'. Based on the form and structure of a typical Xhosa kraal, kraalwood is made up of brushwood and kraal posts (Scheepers 2001; Pote et al 2006). *Also see 'brushwood' and 'kraal posts'*

**Landscape** is used in the generic sense of the term to refer to various forest and woodland patches, differing across a number of social and ecological characteristics, used for the harvesting of fuelwood, brushwood and kraal posts by the local people of Machibi.

**Local knowledge** is an example of informal knowledge that is accumulated through cultural transmission, about the relationship humans have with one another, and their surrounding environment (Berkes and Folke 1998; Berkes et al 2000). Local knowledge is also sometimes referred to as traditional knowledge (Huntington 2000; Klubnikin et al 2000; Turner et al 2000). *Also see informal knowledge*

**Optimal foraging theory** predicts that animals behave in a particular manner so as to maximise some increasing function of expected benefit and decreasing function of expected cost (Hutchinson and McNamara 2000; Kacelnik and Marsh 2002).

**Preference** is a measure of satisfaction that reflects a resource user's 'want' or 'desire' to use a particular resource (Dasgupta and Pearce 1972), and need not be constrained by resource limitations.

**Rational choice** assumes that a consumer weighs up the costs and benefits associated with different resource use options in order to determine the option with the highest net benefits (i.e. the optimal choice) (Turner et al 1994; Ward and Beal 2000; Field 2002).

**Scientific knowledge** is an example of formal knowledge accumulated through a series of systematic observation and inquiry with the help of logical and empirical methods, and subject to strict standards of scientific objectivity and quality, enforced through a peer review process (Mitchell 1997; Holling et al 1998; Ericksen and Woodley 2004). *Also see formal knowledge*

**Thicket (vegetation)** is characterised as very dense, tangled vegetation usually formed by low or tall shrubs and some trees (Mucina and Rutherford 2006), with a total tree canopy cover of greater than nine percent, and canopy height of between two and five metres (Thompson et al 2001).

**Thornveld (vegetation)** is defined as woodland savanna dominated by trees with thorns, mainly *Acacia* species (Mucina and Rutherford 2006).

**Traditional ecological knowledge (TEK)** refers to local knowledge concerning the natural environment and natural resources (Berkes and Folke 1998). *Also see local knowledge*

**Transkei Coastal Belt** is a narrow coastal strip consisting of a mosaic of grassland vegetation on the hill tops and upper hill slopes, alternating with bush clumps and small forests occurring along the steep river valleys of the highly dissected, hilly landscape, which extends along the Wild Coast of Transkei and the Indian Ocean seaboards between Port St Johns in the north and the Great Kei River in the south (Mucina and Rutherford 2006).

**Usefulness** is defined by the criterion/criteria for which a resource is judged to have a certain property (More et al 1996).

**Utilisation/availability ratios** are synonymous with ‘preference ratios’ (Neu et al 1974; Shackleton et al 1994), where a resource is regarded as ‘actively selected’ when used in greater proportion to its availability, and ‘avoided’ when used in smaller proportion to its availability.

**Willingness to pay** is a measure which takes into account the trade-off between the benefits obtained from the use of a particular resource, and the costs incurred to use it. Therefore, this measure aims to capture a resource user's willingness to pay to use a particular resource, but should also reflect their ability to do so (Pearce and Turner 1990).

**Woodland** can be used synonymously with 'savanna' to describe a vegetation type which is a mix of grasses and trees. 'Savanna' is typically characterised as vegetation with a grass-dominated herbaceous layer and scattered low to tall trees. It includes closed woodland and open woodland (Shackleton and Mander 2000; Mucina and Rutherford 2006).