An analysis of ecological and anthropogenic interactions with *Juniperus procera* through the elicitation and representation of local ecological knowledge

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Abstract

The Bale Mountains of Ethiopia are the largest area of Afromontane habitat on the African continent, a unique biodiversity hotspot, and host to numerous endemic species. Forests in which *Juniperus procera* are the dominant species are under increasing pressure from unsustainable utilisation and land use conversion, threatening the long term viability of the natural resource base. As local communities who depend heavily on them harvest the increasingly degraded *J. procera* populations, the borders of agricultural expansion are pushed into higher and higher altitudes.

The Bale EcoRegion Sustainable Management Programme (BERSMP) is attempting to address the issues underlying unsustainable forest utilisation through the development of participatory natural resource management programmes. Under such an arrangement the local communities negotiate user rights to the forests and the responsibility for the sustainable management of the forests is transferred to them.

The aim of the research was to systematically acquire and represent local ecological knowledge about ecological and anthropogenic interactions with *J. procera* around the town of Goba in the Bale Zone. A series of semi-structured interviews and focus group discussions were conducted in three villages close to the mountainsides and remnant *J. procera* popuations.

The study found that local people had knowledge of a range of factors that affect the growth and regeneration of the species, as well as an understanding of different management practices. It is anticipated that the results of the research will aid the development of forest management plans.

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AKT	Agroecological Knowledge Toolkit
APF	African Parks Foundation
BERSMP	Bale EcoRegion Sustainable Management Programme
CBD	Convention Biological Diversity
CBNRM	Community Based Natural Resource Management
DBH	Diameter Breast Height
FGD	Focus Group Discussion
FZS	Frankfurt Zoological Society
IUCN	International Union for the Conservation of Nature
NGO	Non Governmental Organisation
PFMP	Participatory Forest Management Programme

1 Introduction

1.1 Context

1.1.1 Conservation versus utilisation in Ethiopia

The Bale mountains of Ethiopia are a unique biodiversity hot-spot, host to a significant number of endemic species, with pressing conservation issues as forest resource extraction by local communities who depend heavily on them helps to push the borders of agricultural expansion and livestock grazing into higher altitudes and increasingly degraded forests. In July 2006, the Bale EcoRegion Sustainable Management Programme (BERSMP) was launched, which aims to protect the Bale Mountains eco-region and ensure the economic and social well-being of communities dependent on the ecosystem's natural resources (FARM-Africa, 2007a). Nationally, the Ethiopian government and various environmental agencies grapple with the problem of 'protecting' or 'preserving' areas of immense natural beauty and ecological significance whilst honoring the eighth article of the Convention of Biological Diversity by allowing local communities to benefit from the land and natural resources. Mechanisms to control resource use such as laws preventing the cutting of trees or the establishment and maintenance of protected areas and National Parks render activities and entire communities illegal, and their effectiveness is questionable due to the difficulties and expense of enforcing them. Such polices provide a disincentive to long term management by local people because with no security of future access, investment in sustainable practices is an unattractive option for communities living close to the poverty line. Not exploiting the natural resources is an issue of survival.

The gazettement of National Parks and priority forest areas is a major conservation issue in Ethiopia, as most areas established as national parks some decades ago have never been legally accepted by parliament, their boundaries not drawn and inventories not taken. In recent years the Ethiopian government has signed contracts with external agencies to manage a number of national parks and in some cases gazettement took place prior to this. Refugees International (2005) reported that following the Dutch charity African Parks Foundation (APF) signing

an agreement to manage the Nech Sar National Park in 2004, 463 houses of the Guji people were burned down by Ethiopian park officials and police. In 2006, APF took over management of the Omo National Park after the government had demarcated the borders, amidst fears that "an estimated 40,000 tribal people are in danger of being displaced and/or of losing access to their vital subsistence resources" (Native Solutions for Conservation Refugees, 2007a).

Less publicity surrounded the agreement between the Ethiopian government and Frankfurt Zoological Society to manage the Bale Mountains National Park in 2004, where the process of gazettement is yet to take place. When it does, and if the process of excluding local people from it is successful, it may be expected that the pressure on the natural resources outside of the park will increase. This includes the study area of the research.

An alternative approach to conserving the natural resources by restricting use and access by local communities is that of participatory management. Under such an arrangement, local people negotiate user rights to, and management plans of, the natural resources with the local civil administration. In various parts of Ethiopia and West Africa, two non-governmental organisations (NGOs), FARM-Africa and SOS Sahel, have facilitated the development of Participatory Forest Management Programmes (PFMPs). According to FARM-Africa (2007b), PFMP has been proved not only an efficient tool to reduce deforestation, but also as a means of contributing to livelihood and biodiversity conservation and improved local governance. In the last decade, the effectiveness of these projects has pushed participatory management further up the agenda of the Ethiopian government, and in March 2007 the President of Ethiopia delivered the opening address at an international Participatory Forest Management, Biodiversity and Livelihoods conference (FARM-Africa, 2007c).

1.1.2 The Bale EcoRegion Sustainable Management Programme

The Bale EcoRegion Sustainable Management Programme (BERSMP) is a six year project that is run by a partnership between FARM-Africa, SOS Sahel and the Ethiopian government. It aims to enable local people to make livelihood

choices which facilitate long term sustainable management of the natural resource base, through participatory methods and practices, and to secure their rights of access.

BERSMP's (2007: 2) current assessment of the situation in the study area is that a *de facto* open access resource management regime exists, with no land use management plans. Further, there is no control of resource use and land use rights and ownership is confused. "Rapid immigration with unplanned and unrestricted settlement is a significant and mounting problem".

Alongside the necessity of sustainable livelihood development in the area, the ecological significance of the Bale Zone provides a major justification for the programme, particularly the issue of watershed management. Water that originates in the Bale massif supplies an estimated 12 million people in the lower altitude areas of Ethiopia, Somalia and Kenya (BERSMP, 2007).

1.1.3 J. procera in the Bale Zone

The Bale Mountains are the largest single area of Afroalpine habitat in Africa and forests in which *J. procera* is the dominant species cover large areas of the region. The forest area is decreasing as more land is cleared for agricultural expansion, and the remaining forests becoming increasingly degraded as they are harvested for construction and firewood, an important source of income for local people, despite a prohibition on cutting the trees. According to Borghesio *et al* (2004) over-exploitation of the resource presents a significant threat to the continued existence of the juniper forests.

J. procera is included on the IUCN red list of endangered species, and the ecological and economic importance of the juniper forests of Ethiopia has resulted in a great interest in their restoration (Tigabu *et al*, 2006).

1.1.4 Local Ecological Knowledge

The use of local ecological knowledge (LEK) in development projects with a natural resource management component has gradually become more widespread, but it has yet to be formally and systematically incorporated into such projects as a matter of course. Although it would be difficult to argue that the ecological knowledge held by a local community should be disregarded in a project with a sustainability and participatory emphasis, the issues of how and to what extent it should be incorporated into, or indeed provide the foundations for, developments in natural resource management are not clear cut. The acquisition and representation of LEK is rarely a priority for NGOs that work with local communities; consequently its potential utility value is often unrealised, although it may implicitly constitute an element of the project.

1.2 The research

1.2.1 Rationale

The *J. procera* forests of the Afromontane areas of Ethiopia have considerable economic value at a local and national level, whilst their ecological importance is an issue of global concern. According to Amente (2005), sustainable forest management is necessary in Ethiopia to achieve security in food supply for its citizens.

There are significant uncertainties regarding issues relating to the regeneration of *J. procera* within the scientific community and provenance appears to influence the characteristics of the species. The literature also points to the absence of silvicultural knowledge about the natural forests of Ethiopia (Moges & Hunde, 2002; Pohjonen & Pukkala, 1992). Through the formal acquisition and representation of local knowledge of ecological and anthropogenic interactions with *J. procera* in the study area, a basis for future collaboration between local communities and scientists about an uncertain ecological phenomenon can be established.

Irwin and Mitiku (2004) note that in the Borena region of Ethiopia the local community have observed associations between *J. procera* regeneration and the presence of other species and with shade. They recommend that joint research or community based research is undertaken to investigate these observations and explore the ecological processes underway.

Local ecological knowledge has a key role to play in sustainable natural resource management programmes, particularly where these involve complex forest ecosystems which provide products essential for the livelihoods of local communities. The research will contribute to the capacity of the Bale EcoRegion Sustainable Management Programme to benefit from the knowledge that local people have about the resource and to enable local knowledge to feed into adaptive management.

1.2.2 Objectives

1. To examine ecological and anthropogenic interactions with *J. procera* in the Bale Zone through the elicitation and representation of LEK using the software the Agroecological Knowledge Toolkit (AKT).

2. To investigate the opportunities and constraints for NGOs who work within a participatory framework to incorporate formal LEK acquisition into natural resource management programmes.

1.2.3 Questions

1. What do local people know about ecological and anthropogenic interactions with *J. procera* in the study area?

2. Is this knowledge relevant for a participatory natural resource management project working with local people?

3. How can it be successfully incorporated into the project?

4. What are the associated problems, risks and opportunities?

2 Literature Review

The relevant literature for the research project covers a range of topics. Below is a review of some of the material relating to the debate surrounding conservation and the right to use natural resources by local communities; forests and forest management in Ethiopia; the species *Juniperus procera* in Ethiopia, and an examination of some issues raised in the elicitation and representation of local ecological knowledge.

2.1 Approaches to natural resource management

2.1.1 Conservation versus utilisation

The theory and practice of conservation has shifted significantly over the last century, since authorities in former African colonies began to designate the first protected areas. Much of the discourse that has prevailed since then has begun to be viewed as inextricably linked to the colonial experience (Adams and McShane, 1992, cited in Fisher et al, 2005), and the idea that many areas in the global South were 'pristine' and untouched by human interference has gradually been discredited. Places viewed as 'virgin' lands began to be seen as 'widowed' ones, left behind after the death of indigenous peoples (Pretty, 2002), as in many areas of North and South America, where the indigenous inhabitants rapidly died out following the arrival of the white man. The perception of the land as *terra nullius* suited the vested interests of the colonisers (Maffi, 2004).

The biodiversity that exists in places previously viewed as untouched is now, amongst natural and social scientists alike, increasingly considered a product of humans' interaction with nature, of anthropogenic relationships but not anthropocentric ones. Within this context, the logic of excluding indigenous inhabitants and their activities from areas in order to protect them has been questioned and, in some cases, the policy proved counterproductive. Parks in Kenya from which the Maasai have been expelled are increasingly being taken

over by scrub and woodland, resulting in a decrease in grazing land available for antelopes (Adams and McShane, 1992, cited in Pretty, 2003).

Throughout the 1960s and 1970s, however, indigenous people and their practices, such as grazing and shifting cultivation or 'slash and burn' agriculture, were widely regarded as a threat to the environment (Fisher *et al*, 2005). Such perceptions fuelled preservationist approaches to conservation and the establishment of protected areas, parks and reserves, from which local people were excluded. Militaristic tactics were employed to enforce exclusion. Fisher *et al* (2005: 21) cite a number of consequences for rural resource users: forced (sometimes violent) resettlement; prohibited or restricted access to livelihood resources; the break up of communal lands; the collapse of indigenous management systems and social structures; fines and imprisonment and increased social conflict and famine. Such consequences, in addition to constituting gross human rights violations, can hardly be considered to have had a positive impact on the environment, especially if the landscape is viewed as a whole rather than solely the areas within protected area boundaries.

According to Native Solutions to Conservation Refugees (2007b), an organisation established in response to APF taking over management of the Omo national park, conservation rivals resource extraction as the greatest force displacing indigenous people.

Excluding people from using natural resources without providing them with an alternative source of livelihood came to be viewed as ethically unjustifiable and politically infeasible (Brandon & Wells, 1992), although in practice this political and ethical imperative was often ignored (Fisher *et al*, 2005). In the 1980s, the interdependency of conservation and development became more widely recognised and Integrated Conservation and Development Projects (ICDPs) ensued, along with projects encompassing Community Based Natural Resource Management (CBNRM).

According to O'Riordan (2002: 13), "biodiversity cannot be maintained by protection alone: it requires the infusion of more comprehensive ecosystem management". But protected areas continue to constitute a major element of

conservation internationally. Different categories of protected areas, defined at the World Conference on National Parks and Protected Areas in 1992, have different degrees of 'protection', ranging from complete exclusion of local communities to those in which degrees of exploitation is permitted. The three categories of protected areas from which local people are not permitted any access to local resources comprises 46% of the 6.07 million km² land designated in Africa, Asia and Latin America (Pretty, 2002).

The proceedings of various international conferences and the development of action plans and treaties to enshrine the rights of local people within conservation measures and to link sustainable development with environment protection have laid the foundations for future developments. The United Nations Conference of the Environment and Development Earth Summit in Rio de Janeiro in 1992 gave rise to both Agenda 21 and the Convention on Biological Diversity (CBD). Agenda 21 addresses social and economic dimensions as well as the conservation and management of resources for development.

Growing realisation that local practices and ecological knowledge had much to contribute to the conservation of biodiversity and the sustainable use of natural resources (Maffi et al, 2000) have resulted in the 'ecologically noble savage' (Maffi, 2004) challenging the ignorant and primitive tribal stereotype. Article 8(j) of the CBD obliges signatories to "respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity… and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices."

However, it could be questioned whether such traditional lifestyles are still alive in much of the world today, the last century having witnessed social upheaval on a massive scale in many areas of the global South. Conflict, migration, loss of access to land and the penetration of market forces have eroded traditional systems of social organisation and resource management along with the ecological knowledge underlying them. Research has linked unsustainable human-environment relationships with rapid socioeconomic and cultural change (Maffi, 2004).

Though purist ecologists and anthropologists alike may set themselves at opposite sides of practical and theoretical approaches to conservation, neither the perception of local people as threats to nature or as environmentally benign traditional communities which simply need to be left alone in order to thrive is particularly realistic or useful. Substantial threats to the well-being of people as well as the environment demand international intervention, but coercive policies dictated by outsiders are doomed to failure (Adams and McShane, 1996, cited in African Studies Review, 1998). As Maffi (2004) points out, it is not a debate that should take place "over indigenous peoples' heads"; the issue is one of how to increase participation and the self-determination of local people.

2.2 Ethiopia

2.2.1 Conservation

A report on the Conservation Strategy for Ethiopia Project explicitly refers to the pressure exerted by external agencies, namely the World Bank, in attempting to shape the environmental strategy of the country, which included threats to block loans in 1995 if Ethiopia's environmental planning process was not completed within an imposed time scale. The report concludes: "The world needs some mechanism of restraining the global elite not only from polluting and degrading the earth themselves, but also from the use of their influence to penetrate, displace and degrade local and indigenous established systems different from their own, where such local systems are compatible with sustainable development."

However, the above rhetoric sounds rather hollow in the face of the willingness of the Ethiopian government to sign away management of National Parks to external agencies, such as the African Parks Foundation and Frankfurt Zoological Society, and the consequent application of diverse strategies in those areas which suit the managing organisations.

Area closure, the upgrading of two control hunting areas to national parks and the establishment of one new national park are cited as measures taken within the framework of the National Action Plan to combat desertification in Ethiopia's

third national report on the implementation of the United Nations Convention to Combat Desertification (EPA, 2004). Such policies are indicative of a protectionist conservation approach, whilst in other areas, the Ethiopian government's engagement with participatory natural resource management projects signals support for community based conservation and livelihood development.

2.2.2 Forests and forest management

Statistics on the extent, standing volume and growth and depletion rates of Ethiopian forests are inadequate, inconsistent and dated (Ethiopian Ministry of Agriculture, 1998). Ethiopian natural forests are estimated to have decreased from 40% of initial land coverage to 2.4% (EPA, 1998), with an annual depletion rate of 0.8% (FAO, 2001a, cited in Amente, 2005)

Wood fuel remains the most important source of energy in the country, accounting for 78% of total energy consumption, and demand for wood greatly exceeds that which the forest resources can sustainably supply (Amente, 2005). More than 90 % of the domestic supply of industrial wood and firewood comes from natural forests (Thomas and Bekele, 2003).

As one of the poorest countries in the world (World Bank, 2007), and one which has suffered persistent food insecurity, the implications of Ethiopian forest degradation and deforestation for the communities which depend on them are severe. Deforestation is recognised as one of the most important factors to have increased the vulnerability of the population to food shortages (Amente, 2005). According to the Ethiopian Environmental Protection Agency "Ethiopia's largely poor rural population, driven by poverty, attempt to satisfy their survival needs through the clearing of more forest land for agricultural purposes" (EPA, 1998: 29). Alongside poverty, population growth is also cited as one of the main causes of deforestation (Amente, 2005).

Despite the importance of Ethiopian forests to her rural communities, the formal economic contribution of forestry is relatively insignificant. Between 1982 and

1992, forestry accounted for 2.5% of the total GDP[1] (EARO, 2001, cited in Thomas and Bekele, 2003).

Social upheaval in Ethiopia has exacted a heavy toll on the natural resource base. Revolutionary changes of government took place as Haile Selassie's empire was replaced by the military regime of the Derg in 1974, which was in turn succeeded by the present Ethiopian People's Revolutionary Democratic Front (ERPDF). The Derg overhauled the land ownership system and carried out large scale resettlement programmes, which resulted in the breakdown of former systems of natural resource management.

The period of transition from the Derg to the EPRDF between 1991 and 1994 has been cited as an era with particularly high rates of deforestation: "new government structures and controls were not in place and the former community-based institutions, suppressed under the Derg, no longer functioned. Forests became open access; in combination with population growth, a worsening economic situation and communities' retaliation against the Derg's restrictions, this led to rapid uncontrolled forest destruction" (Bradstock *et al*, 2007).

Land in Ethiopia was nationalised by the Derg, who designated 58 national forest priority areas and 6 National Parks. However, the boundaries of most of these areas have still not been accepted by parliament, a process known as gazettement (Amente, 2005).

Following decentralisation of power to regional states in 1994, responsibility for managing the natural resources of the country was devolved to regional states (Amente, 2005). A forest conservation, development and utilisation proclamation was issued, which provided that the sustainable utilisation of the country's forest resources should involve the participation of the people and benefit the communities concerned, and also included the prohibition of excess resource extraction and land use conversion to farming and grazing in the priority forest areas (Amente, 2005). Eviction without the agreement of those affected was also prevented under the proclamation (Alden Wily, 2002).

[1] These figures should be considered as an underestimate due to lack of available economic data and the fact that non-marketed forest products are not reflected in the national accounts.

Oromia regional state produced its own regional forest proclamation in 2003, which stipulates community-based forest management as a strategy for forest conservation and states that "delineation, demarcation, development, protection, rehabilitation and management of protected areas shall be done with the participation of the local communities" (Amente, 2005: 15).

Amente (2005) notes that throughout the country forests placed under community management are mostly degraded and less productive, and that transforming them into productive forests that meet the needs of the community necessitates the development of new silvicultural techniques and practices. However, according to Moges and Hunde (2002) knowledge and experience of the silviculture of Ethiopia's natural forests is completely lacking.

In Amente's (2005) opinion, most remaining natural forests in the country are suffering from open access type of use; attempts to restrict access by local communities has resulted in people utilising forests illegally and unsustainably, as future access is uncertain.

According to FARM-Africa (Bradstock *et al*, 2007), the proclamation of 1994 set the groundwork for participatory approaches, but explicit policy supporting Participatory Forest Management (PFM) is not yet in place. In 8 of the 58 designated forest priority areas PFM is being trialled and in two areas the projects are under government management. Implicit support by the Ethiopian government for participatory natural resource management was demonstrated by the President delivering the opening address at the Participatory Forest Management, Biodiversity and Livelihoods conference in March 2007.

The FARM-Africa publication "From Grassroots to Government" outlines the PFM approach. This involves Forest Management Plans and Forest Management Agreements being drawn up between local communities and the government that define rights of forest use and allocate management responsibilities. Communities with the rights to use the resource take legal responsibility for managing it, and forge an effective partnership with the government, who provides technical support and an enabling environment. Management actions

taken by the community include forest protection, harvesting and monitoring. Both the government and the community assume new roles and activities, with capacity building constituting an integral element of the project. "A central tenet of the approach is that people will conserve forests if they own rights to the resource, if they gain more benefit by retaining the forest than by removing it, and if that benefit is linked directly to the existence of the forest" (Bradstock *et al*, 2007: 27).

2.3 Juniperus procera[2]

2.3.1 Characteristics and distribution

Juniperus procera Hocht. Ex. Endl., one of two conifers indigenous to Ethiopia (Pohjonen & Pukkala, 1992) and the only *Juniperus* species occurring in Africa (Couralet *et al*, 2005), once covered large areas of mountain forests in the country, but its populations have decreased in line with the deforestation that has taken place over the last century (Pohjonen and Pukkala, 1992). Changing land use patterns and the change from indigenous tree species to fast-growing exotics in plantation forestry (Hall, 1981) has resulted in severe genetic depletion of the species (Wubet et al, 2006). According to Mamo *et al* (2006: 320) "juniper populations are extremely small and fragmented in its natural habitat due to anthropogenic disturbance (mainly logging)".

The tallest known *Juniperus* tree, *J. procera* is reported to reach up to 50 metres, but most are commonly 30–40m in height, and on favourable sites about 2.0–2.9m diameter at breast height (Hall, 1981; Pohjonen & Pukkala, 1992). *J. procera* is a dioecious, evergreen, afromontane species, occurring at an altitudinal range of 1050-3500m, though most occur between 1800-2700m (Wubet *et al*, 2006). Its distribution pattern appears unique amongst African trees (Hall, 1984), spreading

[2] Within the scientific community some debate occurred in the 1980's about whether the African species *Juniperus procera* is distinct from *Juniperus excelsa*, which occurs in Europe and Asia. Genetic differentiation appears to have resolved this issue, and *J. procera* remains a recognised species. However, the literature cited in this review includes articles that refer to *J. excelsa* where the trees referred to are located in the African continent.

from Eritrea, Sudan and Ethiopia to as far south as Malawi and Zimbabwe, where occurrences of the tree are rare.

Pollen analysis indicates that *Juniperus* occurred on the Ethiopian Plateau over 2 million years ago (Bonnefille, 1976, 1983, cited in Hall, 1984), and the species has been dated in the Bale Mountains at 3700 BP (Coetzee, 1967; Hamilton, 1982, cited in Hall, 1984). Pohjonen & Pukkala (1992) cite the stands in the Bale Mountains as one of only three notable, natural, older *J. procera* forest areas in the country.

The trees are mainly found in drier mountainous regions, with an annual rainfall of ca 450-1200mm and a pronounced dry period (Hall, 1981; Friis, 1992). Interactions with rainfall and topographic features are important in the distribution of the species; extensive blocks of forests where *J. procera* is dominant are always on the rain shadow sides (Hall, 1984). The species grows where the risk of water stress is high and in areas where mean annual temperature is less than <19°C (Hall, 1984). Competition from broad-leaved species reduces the prevalence of the tree under more equable conditions (Hall, 1984).

According to Wubert *et al* (2006), "The adaptability of this tree to less favourable site conditions at higher altitudes and the value of its timber justify its cultivation in spite of its relatively slow growth". The slow growth of the tree limits its potential as a commercial species (Pohjonen & Pukkala, 1992), particularly in comparison to *Eucalyptus spp.*, a popular exotic commercial tree in Ethiopia. The maximum mean annual increment (MAI) of *J. procera* is estimated by Pohjonen & Pukkala to be about 7.5$m^3 ha^{-1}$ at age 50-60 years. Their study found that this was not sensitive to rotation length. At the age of 120 years the current annual increment (CAI) was found to fall to below 3.5$m^3 ha^{-1}$.

Sharew *et al* (1997) claim that *J. procera* has a role in ameliorating the climate in semi-arid areas. This perception is echoed by the user groups in Amente's (2005) research, who, he reports, believe that the forests in which *J. procera* is dominant play a significant role in improving the local climate, resulting in a stable rain distribution.

The durability of *J. procera* wood contributes to the tree's popularity (Wubet, 2006). Pohjonen & Pukkala (1992) note the improved drought and termite resistance of the species

2.3.2 Regeneration

Yirdaw & Leinonen (2002) highlight the lack of knowledge about the regeneration ecology of dry, afronmontane tree species. Pohjonen & Pukkala (1992) state that regeneration techniques and other silvicultural operations have not been developed for trees indigenous to Ethiopia.

J. procera seeds are observed to have been dispersed by birds faeces prior to germination (Sharew *et al*, 1997).

There is considerable lack of consensus regarding the regeneration ecology of the species, perhaps compounded by the issue of seed dormancy. Pohjonen & Pukkala (1992) claim that *J. procera* regenerates readily naturally. In contrast, Sharew *et al* (1997: 222) state that "the uncertainty of successful *J. procera* natural regeneration either under mature stands or after felling is a major management concern". According to Teketay (1993, cited in Tigabu, 2006), seed dormancy is a major hurdle for artificial regeneration of *J. procera*. The complex dormancy mechanism is said to be the result of the hard seed coat and the dormant embryo (Laurent & Chamshama, 1987, cited in Yirdaw & Leinonen, 2002).

Yirdaw & Leinonen (2002) observe that slow germination and relatively low germination percentage are typical for untreated *J. procera* seeds. They found that germination was restricted to a narrow temperature range and that dormancy was relieved only under very narrow temperature conditions.

Kerfoot (1963) describes *J. procera* as a strong light demander. The results of a study conducted by Yirdaw & Leinonen (2002) into the effect of the germination response of the seeds to red/far-red ratio were consistent with the characterisation of *J. procera* as a pioneer tree that does not regenerate under its own canopy

(White, 1983, cited in Yirdaw & Leinonen, 2002). According to Amente (2005) its regeneration is adapted to areas where there is bright light, in forest clearings, gaps and forest edges, so active reopening of the canopy may be required to enhance the recruitment of trees (Regassa, 2003, cited in Amente, 2005).

However, Sharew *et al* (1997) found that there was no evidence that regeneration was correlated with light intensity. During this experiment, removal of the overstorey vegetation by clear felling did not encourage natural regeneration of *J. procera*, despite the presence of a viable seed bank in the undisturbed forest floor. They concluded that light may not be the main factor limiting regeneration of *J. procera* and that it is unlikely that shade prevents germination of *J. procera* in the undisturbed part of the forest.

According to Eshetu (2001, cited in Yirdaw & Leinonen, 2002), *J. procera* regenerates relatively well under *Eucalyptus globulus* Labill. Eucalyptus plantations seem to provide suitable light and temperature conditions for the germination of *J. procera* seeds, especially during the establishment and coppicing periods.

Mamo *et al* (2006) found that the germination performance of seeds incubated in darkness or sown nursery beds was low compared to those in continuous light, but from some provenances they germinated equally well in light and darkness. They agree with the conclusion drawn by Yirdaw & Leinonen (2002), that the seeds posses photo-dormancy, but the results of their research suggested that its effect varies between provenances.

The effect of provenance was examined by Tigabu *et al* (2007) and Mamo *et al* (2006). Both studies found that there is a high degree of difference in germination capacity among provenances. Mamo *et al* found that seeds from Dodola forest in the Bale Mountains had amongst the lowest mean germination percentage, at below 30%. The highest was found to be 60%.

Tigabu *et al* (2007) conclude that the germinability of seeds can be significantly influenced by maternal factors, such as the age of the mother tree, the position of the seed in the fruit/ tree, as well as environmental factors such as day length,

temperature, light quality, water availability and altitude (Wulff, 1995; Gutterman, 2000, cited in Tigabu *et al*, 2006). Differences in seed germination requirements among populations of different geographic origin suggest that dormancy might be environmentally induced (Bevington, 1986, cited in Mamo *et al*, 2006).

This is consistent with the findings of Mamo *et al* (2006: 325) who state that "morphometric traits, especially seed length and number of seeds per cone... showed a strong correlation with mean annual rainfall of seed collection sites… suggesting that environmental factors play an important role in shaping these characters". None of the populations they studied showed consistent variation for all seed and germination characteristics, however. They recommend that "during bulk seed collection, either for *ex situ* conservation in seed banks or seedling production for plantation establishments, collection should be made from several sources to ensure sufficient genetic variability in future tree crops and to obtain good germination performances… selection of the best provenance of desired species for a given site or region is necessary for achieving maximum productivity in plantation forestry" (326). They also claim that "in Ethiopia, there is insufficient knowledge about provenance and genetic variability of important indigenous species in general and *J. procera* in particular" (321).

Sharew *et al's* (1997) study into the effect of *in situ* ground treatment on germination and natural regeneration of *J. procera* in Ethiopia found that "ground preparation had a significant effect on the natural regeneration of *J. procera*". There was a highly significant increase in percentage germination and survival of *J. procera* seed with raking and burning treatments. They also observed that *J. procera* seedlings and saplings were frequently found where the mineral soil was exposed or the earth was disturbed or compacted, such as logging sites and abandoned trails.

Hall (1984: 58) also claims that "fires at long intervals have been the principal means of intermittently providing the conditions that allow young *J. procera* plants to become established… (due to) exposure of bare mineral soil, good illumination and suppression of potential competitors".

Sharew *et al's* (1997) results suggest that the effect of fire on the regeneration of the species is indirect, acting through a modification of the microenvironment, which can also be achieved by cultivation. They conclude that "management for the regeneration of *J. procera* should involve more complete disturbance of the forest floor to remove barriers for both rooting and seedling emergence above ground". Clearcutting in narrow strips is recommended to provide an adequate seed supply.

2.3.3 Anthropogenic interactions

Both federal and regional forest proclamations prohibit the use of *Juniperus procera* in Ethiopia (Amente, 2005).

Whilst a number of authors refer to the negative impact of human pressures on *J. procera*, and the consequent need for research into regeneration and conservation measures, very few studies examine anthropogenic interactions.

Borghesio *et al* (2004) are an exception to this. They examine the conditions of *J. procera* populations in two different forests, and conclude that promotion of more efficient use of resources, such as high-efficiency stoves, could prove an effective method to reduce pressure in one highly degraded site. At the other site, which was not so degraded, their assessment of the situation is that "most local people are nomadic or semi-nomadic pastoralists who use the forest seasonally, and collect only wood products for their personal use. As these products are free of charge, the local people probably have no interest in making their lifestyles more sustainable. Neither high efficiency stoves nor tree plantations are likely to have any appeal for the human population in Arero. In this area, the most important conservation actions should probably be focused on lowering grazing pressure of domestic animals in the forest" (6).

Hall (1984: 59) rejects *in situ* conservation as a means of preserving genetic diversity of *J. procera*, on the basis that "areas where regeneration might be thought worth encouraging are often on or very close to public land outside the effective formal control of those responsible for the security of the intact forests".

He therefore advocates *ex situ* conservation and the establishment of conservation stands. It is interesting that in being outside of 'formal control' the *de facto* position taken by this author is that the natural forests have little hope of survival, and the implication that within areas of formal control human pressures are alleviated. Hall claims that "*in situ* conservation may appeal… (but) in places where the tree occurs this will seldom be realistic… recent land use trends in the African mountain areas do not engender optimism" (59).

Amente's research stands apart from rest of the literature cited in this review. An examination of rehabilitation and sustainable use of degraded community forests in the Bale Mountains, his thesis assesses the resources in the Adaba-Dodola forest, in which *J. procera* is a dominant species, and then makes recommendations for a silvicultural management system involving multiple uses. The research fitted into a participatory forest management project which "empowers the forest dwellers to get organized and systematically access the forest resource with clearly defined rights and responsibilities" (24), a similar approach to that of the BERSMP.

Amente (2005) determined the annual allowable cut in terms of tree species and volume and found that the user groups' level of wood consumption was far lower than the allowable cut. In contrast to Borghesio *et al* (2004) and Hall (1984), his recommendations centred on facilitating use that was sustainable, rather than either the blanket reduction of use or grazing pressure, or assuming that forests that were used by local communities were beyond saving.

Pohjonen and Pukkala (1992) claim that if *J. procera* stands can be established and managed in a sustainable manner, the species could yield notable amounts of valuable timber. They note that pruning could be a particularly important management operation. Likewise Amente (2005) observes that "heavy shade of *J. excelsa* restricts undergrowth, implying the need for pruning, starting in the early stages of growth".

An issue raised by both Amente (2005) and Couralet et al (2005) is that of the size of the trees that are harvested and the subsequent impact on forest regeneration. Couralet *et al's* results suggest that that intermediate size classes (10–40 cm

diameter at breast height) are most sensitive to disturbances, and intensively harvesting such trees would "endanger the sustainability of the juniper population" (326). The biggest size classes were found to be much less sensitive. Amente found that there had been an over-exploitation of intermediate sized trees in the study area, implying "the need for capacity building in relation to the development of efficient tools and techniques in order to encourage the user groups to utilize the over-mature trees, which will in turn increase the growing space available to the potential crop trees" (87).

2.3.4 Impact of livestock

Amente (2005) determined sustainable livestock stocking rates and found that the current stocking rates in two of the three forests studied were lower than the forests' potential. However, he also noted the negative impact of unequal grazing pressures in different parts of the forest and recommended a rotational grazing system, as well as restricted grazing rights for certain livestock types that cause more damage, such as goats.

Couret *et al* (2005) found that grazing and tramping by livestock were not the most damaging disturbances to the *J. procera* populations they studied and that such practices would not be damaging to future populations. However, they point out that the outcome was dependent on the local climatic, grazing and harvesting conditions in the study site and could not be generalised to other forests under different conditions.

Their results are consistent with those of Tedesse (1999, cited in Amente, 2005) who found that under closed forest conditions there was no difference between grazed and non-grazed forests, and that *J. procera* is reported to be less susceptible to browsing (Tesfaye *et al*, 2002, Tadesse, 1999, cited in Amente, 2005) unless there is a shortage of fodder on the forest floor. According to Amente, they can therefore be regarded as a key species for the rehabilitation of forests where grazing by user groups cannot be avoided.

2.4 Local Ecological Knowledge

> *"The threat of the disappearance of indigenous knowledge, skills and resources is complexly intertwined with the poverty of Third World communities, their degrading health situation, ecological deterioration, and the realities of existing political and economic inequalities"*
>
> *Campilan and Vega, 1999: 33*

2.4.1 LEK and conservation

According to Cotton (1996: 323), "in the light of the progressions made in conservation discourse about the crucial role of human influence on maintaining biodiversity, many ecologists are now beginning to argue in favour of incorporating traditional knowledge into the management of protected areas".

This recent development (Pretty, 2002) is in line with the current trend in development discourse towards participation, sustainability and empowerment. Local ecological knowledge has a central role to play in each of these, conceptually at least. But disillusionment with such rhetoric is growing: the extent to which the language is being translated into changes in the essence of development projects and the approach of aid donors is questionable.

However, though on a macro scale it may be that old policies have been repackaged into eco-friendly boxes, such as Poverty Reduction Strategy Papers[3], on a project level there are plenty of examples of communities exerting their rights over natural resources through demonstration of the effectiveness of

[3] The acceptance of Poverty Reduction Strategy Papers by the International Monetary Fund is a pre-requisite for the receipt of development assistance from multilateral and bilateral donors by recipient countries. Though the development of PRSPs is supposed to involve active participation by civil society, unless the policies outlined within them are accepted by the IMF they will be rejected. The similarities between the policies demanded in PRSPs and structural adjustment programmes has been noted by organisations who were involved in the consultation process and initially welcomed it, such as Oxfam.

management regimes that have evolved from 'traditional' systems or been developed through the fusion of local and exogenous knowledge. This is particularly evident in the field of forestry, where managing multi-species forests sustainably is a complex, multi-dimensional task.

Kartasubrata & Wiersum (1995) present an analysis of traditional and recent advances in tropical silvicultural research in Indonesia, and point to the emergence of a new paradigm resulting from a change from even-aged monocultures to natural forests and multi-species, uneven-aged forest plantations and agroforestry systems. Within this context, research is carried out under farmer-controlled conditions rather than under researcher-controlled conditions. They note the location-specific requirements of improved techniques in comparison to general scientific problem identification. Differences in the management objectives of local communities and professional foresters are discussed, for example, optimisation of multiple products for subsistence use (including non-wood forest products) instead of maximising the production of industrial commodities. They note that "a farmer's opinion regarding the performance of a system is usually not based on the performance of a single component but rather on the overall system performance."

Banzon-Cabinilla (1999:113) claims that a similar paradigm-shift in Phillipine forestry has resulted from the state of crisis bought about by massive deforestation and its enormous environmental and socio-economic consequences. She describes the new paradigm as "systems-focused, community driven and socially orientated", whilst the old was "elementally (timber) focused, market centered, and industrially/commercially-orientated", dominated by "scientific management" which tended to "simplify the culture of the forests in order to efficiently supply the market demands for timber products". This shift has provided the impetus for the incorporation of local knowledge and biodiversity in the U.P. Los Banos College of Forestry and Natural Resources forestry curricula.

Berkes (1999) highlights the contrast between the process and systems focus of traditional forms of ecological management and the product and yield focus of many Western-trained resource management professionals. Historically, the collision of these philosophies has almost always resulted in victory for the

Western paradigm. However, the rise in systems thinking in the West presents both an alternative to reductionist science and a new way of interpreting traditional knowledge and practice. Capra (2002) describes ecosystems as being in a state of dynamic balance that is sustained through multiple feedback loops.

Berkes (1999: 60) states that adaptive management "takes a dynamic view of ecosystems, emphasizes process (including resource use) that are part of ecological cycles of renewal, and stresses the importance of resilience, that is, the buffering ability of the system to absorb change without breaking down or going into another state of equilibrium". He likens this process to traditional knowledge systems and claims that traditional management can be reinterpreted as adaptive management and vice versa. Whilst such generalisations should be treated with caution, within the context of traditionally sustainably managed forests there is clearly some resonance in his argument, given the dynamic nature of the management of regenerative cycles and the demand for adaptation and response to fluxes. Roling and Brouwers (1999: 155) claim that sustainable agriculture also "seems to require the capacity to facilitate learning complex system-management".

Amente (2005: 38) describes participatory action research in a similar way, as involving "a cycle of iterative learning: reflection, planning, action, observation and feedback".

Sinclair and Walker (1999) advocate the use of a systems perspective in agroforestry on the basis that a holistic approach to problem solving is required to reflect the interdisciplinary nature of problems faced by households. Warren *et al* (1995) describe the diverse products and services that the local natural resource base provides for local people, including food, shelter, and ecological services. It follows that the analysis and management of such complex systems requires a holistic approach.

Recognition of the importance of LEK in development coincided with growing uncertainty that modernisation, particularly of agricultural systems, could or would provide a way out of the widespread poverty experienced in countries of the global South. As the problems and limitations of Western-style industrial

agriculture became more apparent, practitioners questioned the ability of these approaches and methods to meet the needs of the resource-poor, complex, diverse and risk-prone agriculture (Chambers, 1994) which characterises many countries in the South. 'Sustainability' became the new buzzword in the development arena, encompassing social and economic goals as well as environmental ones.

'Participation' is a similarly currently popular concept, which should stem from the recognition that participatory processes are essential for 'development' to be democratic and just, with adequate recognition of people's rights, including those of indigenous people over natural resources. Nevertheless, according to Chambers (1994) "many scientists, teachers and extensionists are still trapped in top-down, centre-outwards institutions and transfer of technology thinking and action...where farmer's participation is limited to adoption" (xiii).

In contrast, the work of Sinclair and Walker (1999), and others, on local ecological knowledge involves the flow of information in the opposite direction, that is, the elicitation of LEK by outsiders for the purposes of natural resource management that involves collaboration between local and external people.

Despite the considerable advances that have been made in the last two decades, 'development' is still considered to be a market-driven process, and the commercialisation of production systems an essential component of this. It could be argued that the 'need' to systematically acquire, record and utilise local knowledge is displaced as high-input, standardised modes of production replace the systems that traditional or local ecological knowledge relates to. Pretty (2002) observes that the central assumption of modernisation is that technological solutions are universal, and therefore independent of social context.

Whilst it may be beyond the capacity of LEK acquisition and representation methods to analyse social structures and ensure that local people are involved in the planning and implementation of development projects, when applied within the framework of participation the potential for local knowledge to positively contribute to the development of sustainable systems can begin to be realised. If this knowledge becomes part of an iterative cycle of management the resilience of the system will be further strengthened. Sinclair and Walker (1999: 262) state

that formal analysis of knowledge is not "intended to replace dialogue with farmers, or circumvent a participatory process".

2.4.2 Collaborative knowledge

A number of authors have argued for increased co-operation between scientists and local people through the use of local knowledge. Sinclair and Walker (1999: 254) point out that "investigating local knowledge may be a powerful and efficient means of rapidly filling gaps in scientific understanding about agroforestry... amalgamating specific local knowledge and general scientific knowledge may be more powerful in designing appropriate research and extension that the use of either alone".

Becker and Ghimire (2003) present a study from Ecuador which "demonstrates that synergy between traditional knowledge and western knowledge can result in sustaining both ecosystem services and biodiversity in a forest commons".

Lawrence (2001: 171) stresses the transformation of knowledge that occurs through the process of interaction between outside agencies and local communities: "we must understand that knowledge is *transformed*, not transferred, when it crosses social interfaces". This interaction involves bringing together the holders of different knowledge and the subsequent creation of a 'dynamic knowledge interface'. The knowledge held by both parties evolves as a result and new knowledge is created. Such new knowledge will develop further through its application, in particular through the process of participatory monitoring and evaluation. Lawrence stops short of describing a potential feedback loop in this process, if knowledge and management become part of a cyclical system.

Roling and Brouwers (1999: 155) challenge the role of science as a source of innovation, but claim that it has a facilitatory role to play in farmer expertise and learning. "Research becomes a resource for the farmer to draw upon and to complement his or her systemic knowledge". This approach is echoed by Chambers (1994: xv), who advocates a change in the role of extension workers to

become “conveyors, facilitators, catalysts, consultants and searchers and suppliers for farmers”.

Thuan and Taylor (1999: 119) claim that local knowledge can be “blended with and improved through outside knowledge”; furthermore, that consideration of local knowledge helps to ensure that the technology introduced by governments, international organisations and NGOs is appropriate.

In Pretty’s (2002: 66) view, “the big challenge we face is to find effective ways of synthesizing the best of traditional knowledges and the best that scientific analyses can bring”.

Through the formal acquisition and representation of LEK, using methods such as artificial intelligence computer software as described by Walker & Sinclair (1998) it is possible to create a forum through which local people and scientists can interact equally, and 'speak in the same language'. The potential for local people to benefit from external knowledge and technology should not be overlooked in the focus on the collection and utilisation of LEK. Such potential will be better realised through a bottom-up approach, allowing farmers to articulate what they consider to be deficiencies or sustainability problems in their practices or to identify gaps in their knowledge (Sinclair & Walker, 1999).

A systematic approach to collecting, presenting and analysing local knowledge is powerful not only as a tool to assist the development of natural resource management programmes, but because it has the potential to challenge the still-dominant donor-recipient paradigm of ‘development’ and international development assistance, and to fuel the process of empowerment.

3 Methodology

The research was conducted between the 4th of June and the 17th of July 2007.

The system of knowledge elicitation employed has been described elsewhere by Walker and Sinclair, 1998, and Sinclair and Walker, 1998. It is depicted in figure 3.1. Three stages of this process were conducted: scoping, definition and compilation.

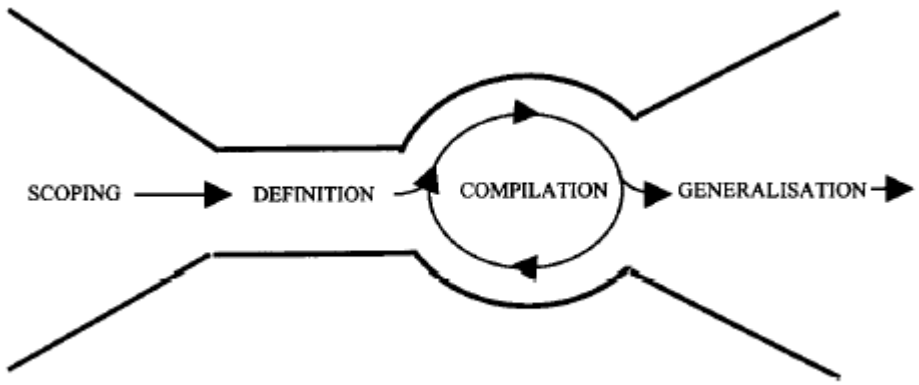


Figure 3.1: The four stages of knowledge acquisition (Walker and Sinclair, 1998)

3.1 Phases of research

3.1.1 Scoping Phase

Objectives:

1) To gain a broad understanding of the area and subject area.
2) To set the priorities for the research.
3) To identify possible variables that may influence the spread of knowledge throughout the communities.

Informal discussions and semi-structured interviews were conducted with FARM-Africa and SOS Sahel employees at the national FARM-Africa office in Addis Ababa and in a number of locations in the Goba woreda. Informants were purposively selected.

The project documents and maps of the area were studied.

3.1.2 Definition Phase

Objectives:

1) To refine the research topics and the boundaries of the research project.
2) To stratify the population based on the variables identified.
3) To select stratum for the compilation phase.

Informal discussions were held with purposively selected BERSMP employees in the Goba woreda. Some initial scoping interviews were conducted in the study area. Results from this preliminary investigation were presented and discussed with the client NGO in the BERSMP offices in Robe to finalise the plan for the third phase of the research.

The population was stratified according to location and gender. It was understood that gender had a significant influence on the work carried out by individuals. This was in turn expected to affect their relationship to the resource and their knowledge about it.

Three villages close to the town of Goba, Faisel Angaso, Shefario and Gama Taga, were selected for the research to take place. Faisel Angaso was located approximately four kilometers to the Southeast of Goba. Shefario and Gama Taga were located to the South and Southwest of Goba respectively. They had been joined with another village, Lashonakona, to form one village administration called Ititu Sura some time before, although geographically they were distinctly different settlements some four kilometers apart. Faisel Angaso and Shefario were the last settlements between Goba and the mountain range to the south,

where forests in which *J. procera* was the dominant species were being cleared at higher and higher altitudes. Such clearance was visible from Faisel Angaso (plate 3.1).

Plate 3.1: The mountain range to the South of Faisel Angaso, showing the clearance of forest land for agriculture.

The basis of selection of the three villages was anecdotal evidence of high levels of exploitation of the *J. procera* forests; the proximity of the villages to the remaining *J. procera* forests in the area and the convenience of access to the villages by the researcher.

The population in the study area was identified as being Amharic or Afanoromo speaking. The religions practiced were Islam and Christianity.

Demographic and socioeconomic information about the villages was not available and information on the likely spread of knowledge throughout the communities amongst BERSMP employees was limited, as the project was still in its infancy and investigations into local knowledge had not been conducted previously. Scoping interviews held in Faisel Angaso and Shefario were used to inform the researcher during the definition phase, in the absence of other sources.

Occupation was rejected as a means of stratifying the population due to the fact that the multiple livelihood strategies typically employed by households were similar: most households had a small area of cultivated land and some livestock. Some had additional sources of income, for example, from the sale of fuel wood or honey.

Religion, ethnicity or culture were not chosen as a means of stratification of the population as it was felt by the researcher that there was insufficient demographic information to select such strata and no information about whether such factors would affect the spread of knowledge throughout the population.

Age was considered as a possible means of stratification but the reasons for this were largely based on conjecture and, given the time constraint, such stratification was also rejected.

3.1.3 Compilation Phase

Objectives:

1) To acquire local ecological knowledge about *Juniperus procera* in the study area.
2) To represent the knowledge elicited by building a knowledge base using the software AKT 5.

3.1.3.1 Knowledge Elicitation

Semi-structured interviews were conducted in the three selected villages with five women and five men in each village. It is understood that knowledge can be considered 'common' when three people within one strata hold it (Pagella, 2007), therefore a sample size of five was chosen to make the process of triangulation robust and to allow for difficulties that may have resulted from people being uncooperative, unrepresentative of the strata or experiencing difficulties in

expressing their knowledge.

Purposive and convenience sampling was used to select informants, on the basis of their willingness to participate in the research and their availability. People from a range of age groups were interviewed. Interviews lasted between half an hour and one and a half hours and second interviews were conducted if the initial interviews were not completed.

In addition to the local resource users, three key informants employed by the local civil administration were interviewed. These were: one forester working for the Rural Development and Agriculture office in the Natural Resources Department who had been involved in planting some of the *J. procera* plantations in the area; one worker in the government nursery, Bamo Nursery, who propagated *J. procera* seeds on a yearly basis, and a Natural Resources Development Agent who worked in the village of Shefario and advised residents on the management and use of local natural resources.

In all cases the interviews followed a standard semi-structured format. Sessions were informal and held in a communal area of the village or on the property or in the workplace of the interviewee. On some occasions participants offered to show the researcher specific objects or areas, in which case the researcher walked with the interviewee to such a place and the discussion continued. Topics were decided in advance but only some of the questions were predetermined and new questions or lines of questioning arose during the interviews in response to answers from those interviewed (McCracken et al, 1988).

The purpose of the interview was explained at the outset and a brief description of the BERSMP given. A translator was present during the interviews.

Detailed notes were made by the researcher during the interviews and on some occasions a voice recorder was also used.

Photographs were taken to provide documentary evidence of the locality, the natural resources within it, things referred to by interviewees and the practices of local people.

Following completion of the interviews, one focus group discussion (FGD) was held in each village and all interviewees invited to attend. In some instances other people attended. Between 6 and 8 people were present during the FGDs.

3.1.3.2 Knowledge representation

The knowledge recorded during the interviews was entered by the researcher into the software AKT 5. The knowledge base 'juniper.kb' was gradually built throughout the research.

The process of entering knowledge into AKT involves translation into unitary sentences, containing singular pieces of information, which are then encoded into a text and syntax format that the software can read. Objects, attributes, values, processes and actions are 'labeled' as such through the sentence structure or format. Where causality is represented, the sentence contains both a cause and effect. Conditionality can be added.

The source of each statement was recorded in the knowledge base. When the same knowledge was offered by more than one person, multiple sources were attached to the statements entered. If five or more informants conveyed the same piece of knowledge, 'more than five informants' was used as a generic source.

A full description of the method of encoding sentences for AKT can be found in Dixon et al (2000).

3.2 Limitations of research

3.2.1 Translation

The interviews and FGDs were translated from Afanoromo or Amharic into English, the language of the researcher, by an interpreter. There are constraints to this process, as it is likely that at times the meaning of the interviewees was not

accurately conveyed to the researcher, or that some of what they said was omitted. Further, differences in the language and terms of reference may have meant it was not possible for the exact meaning to be conveyed.

3.2.2 Time constraints

The most significant limitation of the research was the amount of time available to carry it out. It was not possible to carry out secondary or tertiary interviews with participants, so the iterative cycle of knowledge exploration, as described by Walker & Sinclair (1998) was restricted. Consequently there was limited scope to probe areas where it seemed that there were inconsistencies in the knowledge offered by an individual. Where contradictions were apparent in the information offered by different informants there was scant opportunity to explore such contradictions. When new issues were raised during later interviews it was not possible to discuss them with interviewees who participated at an earlier stage of the research.

The lack of time available also meant that no generalisation phase took place. The implications of this are that, from the results obtained, it is not possible to infer anything about the representativeness of the knowledge elicited.

The interviews were also affected by the other demands on the interviewees' time, which was particularly evident during the interviews with women who were caring for young children.

3.2.3 Limitations of AKT methodology

3.2.3.1 Representation as 'common' knowledge

Due to the lack of a generalisation phase it was not possible to establish which knowledge was 'common' and which was held exclusively by one or more individuals: both were entered into the knowledge base, and both would be represented in the diagrams generated by AKT. Through the examination of sources it is possible to see which knowledge was held by more than one

informant and hence which was likely to be common. However, should be noted that a superficial examination of the knowledge contained within the knowledge base, in either the sentence or diagrammatic forms, will not differentiate between common and exclusive knowledge. AKT does not have the ability to weight statements, for example, according to the number of people who said them.

3.2.3.2 Translation into unitary statements

The knowledge represented in the knowledge base is the encoder/researcher's hypothesis of the knowledge, as it has been through the process of being translated into unitary statements before being entered into AKT. As such is subject to the ability of the researcher to interpret the knowledge and to represent it in such a way. The same statement can be entered in more than one way in AKT.

Often when interviewees spoke the terms that they used were relative, for example “I transplant seedlings where it is drier”, or “red soil is found higher up”. It was apparent at the time that the person speaking was making a comparison to nearby areas in the same locality. However, because of the unitary nature of the knowledge that is entered into AKT, such relativity is difficult to convey or represent. To change such statements into absolute ones, such as “I transplant seedlings where it is dry” would not be an accurate translation of the information offered, but to apply a relative value when the source of comparison is not referred to is illogical. How to deal with such issues is again subject to the judgment of the encoder.

Due to the unitary nature of the information entered into AKT, it is difficult to represent a situation where an effect is the result of a combination of causes which both have an equal impact. For example, the knowledge that seeds bursting was a result of warm temperatures during the day followed by colder temperatures at night would need to be entered as two separate statements, in which case the combination of events is not conveyed, or as two parts of the same statement, in which case the two processes would not be of equal weight, or as two conditions of the same statement in which case the causality conveyed by the interviewee

would not be not represented in the statement.

3.2.3.3 Locational restrictions of software

Representing locational information within AKT is awkward. Accepted practice is to include this in the 'value' part of statements, which means using a preposition in front of the term, for example, 'on_black_soil' or 'on_hillside'. This limits the scope of the search facility, which will not pick up such values when searching for 'black soil' or 'hillside'. Consequently, in order to use the search facility competently it is necessary to have some prior understanding of the idiosyncrasies of the software, and its limitations.

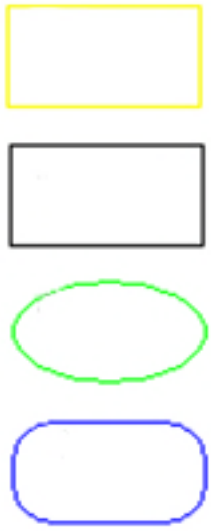
Furthermore, the knowledge that is represented within one knowledge base may contain statements that have been given by individuals within different localities. In the juniper knowledge base, for example, research was carried out in three different villages. Although the information about where each respondent lived is contained within the knowledge base, combining analysis of the statements themselves with the location of the source makes analysis of the knowledge more complex. Such analysis would be particularly relevent with regard to, for example, the soil types referred to, as adjacent villages may have quite different soils surrounding them. Terms such as 'red' and 'black' soil may be based on comparative qualities which are influenced by location.

4 Results

The knowledge elicited during the research is contained within the knowledge base 'juniper.kb'. Sections of the juniper knowledge base have been used to create subsidiary knowledge bases relating to the topics 'germination' and 'seedlings and saplings'.

4.0 Interpreting Agroecological Knowledge Toolkit diagrams

AKT 5 has a diagrammatic facility that enables causal and link statements to be represented graphically. The statements are represented as nodes with arrows and labels between them, indicating the nature of the relationship. AKT generates four different types of nodes which represent different elements of statements. Figure 5.1 shows the types of nodes within diagrams generated by AKT and their associated statement type.



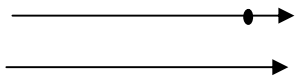
Object node

Attribute node

Process node

Action node

Nodes represent either natural processes (ovals), actions (boxes with rounded corners) or attributes of objects, processes or actions (boxes with straight edges).



Arrows connecting nodes denote the direction of causal influence. A black dot on a causal arrow indicates a negation of the node it is coming from or going to.

Figure 4.1: Key to nodes in AKT diagrams (after Dixon *et al*. 2001)

4.1 Juniper knowledge base

4.1.1 Composition

The juniper knowledge base contains 508 statements, of which 443 represent causal relationships. The number of causal statements as a percentage of the total is 87.2 %. This high degree of causality is indicative of some depth of knowledge of ecological and anthropogenic interactions with *J. procera*.

4.1.2 Knowledge categories

Within the juniper knowledge base, the knowledge elicited has been categorised into the following topics:

- Animal interactions
- Germination
- Grazing animals
- Human interactions
- Light/shade
- Location
- Other tree species
- Planting and transplanting
- Pollarding
- Seedlings and saplings
- Soil
- Weather

Selecting different topics will generate all of the statements relating to each topic. 'Human interactions' is topic hierarchy that contains the sub-topics coppicing, pollarding and planting and transplanting.

4.2 Germination

The knowledge base 'germination.kb' contains a section of the juniper knowledge

base with knowledge relating to germination. There are 16 process terms in the germination knowledge base, which refer to the ecological processes identified by interviewees. Farmers had observed a range of different process that contributed to the germination of the seeds.

Two farmers were also collecting and propagating the seeds themselves. Searching for the topic 'propagation' within the germination knowledge base will generate all of the related statements. Propagation is discussed in the section 4.3 below.

4.2.1 Germination mechanisms

Interviewees described two mechanisms of germination:

- From a ripe, sun-dried berry bursting
- From the distribution of bird feces

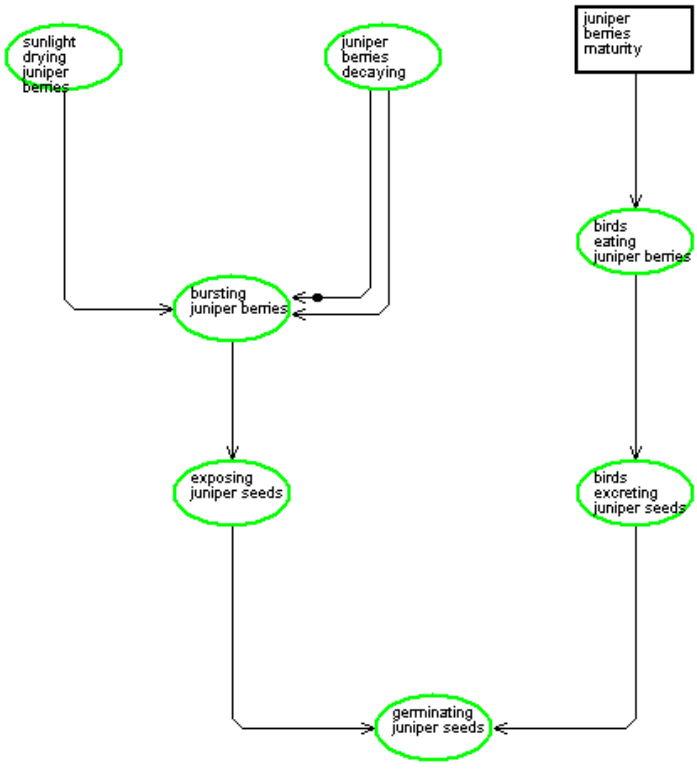


Figure 4.2: Germination mechanisms of *J. procera*

There was not consensus about whether or not both of these processes were successful in producing seeds that germinated. Some interviewees said that only

seeds dropped from birds would germinate, others said that berries which were dropped from the tree and were dried by the sun would burst and then germinate. One farmer said that the berries also burst whilst they were on the tree, and that these were the only seeds that would successfully germinate. Both process are depicted diagrammatically in figure 4.2.

4.2.2 Berries and seeds

Interviewees recognised that not all seeds would germinate and reasons for this were given, relating to the condition and maturity of the berries as well as environmental factors. The soil upon which the tree grew was regarded as a factor in determining the condition of the berries and seeds produced.

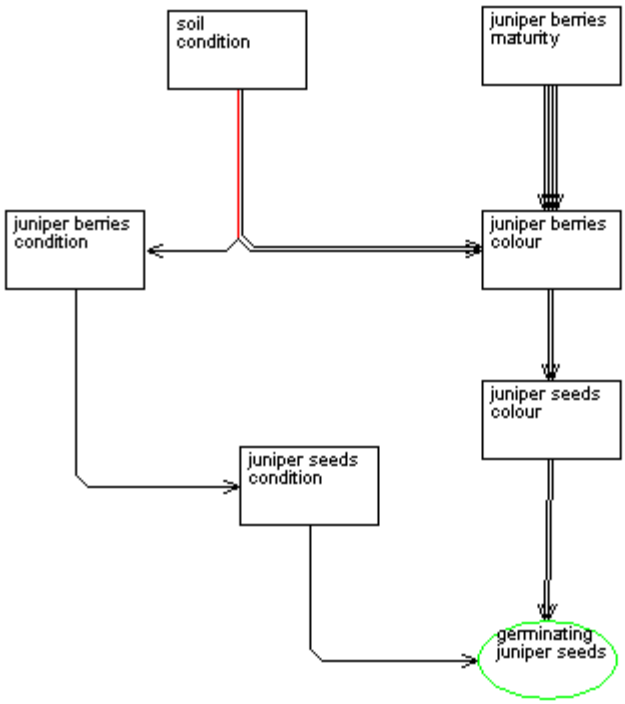


Figure 4.3: Colour and condition of berries and seeds.

Figure 4.3 represents the statements that were made about the maturity and condition of the berries and seeds. Multiple lines connecting nodes represent multiple statements which refer to the attributes or processes within the nodes. For example, the four lines connecting the nodes 'juniper berries maturity' and 'juniper berries colour' indicate that four different statements were made about

the colour of mature and immature berries.

4.2.3 Environmental conditions for germination

Sunlight, shade, air temperature, soil condition and soil moisture content were environmental factors which were stated to affect the germination and speed of germination of juniper seeds. These relationships are represented in figure 5.5.

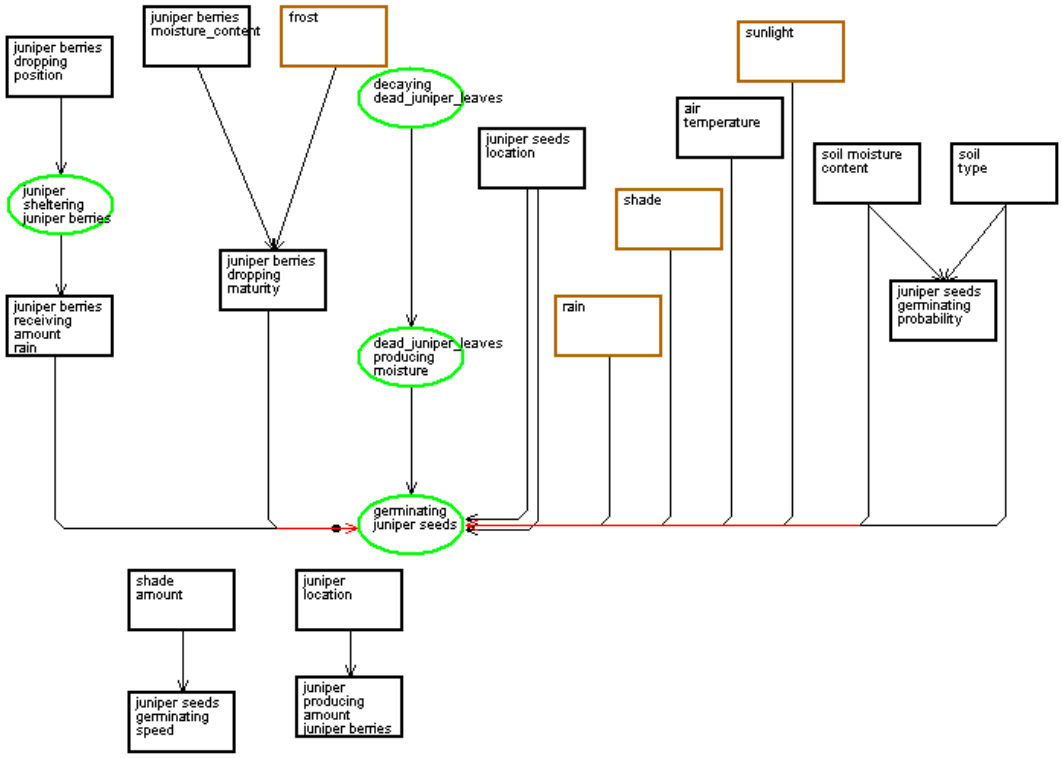


Figure 4.4: Environmental factors affecting germination of *J. procera* seeds.

4.3 Propagation and transplanting of *J. procera*

Of thirty farmers interviewed, two were able to describe in some detail the way in which they had propagated *J. procera* from seed. The topic 'Planting and transplanting' in the juniper knowledge base contains all of the related statements.

J. procera seeds were selected or the berries selected and processed in order to separate the seeds. Seed beds were created by mixing decaying juniper leaves

with soil. The seeds were protected from birds and strong sunlight using soil and shade respectively.

One farmer described transplanting the seedlings after one year. The optimum conditions of the location for transplanting were given as:

- Warmer
- Shaded
- Away from village
- Higher up
- Not swampy
- Drier
- Close to hagenia

One of the farmers that had been propagating *J. procera* stated that he had experienced some conflict with his neighbours as a result, and some of the seedlings he had planted had been stolen.

4.4 Seedlings and saplings

Interviewees articulated that at different stages in the growth and development of *J. procera* the seedlings, saplings and grown trees exhibit different responses to environmental stresses and are subject to different biotic interactions. The knowledge base 'Seedlings and saplings' contains all of the statements which refer to these stages of growth.

4.4.1 Environmental conditions affecting seedlings and saplings

The mortality and growth rate of juniper seedlings and/or saplings were said to be affected by:

- Rain/drought
- Sunlight
- Shade
- Temperature

- Wind

At different ages and heights the sensitivity of seedlings to abiotic stresses was said to decrease, for example, above the height of 35 centimetres the seedlings were said to be able to withstand a 3 month drought.

Interactions between environmental conditions were referred to by interviewees. The impact of sunlight was said to depend on the presence or absence of shade or rain. The age of one year and height of 15 cm was stated to mark a change in response of juniper seedlings to light and shade conditions.

Rain was associated with increased growth rate of immature juniper trees unless it was excessive. Below the age of one year seedlings were said to be vulnerable to increased mortality as a result of excessive amounts of rain.

4.4.2 Impact of grazing animals on seedlings and saplings

Livestock was said to have an impact on juniper saplings in five ways:

- Eating parts of them
- Compacting the soil around them
- Urinating on the soil around them
- Rubbing against them and breaking them
- Stamping on them

The knowledge elicited during the research relating to the impact of grazing animals on *J. procera* seedlings and saplings is represented in figure 5.5. The presence of livestock was considered to decrease the growth rate of young juniper trees or result in their death. During the research it was possible for the researcher to observe juniper saplings whose growth had been stunted as a result of being exposed to livestock (plate 4.1).

Plate 4.1: Livestock in an area where stunted *J. procera* saplings can be seen in the foreground.

Plate 4.2: *J. procera* saplings with stunted growth.

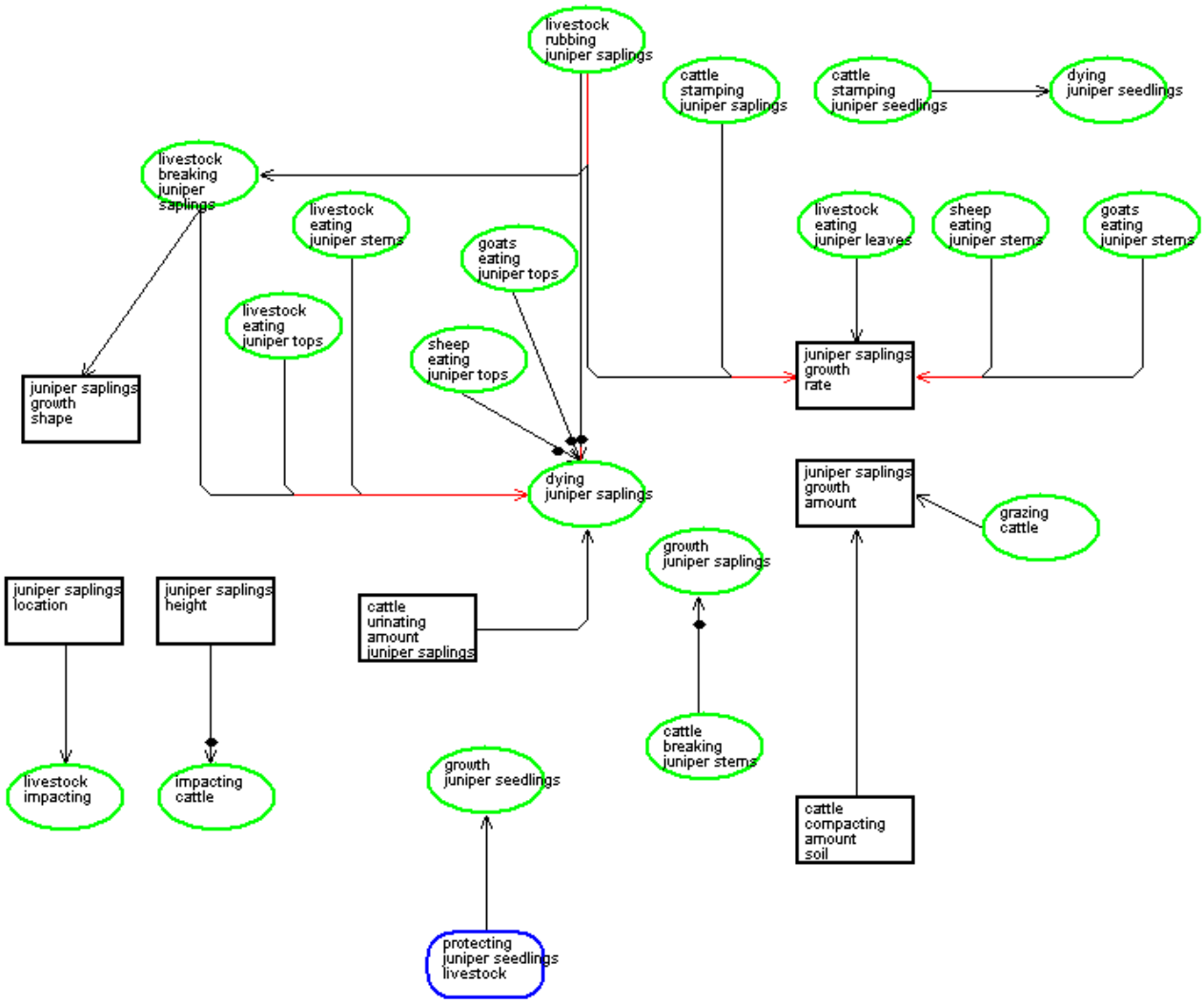


Figure 4.5: Impact of livestock on *J. procera* seedlings and saplings

4.5 Location Characteristics

In the study area, *J. procera* is the dominant tree of the forests close to the villages and trees likely to be from remnant forests were located in and around the villages in the lower altitude areas. Different environmental conditions in different locations were said to have an impact on the characteristics of the trees. Figure 5.6 is a diagrammatic representation of some of the pressures and environmental conditions that the trees were subject to in different locations. There was not consensus about whether the trees on the hillside exhibited improved characteristics than those in the lower areas. The topic 'Location' in the juniper knowledge base contains the relevant knowledge.

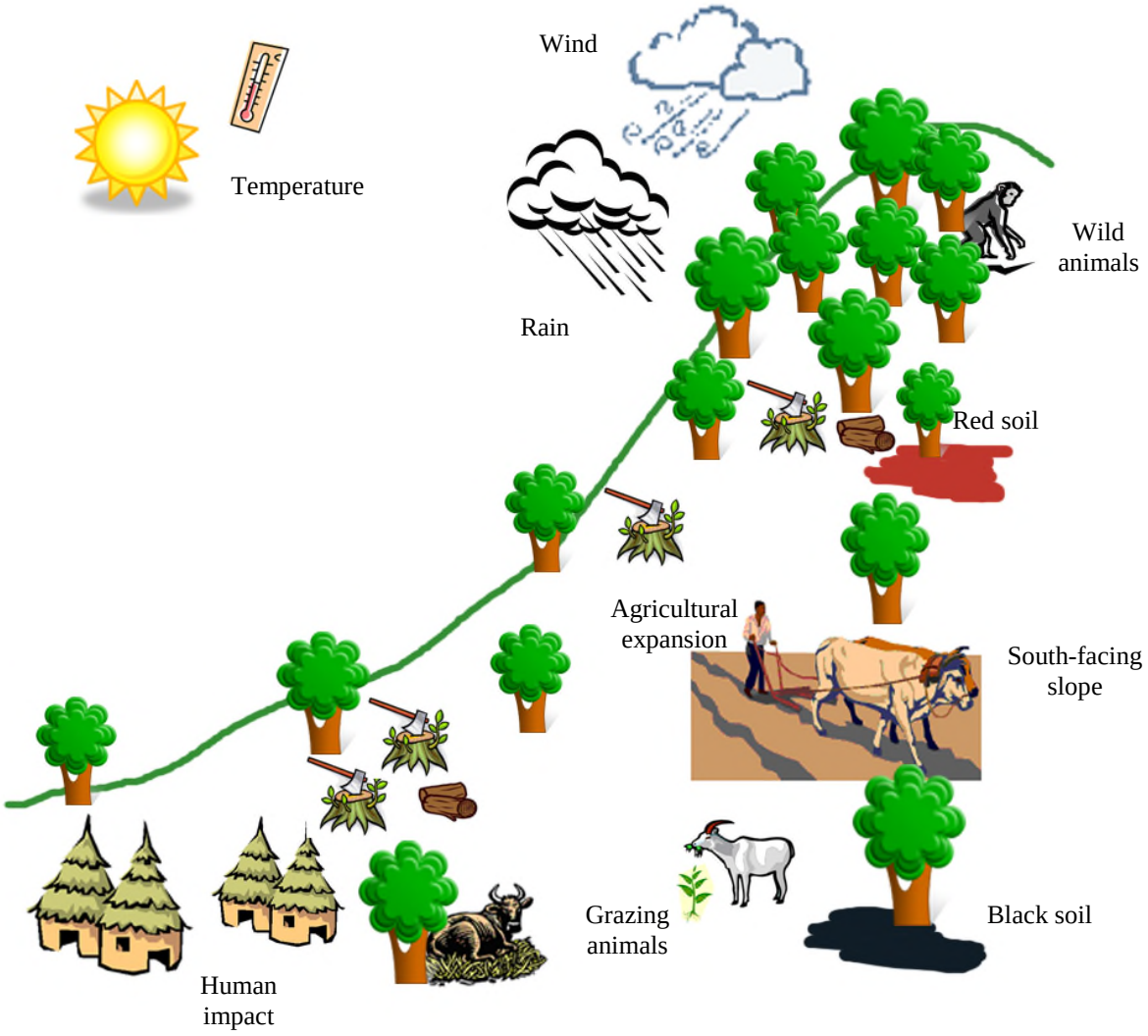


Figure 4.6: Pressures and environmental conditions affecting *J. procera* in different locations

In different locations the following environmental conditions were said to have an impact:

- Rain
- Temperature
- Wind
- Frost
- Amount of shade
- Soil (type, depth/quantity, texture, moisture content)
- Aspect of slope

The impact of livestock and people was said to be greater in the valley or villages.

Different locations were said to affect the following characteristics of the trees:

- Rate of growth
- Height
- Strength
- Thickness
- Shape
- Ease of roots spreading

4.5.1 Location information obtained during focus group discussions

Location characteristics were explored further during the focus group discussions. There were differences in opinion between the three villages about whether *J. procera* grew better on the hillside or in the valley. Participants in Gama Taga and Faisel Angaso said that the trees grew better on the hillside and the reasons for this varied from the amount of rain the trees receive, the mist or cloud, the slope of the land and the soil. In Gama Taga, participants ranked the reasons, in order of importance, as being the soil, the rain, reduced human impact, the temperature or air, the reduced animal impact and reduced soil erosion. In Shefario, however, the trees were regarded as growing better in the valley because the soil was black and more fertile, whereas on the hillside it was eroded; also because the amount of water contained in the soil stayed for longer, and because the trees were not as affected by wind.

There were differences in the types of soils in the different places identified during the focus group discussions in the three villages. Whilst black soil was said to be predominant in the valley close to Shefario and Faisel Angaso, in Gama Taga red soil was also said to be present. In Gama Taga and Faisel Angaso the soil on the hillside was said to be grey, whilst in Shefario it was said to be red and grey (see section 4.6).

In Faisel Angaso and Gama Taga the rain was said to be heavier and of greater quantity on the hillside. In Shefario participants said that the amount of rain that falls is the same but in the valley the amount of water was said to be more, and may be stagnant because the land is flat. One participant said that the amount of

rain that falls where there are trees is greater and that if there were trees in both places the amount of rain would be the same. He also said that the temperature was affected by the presence or absence of trees; that in an area where there are trees the temperature is lower. Most other participants in the three villages said that the temperature was lower on the hillside.

The wind was said to be stronger and the soil rockier on the hillside in all three villages. In Faisel Angaso and Shefario soil erosion was said to be greater on the hillside, whilst in Gama Taga the presence of trees on the hillside was said to reduce the amount of soil erosion.

Contrary to the information that was provided in the interviews, during the focus group discussions the impact of human population on *J. procera* was said to be greater on the hillside because it was far away from where people could be seen cutting trees. In Gama Taga, the impact of livestock was said to be greater in the valley but people were uncertain about the impact from wild animals.

4.6 Soil

Between two and five different soils were identified by interviewees in the three different villages. In total, seven soils were identified. Table 4 summarises some of the information offered by interviewees regarding different soils and their impact on *J. procera*. There were clearly inconsistencies and conflict in the knowledge obtained, illustrated by both ‘increase’ and ‘decrease’ values in the boxes. This may have been as a result of the differences in location or the differences in classification of interviewees.

Soil type/ Attribute	Black soil	Red soil	Brown soil	Grey soil	Yellow soil
Growth rate	Increase	Increase/ Decrease	Increase/ Decrease	Increase/ Decrease	Increase/ Decrease
Height	Increase	Increase	Increase	Increase	
Strength	Increase	Increase/ Decrease	Decrease	Increase/ Decrease	Increase Decrease
Thickness	Increase	Increase	Increase	Increase	
Diameter	Increase				

Table 4.1: Soil types and effects on *J. procera*.

4.7 Weather

Seasons in the study area were described as dry season, rainy season and badessa, or the start of the rainy season. There was not consensus about the start and end months of the rainy season, for example, one interviewee stated that it started in January and another in April. The rainy season was bimodal: a period of little rain occurred in the middle of the rainy season which may last for a couple of months.

4.7.1 Seasonal processes

In relation to *J. procera*, a number of statements were made about the processes which occurred at different times of the year. These are summarised in table 5. The table indicates that there was some differences in opinion about which processes happened at different times of year. For example, the berries were said to ripen in both the dry and the rainy seasons. Rain was associated with increased growth rate of the tree.

Season	Age of J. procera	Process
Dry season	Mature tree	Picking juniper berries Ripening juniper berries Dropping juniper berries Juniper producing berries
Badessa	Seeds Seedlings Mature tree	Germinating Increase growth rate Planting seeds Producing berries time beginning Flowering
Rainy season	Seeds Seedlings Mature tree	Germinating Increase growth rate Growth Ripening of berries Producing berries Increase growth rate Flowering

Table 4.2: Seasonal processes of *J. procera*

4.7.2 Impact of weather conditions and light and shade

A range of opinions were expressed by interviewees about the impact of changes in the weather and light and shade conditions on *J. procera*. These are presented in tables 4.3 and 4.3. It was generally perceived by interviewees that when the trees reached a certain level of maturity their sensitivity to water stress decreased. Temperature and wind were considered by some to have no impact and by others to affect the growth of the tree. Sunlight and shade were both stated to be the optimum conditions for growth.

In the study area it was very unusual for a drought to last longer than a few months, therefore many participants were not sure of what the impact of a longer drought would be.

Weather conditions	Effect	Conditions
Drought duration		
6 months	No impact	
2-3 years	Surviving	Height above 6 metres
Not specified	Changing colour grey	
	Changing colour brown-red	Location in open area
	No colour change	Location in forest
Rain		
Not rain	Dying	Height 5 foot
Decrease	Colour grey	
	Growth rate decrease	Below 20 metres
	No change growth rate	Above 20 metres
Increase	Increase growth rate	
Intensity heavy	Not affecting	
All year	Conditions optimum	
Amount requiring	Fortnightly	
	Low	
	Lots	
Requiring rain decrease		Height above 6 metres
Temperature		
Decrease	Increase growth rate	
Increase	Increase growth rate	
	Increase strength	
	Increase height	
Medium	Temperature optimum	
Change	No change growth rate	
Wind		
Wind	Not affecting	
Strength strong	Uprooting	
	Breaking branches	
	Breaking trunk	
	Changing colour grey	
Shaking juniper	Decrease growth rate	

Table 4.3: Impact of weather conditions on *J. procera*.

Light and shade conditions	Effect
Shade	
Shade	Increase growth rate
	Conditions optimum
Amount heavy	Decrease growth rate
	Decrease strength
Amount constant	Changing colour yellow
	Condition not healthy
Sunlight	
Sunlight	Conditions optimum
	Decrease rate of growth
	Production of sticky substance

Table 4.4: Impact of light and shade conditions on *J. procera*

In addition to the impact of the weather on *J. procera*, interviewees stated that *J. procera* had an impact on the weather, specifically in drawing the rain or the wind.

4.8 Other tree species

Interviewees discussed interactions between *J. procera* and other common tree species in the area, namely eucalyptus, hagenia and olive. Figure 4.7 represents these relationships.

A number of interviewees stated that other tree species did not have an effect on *J. procera* if they were located close to it. Others discussed the impact of eucalyptus absorbing water on the growth, growth rate and mortality of *J. procera*. Some of this apparent contradiction can be explained through conditionality, notably the age of the juniper and the number of eucalyptus trees in the locality, described in the above diagram as the population size of eucalyptus. However, some informants stated that other species did not affect juniper under any conditions. Eucalyptus shadowing juniper was stated to reduce the strength of juniper.

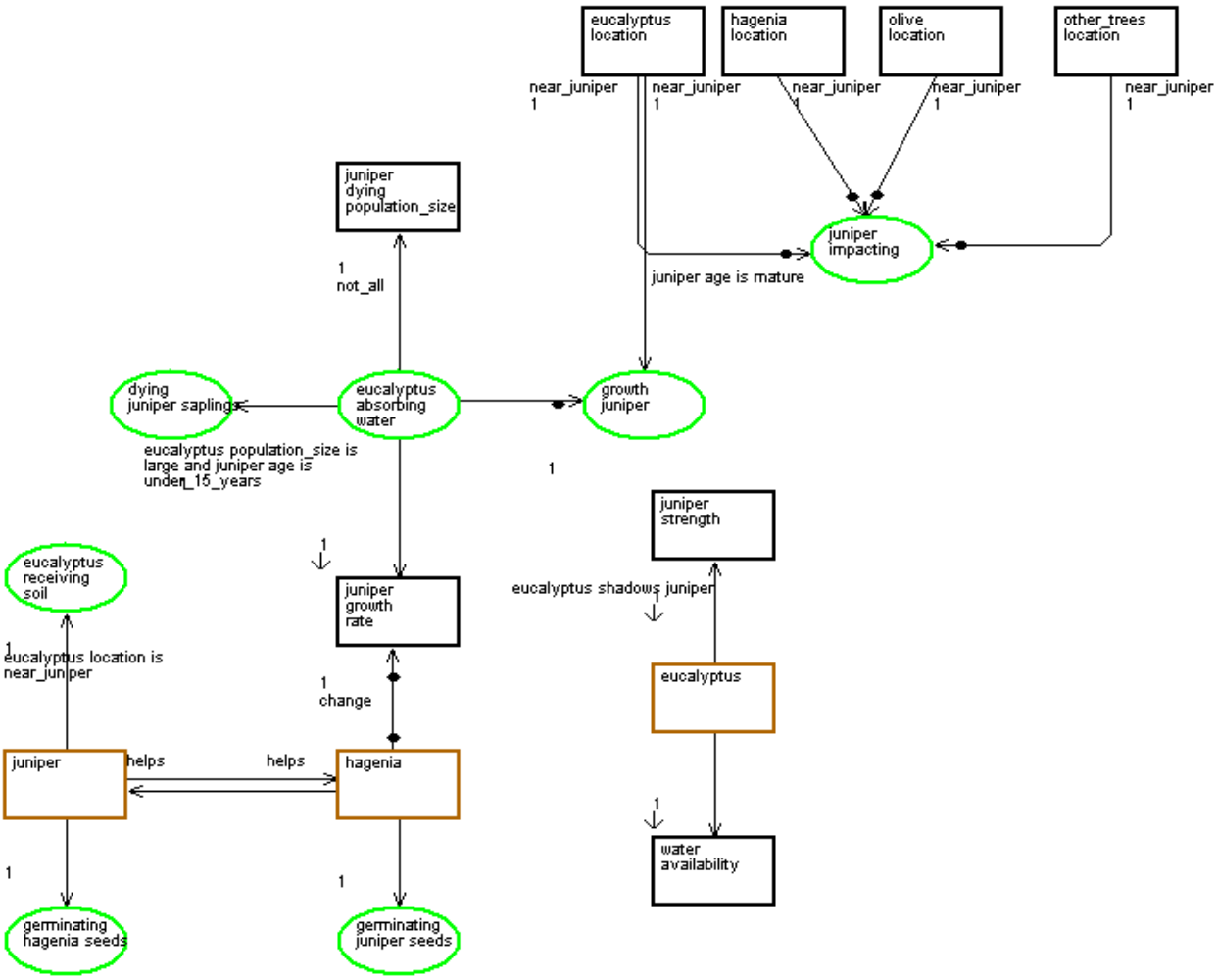


Figure 4.7: Interactions between *J. procera* and other common tree species in the locality. The text outside of the boxes give the conditions attached to the statements.

It was observed by one informant that juniper and hagenia help each other. When asked to explain this relationship further, the informant stated that he had seen the two trees growing together in the forest. He had observed an association between

the two and assumed a mutually beneficial relationship. He was not able to describe which interactions contributed to this relationship.

4.9 Coppicing and pollarding *J. procera*

The knowledge about coppicing and pollarding elicited during the research is potentially rich, due to the fact that these were activities that a number of people were carrying out.

4.9.1 Pollarding

Informants noted the positive effect that pollarding had on the production of new shoots and the growth rate and shape of the trees. Cutting the branches of the trees was stated not to affect their mortality.

Some knowledge was elicited about the impact of different actions associated with cutting. Cutting branches with a saw was said to increase the ability of the tree to grow new shoots, whilst cutting it with an axe would decrease this ability. One informant stated that putting grass or soil on the cut stump would prevent the cut stump from becoming dry and hence increase the number of shoots produced by the tree.

4.9.2 Coppicing

Cutting the trunk of *J. procera* was stated by interviewees to have an impact on the growth, growth rate, height and mortality of the trees. The degree to which the trunk was cut was said to affect the response of the tree (plate 4.3), in addition to other variables such as the age and moisture content of the tree. Increased maturity and decreased moisture content was said to reduce the ability of the tree to grow again after having been cut.

Plate 4.3: A *J. procera* tree that has been cut extensively, but still appears to be alive.

In figure 3, the node labelled 'amount juniper trunk cutting' is linked to the nodes 'growth juniper' and 'dying juniper' with two arrows, one representing a positive causal relationship and one, with a black dot, representing a negative causal relationship. In the juniper knowledge base, more than two statements refer to relationships between these nodes, but for the purposes of ease of interpretation, the lines representing these statements have been hidden.

The conditions attached to some of the statements explain some of the apparent contradiction depicted in the diagram in the form of both causal arrows and negated causal arrows.

Poverty was said to be a major factor spurring unsustainable cutting of *J. procera*. Cutting juniper for firewood and construction wood was described as causing a threat to the population of *J. procera*.

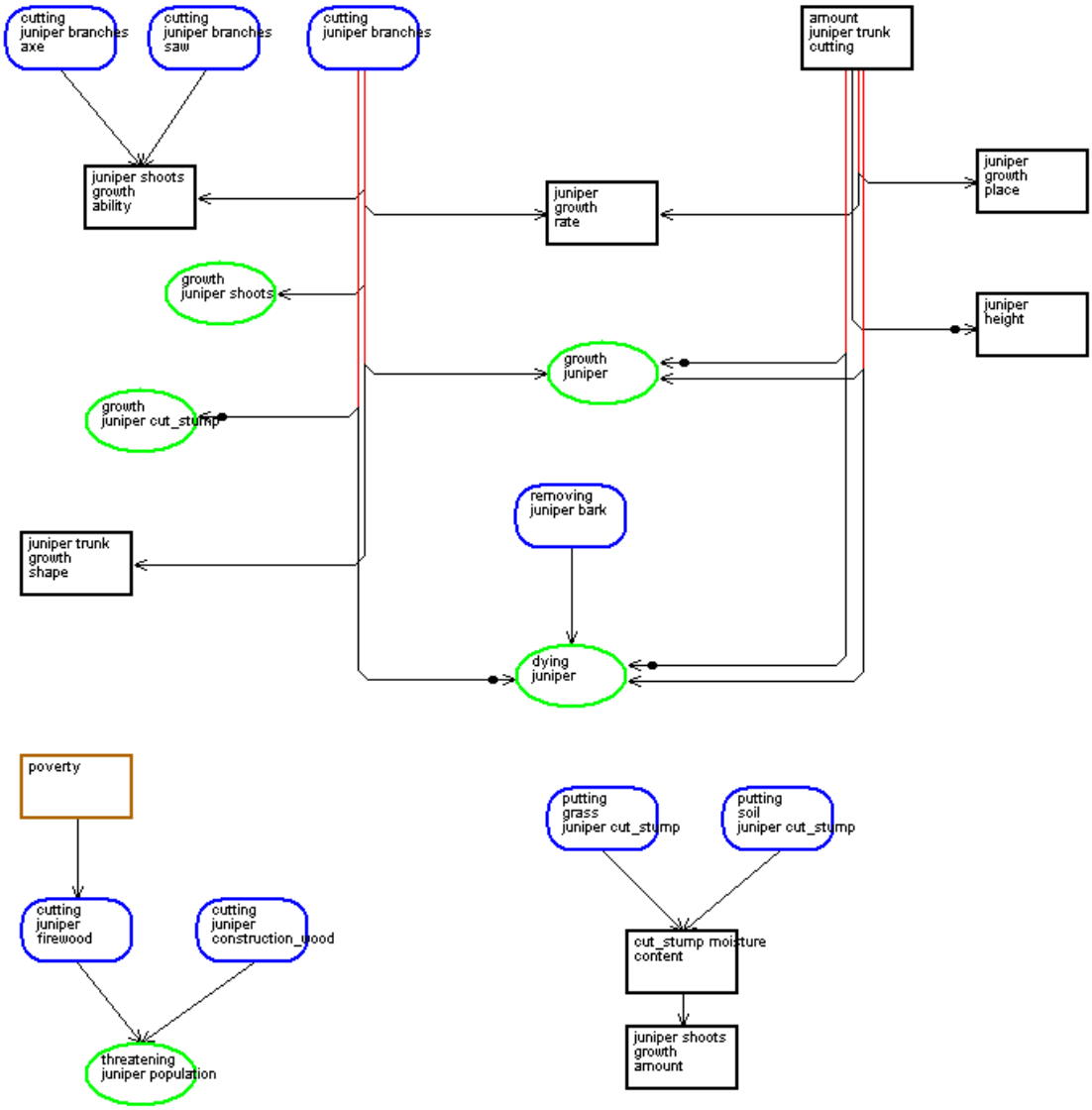


Figure 4.8: The impact of coppicing and pollarding *J. procera*

4.10 Focus group discussions

Focus group discussions in the three villages were used to explore some of the issues raised in the interviews in more depth, in particular anthropogenic interactions with *J. procera*, and to examine some of the social issues raised during the research. The information detailed below is not contained within the juniper knowledge base.

4.10.1 The importance of J. procera

In each of the focus group discussions that took place in the three villages, all of

the participants stated that they considered *J. procera* to be the most important tree. One of the reasons given for this was "jeroof gerenyakena", which, though the translation is not entirely clear, means roughly for our life, our lives or our living, or to live in a better way. The quality of life in the study area was clearly closely associated with the presence of the juniper trees. One of the reasons for this, discussed in the FGD that took place in Faisel Angaso, was that the trees improved the quality of the air. At the altitude where *J. procera* grew the air was considered to be better and the people thought to live longer. Below and above the tree zone the air was considered to be dry. One participant stated "the people who live closer to these trees do not get easily aged, they live longer than others." The role that *J. procera* was understood to have in relation to the weather was also closely connected to this statement, particularly the perception that it draws the rain, without which people could not grow crops.

In terms of its ecological value, *J. procera* was stated to be important for the prevention of soil erosion. In Faisel Angaso, there was concern raised that without such trees the country would become a desert.

Other reasons that the tree was considered to be so important were related to the practical utility of the tree, its importance as timber and firewood, or for building furniture. The durability of *J. procera* made it the preferred choice of construction wood. The sap was said to be used as a glue.

In Faisel Angaso, the importance of the tree in times of political unrest was discussed, as it provided a habitat for wild animals which were eaten by people that had been displaced or chose or forced to live outside of communities during the Derg regime. It was also considered to be important because in the event of a food shortage or famine the wild animals that juniper provides a habitat for would be an important means of survival.

Other reasons given for the importance of *J. procera* were as a tourist attraction, a means of protecting the house from wind, and for sheltering cattle. One traditional healer said that the tree was used for 12 diseases; another person said it was used for cattle diarrhea.

Other trees in the study area identified during the focus group discussions were: hybericum, hagenia, discombadium, rapania, shevrolera, gurumbe, erica, olive, euphorbia, pitosparra, eucalyptus, mitiness, and quoshimo. Nobody considered any other tree to be more important than *J. procera*.

4.10.2 Previous management

There was not consensus about whether or not there was any collective management of *J. procera* in the past, before the Derg regime placed restrictions on cutting it. One participant stated that traditionally their fathers did not allow them to cut it, which was a rule passed at a local level. Another said that cutting juniper and hagenia was banned by the government during Haile Selassie's reign. Another said that prior to the Derg regime, when private ownership of land was common, people would not allow others to cut trees on their land, but there was no particular management of juniper. It was stated that in the past people did not cut the tree the way they currently do.

4.10.3 Threats to J. procera

4.10.3.1 Unsustainable utilisation

Poverty was universally regarded as the reason for unsustainable exploitation of *J. procera* in the study area. Some participants stated that population increase had lead to rising poverty. The biggest threats to the *J. procera* population were considered to be demand for agricultural land (plate 4.4), fuel wood and construction wood, although there was not consensus about which presented the biggest threat. Demand for pasture was not considered to cause a threat as livestock were able to move between the trees.

In Gama Taga, participants stated that the tree was no longer threatened because people had stopped cutting it continuously as a result of the ban. Also, it was thought by some participants that because of projects such as the Bale EcoRegion Sustainable Management Programme, people in the future would become more

Plate 4.4: High altitude land being ploughed for agricultural use.

Plate 4.5: A new house in the process of being constructed, with the frame made from *J. procera* wood.

educated, that people “are having better and better knowledge of the advantages of the tree so in the future there is no threat to it”. Although it was agreed during the meeting that the ban was effective and people had stopped cutting the trees, during the same meeting it was stated that the trees were cut during the night and ‘stolen’. Furthermore, during a visit to the home of one of the participants where a new house was in the process of being constructed, juniper was the wood being used for this construction (plate 4.5).

One of the participants in the meetings was the second village chairman and contributed much to the discussion about the importance of the tree. He was also a very vocal supporter of plans to plant more *J. procera*. However, during a visit to the person’s house when some weeks previously, a large pile of juniper wood was observed (plate 4.6) and his wife stated that an income was earned in the household from the sale of firewood.

Plate 4.6: A pile of *J. procera* firewood that will be sold.

All participants in Faisel Angaso and Gama Taga agreed with the prohibition on cutting *J. procera*. In Shefario, people said that on one hand they agreed and on the other they did not agree. They knew it was useful but because their

livelihoods depended on it they did not want it to be banned.

Plate 4.7: A woman carrying *J. procera* firewood on a horse and mule.

Plate 4.8: *J. procera* firewood being sold on the roadside.

Throughout the research, the majority of people observed cutting and carrying wood from the hillsides and many of those selling it in the town were women (plates 4.7 and 4.8).

4.10.3.2 Other threats to the J. procera

Seedlings below one metre were considered to be threatened by stamping, eating and urinating of cattle. At the height of two metres, the only threat was considered to be animals rubbing the tree. Above the height of four metres, people cutting the trunk of the tree, burning it or cattle sheltering and urinating around it was considered to be a threat.

4.10.4 Millennium planting

By the Ethiopian calendar, the millennium fell in September 2007 in the Gregorian calendar. As part of the millennium celebrations, the government initiated a tree planting scheme that two of the villages were participating in. In Faisel Angaso, 5,000 juniper seedlings were to be planted, and Gama Taga they planned to plant 2,000 to 3,000.

The reasons given for the selection of *J. procera* as the species to plant were to replace the native trees that were in bad straits, endangered or going to disappear so that the next generation would inherit the new trees, and to prevent the country from becoming desert.

4.11 Interviews with key informants

Three key informants were interviewed during the research and the information they provided gave additional context for the results of the research. Some of the knowledge they imparted was complementary to that offered by local informants; others was not.

4.11.1 Anthropogenic interactions

The forester working for the Rural Development and Agriculture office in the Natural Resources Department of the local civil administration was able to provide some information which supplemented the knowledge offered by interviewees. In relation to coppicing the tree, he explained that the ability of the tree to grow again after the trunk was cut was related to its age because the maximum volume increment of the biomass of the tree would begin to decrease after a certain age. After this age the probability of the tree regrowing after coppicing would decrease. He was not certain which age this was as he said that he had not found such information about indigenous tree species, but he assumed it was about 60 years old. In comparison, eucalyptus reached the age of maximum biomass increase at 7 years.

In relation to pollarding, cutting the branches of the trees with a saw rather than an axe was explained by the forester to enhance regrowth because the stump would be smooth and water would flow over it. If cut with an axe, the stump would potentially collect water and be vulnerable to rotting and fungal diseases. Pollarding was considered by the forester to be good for the tree but because the forests were very diminished and he considered that the people did not have knowledge on how to manage the trees he supported the complete ban on cutting it.

The interviewee who had conveyed the knowledge about cutting the tree with a saw and placing wet soil on the cut stump to enhance growth had said that he had received training from a government employed development agent in which this was said. When asked, however, the Development Agent from the same village, Shefario, did not differentiate between cutting in these ways and had no knowledge of the impact of putting soil on the cut stump. She stated that above the height of two metres the tree would not regenerate if it was pollarded.

The Development Agent was of the opinion that it was impossible to completely stop people from cutting *J. procera* because their livelihoods were dependent on it, but the impact could be minimised through programmes such as the distribution of seedlings. Eucalyptus, hagenia and juniper seedlings were being distributed by

Development Agents in the area. Also, some poorer people were being given cows, beehives and chickens in order for them to gain another source of income. In addition some people were being granted loans.

The Development Agent said that the sentence for being caught with wood from a banned tree was five years imprisonment, but due to a decrease in the number of guards working locally the ban had been *de facto* relaxed. Two or three years ago a number of guards had been sacked due to the discovery of bribery and corruption, and a shortage of budget meant that replacement guards were not employed.

The forester did not consider *J. procera* to be a profitable species because of the slow rate of growth compared to species such as eucalyptus. The focus had therefore shifted to exotic species rather than indigenous ones.

4.11.2 Mother trees

The forester thought that the best quality juniper had already been extracted from the surrounding forests and that what remained were remnant forests, with stunted and crooked trees. Such trees had a lower value for construction. He discussed the implications for this for regeneration, due to the difficulty of finding suitable mother trees from which to obtain seeds. In selecting such trees he would look for a cylindrical shaped bowl and uniform branching. These were hard to find as the best stands had been removed.

That the mother trees were hard to find was also discussed by the key informant who was an employee at Bamo nursery, where juniper seeds were propagated annually. He said that mother trees in Bale were almost completely finished except in churchyards, mosques or holy places, where the trees are protected from being cut. From such places he collected the seeds for propagation, or they were bought to the nursery from elsewhere in the country, in the Southwest or close to Addis Ababa, where there were more mother trees. The oldest and straightest trees were selected as mother trees.

4.11.3 Propagation

The process of propagating *J. procera* seeds was described by the key informant at Bamo nursery. The fresh berries were crushed in a motar. Then they were dried and when they became dry they were rubbed between the hands to get rid of the husk. The seed remained.

Between 40% and 90% of the seeds germinated at Bamo nursery. Seeds that were bought from another area had a 40% germination rate, but when berries were collected from the Bale area and processed in the nursery a 90% germination rate was usual (plate 4.9). The key informant considered this high germination rate to be because of selecting suitable seeds and the way in which they were processed. If the seeds were kept for more than six months the probability of germination was thought to be much less.

Plate 4.9: *J. procera* seeds at Bamo nursery.

The seeds were planted in plastic bags in a mixture of forest soil because of its nutrient value, soil from the surrounding area, sand to assist water filtration and fertilizer.

Grass was put over the seeds to prevent the soil eroding, and was removed when the seedlings were about half a centimetre high, when a bigger shade was built for them. The shade was removed and the seedlings transplanted when they were about 10 cm high and aged about one year and six months (plate 4.10). At that age if they continued to grow in shade the employee thought that strength of the seedlings would decrease. Sometimes, however, shade was necessary to protect them from frost and hail, which resulted in the leaves becoming dry and the seedlings dying. While in the nursery and still in plastic bags the seedlings were vulnerable to frost or hail; after they were transplanted in the open and the roots became established they could resist such extremes.

Plate 4.10: *J. procera* seedlings at Bamo nursery.

4.11.4 Qualities of J. procera

The forester explained that *J. procera* was pest and drought resistant and could survive on degraded land, hence it was considered a superior species. Furthermore, the wood was termite resistant.

He was unsure about whether the tree was light demanding or shade tolerant. He also thought that the aspect of the slope may have had an impact on whether or not *J. procera* grew in a certain area, as there were some areas in the district where juniper did not grow. The most favourable altitude for *J. procera* was between 2500 to 3000, according to the forester.

The forester showed the researcher an area of eucalyptus and juniper growing together and explained that if the water resource was scarce the juniper would suffer but if not they would grow together.

4.11.5 Ethiopian forests

According to the forester, decentralisation of control over Ethiopian forests had lead to a decrease in the budget available for forestry. Previously there was high amount of budgeted afforestation programme but the budget was no longer available to manage plantations.

Like the Ethiopian National Parks, most of the priority forest areas are not gazetted, or legally accepted by parliament. They remain proposed parks or priority forest areas. There has been no inventory of priority forest areas and the boundaries are not demarcated.

5 Discussion

The discussion that follows will firstly examine each of the research questions; then assess the local knowledge elicited in the light of published scientific material about *Juniperus procera*. This will be followed by some recommendations for further research, a discussion of additional issues raised in the application of the methodology and some potential future developments for the methodology, and lastly look at the potential for the forests in Bale.

5.1 Research questions

5.1.1 Local knowledge of J. procera in the study area

From the knowledge elicited during the research it was possible to establish that some interviewees held sophisticated knowledge about ecological and anthropogenic interactions with *J. procera* in the study area. Their areas of knowledge covered a range of topics, from the natural regeneration of the species to factors that affect its mortality.

Some conflicting knowledge was obtained, highlighting the need for further research to explore such issues in more depth.

Farmers were able to describe the processes leading to regeneration of juniper and various environmental factors which affect it. Some knowledge came from observation and some from direct experience of propagating *J. procera*. That farmers were germinating and growing seeds themselves was previously unknown to the client NGO and the professional key informants who were interviewed.

Interviewees discussed a range of environmental factors that influenced the growth of *J. procera* and related these to the different conditions in different areas. There was a lack of consensus about where the trees grew best, which may have been a result of the fact that more trees were observed growing in the higher

altitude areas than the valleys, where the villages were situated. The mountainsides were associated with the forests and it may be that from such an association better growing conditions were assumed.

The lack of consensus regarding the impact of different soil types on the growth of the tree may also have been related to these locational variations, as red soil was observed as being prevalent on the hillside where many people stated that the tree grew better. The majority of participants, however, associated black soil with improved growth of *J. procera*.

It may also be expected that in different villages the types of soil were different and that people's classification of soils were comparative, so that 'black' in one village may have been 'grey' in another. People had different systems of soil identification that did not appear to be related to gender, location or socio-economic variables, with some informants identifying as many as five soils and others only two.

There was a high level of consensus regarding the impact of livestock on the species, with seedlings and saplings being regarded as vulnerable to decreased growth rates or mortality and the impact on older trees confined to the urine of animals. Where some inconsistencies were apparent in the knowledge obtained it may have been the result of different informants describing different degrees of grazing. Some of the knowledge obtained about which animals ate the immature trees was also conflicting. This may have been the result of conditions, for example, during times when there was little fodder animals may be inclined to eat species they would not ordinarily.

Interviewees described anthropogenic interactions with *J. procera* and discussed the impact of different degrees and methods of coppicing and pollarding the trees. The impact of such practices was said to depend on characteristics of the trees. Whilst it was known by some informants that different methods of cutting affected the regrowth of the tree, it was not possible to establish whether this knowledge was common amongst the population.

Participants in the research described the socio-economic conditions leading to

unsustainable exploitation of *J. procera* and, although they were in favour of conserving the resource, most felt that addressing poverty in the area would be a more effective way of maintaining *J. procera* populations than banning cutting the tree.

5.1.2 Relevance and incorporation of knowledge

The BERSMP aims to facilitate the development of agreements between local communities and the civil administration that enable local people to benefit from the surrounding forests at the same time as taking responsibility for their sustainable management. The agreements will involve management plans which will allow people to legally harvest *J. procera*, a practice currently prohibited.

Local knowledge has a key role to play in the development of management plans which involve sustainable exploitation. Interviewees expressed knowledge about a range of factors that affect the ability of *J. procera* to regrow after having been cut. They were also aware of circumstances in which cutting the trees would be beneficial to their growth. Further exploration of these issues by the client NGO with the local community should provide the foundations for plans for future sustainable use of the forests. This should be complemented with scientific, silvicultural knowledge and research in order to establish allowable cut levels that enhance forest regeneration.

In order for a management programme to be successful, feedback on progress obtained from the farmers could be used to adapt the programme. It is recommended that their knowledge on the impact of the management plan is regularly obtained and mechanisms for feeding it back into a cycle of adaptive management are explored.

The BERSMP has much to gain from the knowledge of the farmers who are planting the trees themselves, and these people should be identified and supported in this activity. The problems they have encountered as a result, in particular with regard to social relations with their peers, should be carefully and sensitively explored. That one farmer stated that some of his seedlings had been stolen is

indicative that there is a demand for seedlings which is not currently being met by the distribution service provided by the government. Peer to peer training in propagation techniques could be one way of attempting to address this issue.

Local people were able to assess a range of environmental factors that affect the growth of the tree and such issues will be relevant to future attempts to create areas of both natural and man-made forest regeneration. Selecting areas where conditions such as soil type are favourable will have a significant impact on the success of such projects.

How the age of the trees affects their vulnerability to the impact of livestock has significant management implications, as agreements being devised may incorporate the grazing of livestock on areas of land where natural regeneration of *J. procera* may take place. Establishing when and under what conditions grazing does not threaten regeneration will allow for increased utilisation of the space.

The methods employed by local farmers propagating the seeds themselves differ from those used in the government nursery. In the nursery inorganic fertilisers were being applied, whilst farmers used decaying juniper leaves. If the nursery wanted to convert some of their activities to organic production, such knowledge of the farmers could be very useful.

5.1.3 Associated problems, risks and opportunities

Some of the associated problems and risks inherent in the acquisition of local knowledge and its incorporation into a sustainable development project could be regarded as generic to many research and development projects that take place. Such issues include:

- The time and cost to the project to carrying out the research
- The opportunity cost of time for participants
- Expectations of enumeration or other immediate benefits by participants
- Raising expectations of participants
- Challenging existing social structures

Specific problems and risks involved in the research into local knowledge of *J. procera* in the study area and the incorporation of this knowledge into the BERSMP include:

- Too much focus on one species and one which may have limited potential for income generation due to its slow growth
- The sensitivity of examining activities currently illegal
- Potential unwillingness of participants to divulge information on activities currently illegal
- Potential inaccurate information divulged by people in relation to harvesting as a result of the perception that such information will enable people to increase user rights
- The range of issues involved in ecological and anthropogenic interactions with *J. procera*, the complexity of the issues and the inconsistencies and conflicts apparent in the knowledge obtained

With regard to the latter point, an appropriate response of the BERSMP might be to not attempt to find definite 'answers' but to further explore areas of conflict and inconsistencies. Such a problem consequently gives rise to an important opportunity that the elicitation of local knowledge presents. It could be argued that it is the exploration of knowledge, the discussion and recognition of its importance that the value in such an approach lies. Through the generation of debate, the issues involved become 'live' and the profile raised; people engage with the problems; looking for sustainable solutions is not a task afforded to outside agencies but one which is discussed in people's houses, between and within families, a current issue rather than an unspoken one. Valuing peoples' knowledge, experience and opinions can lead to the more active engagement of the community in conservation. The participation underpinning the approach taken by the BERSMP lends itself to such a level of engagement.

As the research currently stands, however, it could not be regarded as a participatory: the context of a researcher going into the field and carrying out a series of interviews and focus group discussions is not a participatory one. Furthermore, to use the results of the research solely as a means of analysing the knowledge, rather than as part of an adaptive forest management programme and participatory process, is extractive.

The results of the research and the knowledge base produced should be regarded as a tool. Like a hammer, it is only useful if someone picks it up and uses it. It is what happens to the knowledge elicited in the future that will both determine its utility and lodge the research into the ethical framework within which it should be evaluated.

5.2 Local and scientific knowledge of *J. procera*

The type of knowledge conveyed in the scientific literature discussed in section 3 and that elicited from local people is vastly different and makes comparison a difficult task, in fact, drawing direct comparisons, such as the light requirement of seeds, would be meaningless because the terms of reference are so different.

One of the issues raised by a number of authors about *J. procera* is the influence of provenance on the trees and germinability of the seeds. Obviously, it is here that the 'localness' of local knowledge is significant. In order for this issue to be explored through the elicitation of local knowledge the research would need to be repeated in a different locality.

Interestingly, though problems associated with the germination of *J. procera* were referred to in the scientific literature, in the government nursery this process was being carried out very effectively and it was evident during the research that post-transplanting management of saplings was perhaps a more significant constraint for effective repopulating of the species, for example, because of seedlings and saplings becoming stunted as a result of grazing.

Comparison of the nature of the knowledge obtained during the research and published scientific knowledge is interesting in itself. The knowledge offered by interviewees, covering as it does a wide range of environmental, anthropogenic and socio-economic factors, is in contrast to the limited focus of many of the experiments described in the scientific literature, which mostly present analysis of specific variables under controlled experimentation. It could be argued that the knowledge held by local people lends itself to a more holistic approach to

conservation.

5.3 Recommendations

5.3.1 Local knowledge of J. procera in the study area

Further exploration of local knowledge about *J. procera* in the study area is recommended. This may involve investigation of the areas highlighted by this research where knowledge of the local population was inconsistent or conflicting. These areas include:

- Soil properties and their effects on *J. procera*
- The impact of location and locational characteristics on the growth and characteristics of *J. procera*

Some topics investigated during the research have significant management implications and these areas deserve further exploration with local people. They are:

- The impact of degrees and methods of coppicing and pollarding
- The impact of livestock

It is recommended that in subsequent research the farmers that are propagating *J. procera* from seed are selected as a stratum of the population, as their knowledge is likely to be significantly different from those that are not. The knowledge that they hold on the issues of propagation and transplanting should be explored in more depth. The possibilities for mechanisms of transferring some of this knowledge to other local people could be investigated by the client NGO.

The completion of a generalisation phase of the research would enable conclusions to be drawn regarding how representative the knowledge elicited is of the knowledge held by the population as a whole.

5.3.2 Combining local knowledge with applied silvicultural research

In order to produce the most effective and efficient forest management plans it is recommended that silvicultural research is conducted in the study area similar to that described by Amente (2005). This took place in the Adaba-Dodola forest, which is also located in the Bale mountains in which *J. procera* is the dominant species. Such research would benefit from the incorporation of local knowledge in order to establish:

- Allowable cut levels
- Recommendations for methods of extraction
- Suitable livestock stocking rates

5.3.3 Combining local knowledge with Geographical Information Systems

The Bale EcoRegion Sustainable Management Programme is currently in the process of mapping the region with Geographical Information System (GIS) technology in order to accurately ascertain the natural resource base that exists there. Combining such information with local knowledge could add significant depth to the results obtained. For example, the ability of the project to map the soils in different locations would be greatly enhanced by conducting field work with local people. Whilst the classification systems employed by local people and scientists may be different, to research the systems used by local people and to produce maps based on them would be more relevant to them and consequently enhance the work of the project.

5.4 Applying a systematic approach to knowledge elicitation and representation: the use of AKT

In addition to the constraints referred to in section 3.2, a number of issues were raised during the research in relation to applying a systematic approach to knowledge acquisition and the use of the software AKT.

The statements in the knowledge base are computer software generated 'natural'

language statements derived from programming text entered by the researcher encoding a sentence, a process that involves a heavy element of interpretation as there is more than one way of entering similar statements. The original sentence, before it reaches the encoder, has been translated into the language of the researcher/encoder. The resultant product, a series of standard format sentences, which have been squeezed to reduce repetition and for the purposes of consistency, has evolved somewhat from the words of the farmer and the field in which he spoke. The knowledge represented by AKT has been stripped of its context, the living environment from which it came.

Exploration of the context is an important part of the research but representation of it does not sit comfortably within AKT, where units of information hang within loosely pinned frames or topics, connected or not to other singular units of information through the sentence structure. Such knowledge is indeed, as Sinclair & Walker (1999) say, an abstraction, as it does not and cannot represent the interconnected nature of the units referred to. In AKT 5 it is not possible to enter a 'part' of a 'part', so, for example, the moisture content of juniper berries is unrepresentable, as are the atoms which exist within it.

A knowledge base is not capable of representing the changing pressures and fluxes of ecological and anthropogenic activity, the multi-dimensional relationships and interactions within and between systems. It is these issues that a holistic approach to natural resource management must address.

What exists in the knowledge base is a static, simplified snapshot, a hypothesis of knowledge conveyed by multiple sources. It allows areas of conflict and consensus to be identified and it goes some way to conveying the types of reasoning being employed by the sources of the knowledge and the classification systems they use. Rather than representing peoples' relationship with their environment, it presents their understanding of parts of it, the lens of analysis they use.

Perhaps the powerful aspect of the representation of local knowledge in a format that it can be systematically scrutinised is that it provides a channel through which an echo of the voice of a farmer can be analysed by people who, conceptually and

geographically, are a long way from him or her. The process of shifting the focus to the farmer, directing attention to the reasoning he or she employs, is a significantly radical shift from the dominant development paradigm, which continues to follow a model of technology, ideology and policy transfer from the global North to the global South.

5.5 Potential future developments of software and methodology

Perhaps the most obvious potential future development of the software AKT is to link knowledge bases with geographic information systems (GIS) and global positioning systems (GPS). This combination could work on a number of levels. As discussed above, combining local knowledge with GIS could add depth and local meaning to the results produced. Knowledge bases could be used to enhance the accuracy of GIS, as this could provide one mechanism for ground level research and information to be combined with information gathered from satellite imagery or aerial photography.

Combining AKT with GPS could mean that the knowledge within one knowledge base could be tagged with geographic, information that is accurate to within the space of one metre. Some of the locational restrictions of the software discussed in section 3.2.3.3 could consequently be overcome. In relation to the research project the issue of the influence of provenance on the characteristics of *J. procera* is clearly relevant.

Within such contexts it is possible to visualise the potential for exploration and representation of local knowledge expanding and its utility as a tool gathering new momentum. In developing such combinations of information a collection of disconnected knowledge bases have the potential to become a detailed network or grid of global ecological knowledge, pertaining to potentially hundreds of species or environments.

However, in the potential development of such information systems perhaps the biggest risk of exploitation or abuse of local knowledge lies. If such information was publicly available, as certain chunks of it surely would be, a whole new arena

would open up for bio-prospectors. Furthermore, knowledge within such a network would have been extracted to a higher level. Much of its value would lie in its connections with the rest of the system, rather than in direct reference to the location from which the knowledge came and the people who provided it. Who would have the power to access and use such knowledge?

5.6 Protection and pragmatism: the future for forests in Bale

The 'conservation versus utilisation' debate squarely divides protagonists into two camps, but if attempts are made to address the complex issues involved, rigidly sticking to an ideological or theoretical stance is counterproductive. In attempting to frame research within the current literary debate it is crucial not to ignore the fundamental issue that each system is different, subject to different pressures and fluxes, where different species and cultural values coexist.

Whilst it may be the case that the ancestors of the inhabitants of the Bale mountains have lived in the area for generations and that the landscape there has evolved with human habitation not in spite of it, it is also true that massive social upheaval in Ethiopia has eroded traditional natural resource management systems and that unsustainable use of resources presents a real threat to both landscapes and the ability of people to survive. The picture is not a romantic one of tribal people living ancient ways of life any more than it is of destructive, uncivilised communities senselessly destroying environments.

In the study area, people were making livelihood choices which resulted in unsustainable use of natural resources because there were few, if any, other livelihood choices open to them. Taking an axe and cutting a tree with a two metre diameter is not a comfortable task, especially for a woman with a baby on her back and a young child around her legs. Viable alternative livelihood choices must be available. As Aman Waliye said during the focus group discussion in Shefario, banning cutting juniper is meaningless without addressing people's poverty. For a household which depends on income from the sale of wood the margin between feeding and not feeding children is a narrow one.

The gazettement of national parks and its implications are a key issue in Ethiopia. When the land becomes 'legal' the people on it or using it become 'illegalised', a process unlikely to present more livelihood choices but perhaps to increase pressure on the land which lies outside of protected areas, the study area included. Gazettement results in the authorities being able to exert more force over the local population, though not the resources to carry it through. In the case of the Nech Sar park and the African Parks Foundation, this may be where outside agencies are called to step in.

It is unsurprising that the Frankfurt Zoological Society supports the gazettement of the Bale Mountains National Park; the process seems necessary for their task to be carried through. But clearly protection is not the only approach and it will be interesting to observe the effect of the different management approaches of FZS and the BERSMP in the Bale mountains. The success of previous participatory natural resource management programmes in Ethiopia is encouraging.

6 Conclusion

Multi-scale and multi-dimensional issues are involved in the interface between humans and habitat. Conservation and utilisation of the natural resource base are not mutually exclusive, but attempting to combine the two is a complex process and one which must not simply involve the local communities but be directed by them.

The acquisition and representation of local ecological knowledge is not an end in itself but a thread with which it may be possible to lace some of the issues together. The knowledge that people hold, derived as it is from their experience of their environment, is a valuable resource that can feed into natural resource management programmes. Through the exploration of LEK it may be possible to broaden the focus of conservation beyond a narrow, scientific analysis of the specific requirements of species. It may also be possible to narrow the focus from an arms length discussion about the merits and deficiencies of different approaches to conservation, to the realities of different situations in different places.

During the research local people discussed multiple issues that affect the *J. procera* population in the study area: germination; propagation and transplanting; different threats to the species at different ages; the optimum conditions for growth; the impact of livestock and of coppicing and pollarding. All of these subjects are important for *in situ* conservation but what is more important are the people who communicated their knowledge. For it is their practices that will determine the success, or otherwise, of natural resource management. Practices are influenced by knowledge as well as socioeconomic conditions; by raising the profile of the knowledge and affording it its due value it may be that people begin to see themselves more as part of potential solutions than as part of the problems, which seems to be, in part, a consequence of the rules, restrictions and prohibitions that are dictated from ‘above’ or ‘outside’, which fail to address the constraints that people experience.

The research has not provided a set of definite conclusions; rather it has

highlighted issues significant for the growth and regeneration of *J. procera* in the Bale Zone, and areas of conflict and consensus which need to be explored in greater depth with the local communities as part of the participatory processes underway.

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