Protecting natural resources:

an overview of the wattle invasion in the Maluti district

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Abstract

Alien invasive species are a main concern in South Africa due to environmental impacts. A government sponsored program was created in 1995 to address this issue. This research has its focus on one of the areas where the program has been clearing the species *Acacia mearnsii* and *Acacia dealbata*. The main aims are to evaluate the present status of wattle and to compare it with the development in the past; to evaluate the importance and perception of the wattle on villages with different extents of accessibility to wattle; to evaluate the impact of the WfWP and define its organization as a system, to assess its effectiveness on eradication and environmental impact, and, finally, to evaluate the status of the landscape.

There has not been a significant change on the wattle spread between 2000 and 2007. Independently of the accessibility to wattle, the people see wattle as a resource and, due to that, the majority does not agree with the clearing program. The later, although, is not effective due to the high rate of regeneration and it is not working on a sustainable way since the communication between the different levels of the organization is not efficient. Finally, the landscape is suffering from enormous changes by the spread of wattle and by the outcome of the clearing. This can have a negative impact on tourism in the area.

We conclude that the program is not being effective in all its extent. We suggest thus that integrated, flexible and resilient adaptive management strategies should be used in order to integrate social and environmental change on the planning of the eradication.

Keywords

Invasive wattle species, natural resources, sustainability, management strategies, landscape, ecology, Acacia mearnsii, Acacia dealbata, livelihoods

"And always behind them the dim wall of the wattles, like ghosts in the mist."

Alan Paton, Cry the beloved country, p. 13

Introduction

Alien plants invasions in general are generating a great concern in terms of environmental impacts (Binns et al., 2001). In South Africa, invasive alien species (IAS) are causing billions of Rands of damage to the economy every year, and are the single biggest threat to the country's biological biodiversity (http://www.dwaf.gov.za/wfw/). This problem has been regulated on the national legislation by the Conservation of Agricultural Resources Act (Act No 43 of 1983), Regulation 15. The latter classifies into categories the different alien invasive plants, according to their invasiveness and its commercial or ornamental value. One of the main IAS belongs to the genera Acacia, namely *A. mearnsii* (black wattle) and *A. dealbata* (silver wattle).

Wattle

These wattle species are fast growing and their extensive spread over South Africa since the 19th century has diminished the indigenous vegetation, like fynbos and grassland (Dye & Jarmain, 2004). Acacia species are evergreen, permit transpiration all year long and consume considerable amounts of water (Dye & Jarmain, 2004). In the province of Eastern Cape, these species are classified as category 2 – Plant Invaders (Commercial value) – which are plants that have proved to be potentially invasive, but that offer some beneficial characteristics in terms of commercial or utility purposes (source: NDA). The fact that these species have commercial and utility value raises some controversy in terms of eradicating the species and promotes the study of alternative management strategies (e.g. de Wit *et al*., 2001).

Furthermore, despite the biological invasive nature of wattle, it is extensively used by local rural communities. They are adapted to the availability of wattle and have included it in their local resource pool.

The Working for Water Program (WfWP)

However, due to the threat IAS have on the South African water resources, a nation-wide eradication program was introduced in 1995 – the Working for Water programme (WfWP). This programme aims at the eradication of invasive species, namely wattle, by working together with the local communities, using local contractors and paying the locals for eradicating the wattle (Binns *et*

al., 2001). It has the dual purpose of protecting water resources and poverty alleviation by job creation (van Wilgen *et al*., 2001).

Ecological aspects

There is no consensus among scientists regarding the issue of the ecological benefits of the WfWP. While some authors state its ecological benefits (Le Maitre *et al*., 2002), others point to the fact that the ecological succession must be considered, and that the WfWP brings along the problem of an erosion threat between clearance and the establishment of indigenous vegetation (Binns et al., 2001). Furthermore, Anon (2002) states that although the programme has been proposed during the last 20 years, the progress towards achieving the goal of clearing major infestations within that period has not yet been assessed.

Social aspects

Some authors highlight the social role of the program. Job creation, poverty alleviation, training and empowerment, environmental awareness, life skill courses and increase of community spirit are some of the effects pointed out (Le Maitre et al., 2002; Binns et al., 2001). Despite the opinions of these authors, Anon (2003) states that although most of the program's social development interventions were aimed at improving economic conditions in poor rural communities, the implications for the lives of the affected people is not fully investigated.

Some authors already indicate some weaknesses of the programme. For Magadlela & Mdzeke (2004), the exit strategy for the workers has not been developed so far, and preliminary findings in 2002 revealed that most workers and contractors leaving the program were not fully equipped to secure work outside it (although this situation also reflects the general economic depression in rural areas). It is possible to presume thus that the programme is not really building up capacity. On their turn, de Neergaard et al. (2005) stress a potential conflict between the perceived interests of society (control of the wattle) and local communities (a continued resource of woody species).

Economical aspects

Some studies conclude that the clearing of the trees was justified due to the cost of clearing being much less than the value of benefits from the improved water supply (van Wilgen et al. 1996) and that clearing programmes are a wise and cost-effective method of protecting vital water resources in South Africa. (Le Maitre *et al*., 2002). Binns et al. (2001) adds that this cash-flow created by the program can give uplift to poor rural communities.

Having a completely opposite position, other authors state that the WfWP program in the Madlangala area is unsustainable due to that fact that it relies on external funding (de Neergard,et al. 2005). Furthermore the economical benefits from alien species must not be forgotten. These are not restricted to the ones of commercial plantations; in rural communities, they also provide fuel and other products; they provide land restoration and the development of agro-forestry.

Aims of this research

There is no consensus among authors who conducted research concerning the wattle invasion and the role of the WfWP program in South Africa. Furthermore the literature review shows that the spatial, social-economical and ecological aspects of both the Acacia sp. and the WfWP are not well explored. At the moment our understanding of a number of important aspects of the dynamics of the wattle invasion remains relatively poor.

This research work intents thus to examine the spatial, ecological and social influences of the spread of wattle. For that, five aims were formulated. The first one is to evaluate the present status of wattle and to compare it with the development on the past years. The second objective is to evaluate the importance of wattle for the villagers of Madlangala and to compare the people's perception on wattle between the villages with different extents of accessibility to wattle. This also includes an analysis of level of dependence and adaptation of local communities towards wattle. The third aim is to evaluate the impact of the WfWP and to efine its organization as a system. The fourth aim is to investigate the effectiveness of the WFWP towards eradicating wattle and its influence on community. This includes an analysis of the effect of wattle on the biodiversity. Finally, the status of the landscape is enormously influenced by the wattle invasion and the clearing programme, which makes the evaluation of its status the fifth aim of this research.

Study site description

The community of Madlangala consists of the villages Pepela, Makomereng and Goxe with approximately 100 households in each. It's located in the local municipality of Matatiele, Eastern Cape Province (30°10'39.00"S and 28°35'40.00"E) (Before 2001 KwaZulu Natal Province) (de Neergaard *et al*., 2005). The two main study villages were Pepela and Makomereng, and their situated just at the foot of the Drakensbergs Mountains, close to the border of Lesotho, and the majority of the villagers in this local municipality speaks IsiXhosa and SeSotho (Municipal Demarcation Board, - http://www.demarcation.org.za/).

The vegetation in the area is now dominated by black wattle (*A. mearnsii*) and silver wattle (*A. dealbata*) and grassland. But the area of Drakensberg is one of the worlds oldest centres of endemism, and is has a very rich biodiversity (http://www.unep-wcmc.org/sites/wh/draken.html).

The chieftess living in Pepela is responsible for both Pepela and Makomereng, but being helped by different comities.

Each village has a school, and Matatiele, the nearest town, is connected to the villages by dirt roads. A local bus is going twice a day.

The majority of the population does not have a personal income but relays on governmental grants like pension and child support (2001, Municipal Demarcation Board, - http://www.demarcation.org.za/).

The climate of the region is dominated by the influence of subtropical anticyclones, and the Drakensberg is one of the best watered, least drought-prone areas of southern Africa. The rainy season is from October to March with an annual precipitation is around 710 mm (de Neergaard *et al*., 2005). In winter, the subsidence of cold air causes atmospheric stability and a distinct dry season, though frost due occur frequently (http://www.unep-wcmc.org/sites/wh/draken.html; de Neergaard, 2005)

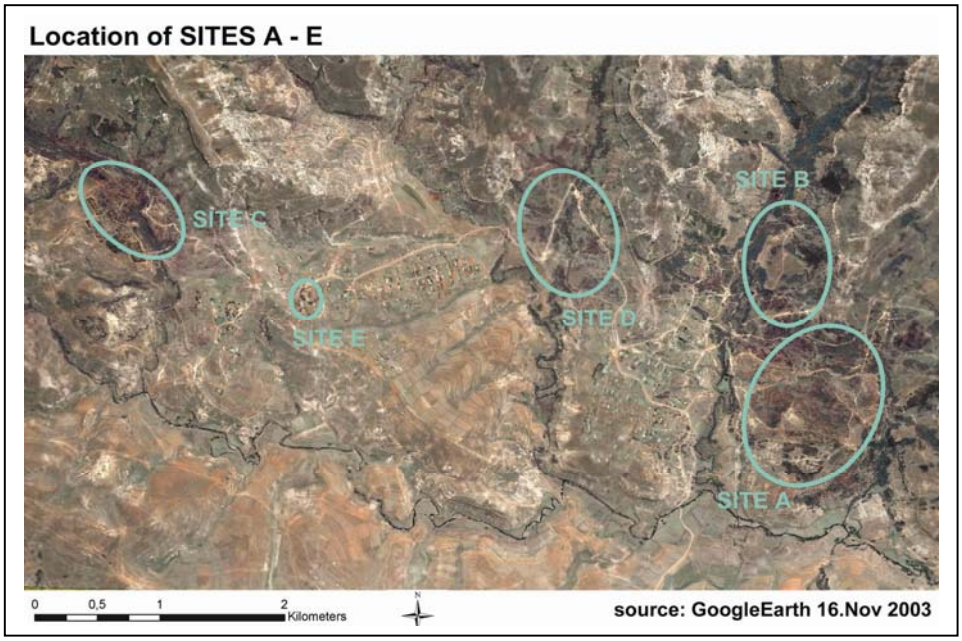
Methodology

The methods were chosen to gain data about the biophysical impact of the spread of wattle and the effectiveness of the eradication (GPS mapping, regeneration survey, vegetation sampling, growing stock density method, soil analysis, germination tests and landscape observation) as well as the social impact of wattle and the WfWP on the community and their adaptation to the resource (semi-structured interviews, questionnaires, mind mapping, drawing exercises, participatory mapping and ranking exercises). Within the biophysical methods as well as within the social methods data was triangulated to gain reliable results.

GPS mapping

Table1: GPS Mapping.

Site	Methods	Material	Aim
A, B, C	Mapping of the boundaries between patches of grassland and wattle stands	Garmin GPS devices/Software ArcGIS 8.1/Aerial picture from 2000	To locate the clearings taken place between 200-2003 and to identify changes in the dimension of the wattle stands
E	Mapping of the boundaries of the wattle stands		To identify changes in the dimension of the wattle stands
	Digitization of the poligons and overlaid with geo-referenced picture		



Map 1: Location of sites A-E.

Regeneration survey

At site D, 16 sample plots of 5x5 meters have been identified and referenced with a GPS device. The plot was laid out and dead stumps of wattle were counted. The regenerated wattle plants were counted and divided in classes by height (<0,1m; 0,1-1m; >1m) to describe the stage of regeneration. The aim is to evaluate the effectiveness of the clearings on eradicating wattle.

Vegetation Sampling

Vegetation sampling was carried out on site B (map 1) to find out the effect of wattle on the floral biodiversity of the area. Three GPS referenced sample plots of 5x5 m were laid covering dense wattle, transitional area between wattle and grassland and open grassland. The number of individual plant species in each of the sample plot was recorded and used to identify absolute species richness (alpha diversity).

Growing stock density methodology

The volume of above ground woody biomass of wattle was calculated for the site A to find out the amount of woody biomass on 20m^2 of site A. The Girth at Breast Height (GBH) and height of 50 trees was measured. The trees were chosen randomly from various areas within the site A.

$$\text{Full circular volume } V_1 = \frac{g^2}{4\pi} \times l$$

The GBH was measured using the tape measure and height was calculated based on ocular measurements. The volume of woody biomass in the site was computed using the full circular volume calculation formula derived from quarter girth formula.

Soil Sampling

Thirteen soil samples were taken, on sites B and C. The samples were taken from dense wattle stands, grassland and open cleared land. Three soil samples from each area in site B were used for the germination tests.

Soil Analysis

The soil samples were analysed in the field and in the laboratory. In the field, the pH, electric conductivity (EC) and phosphorus were measured. In the laboratory in Copenhagen (KU-Life), the measurement of the carbon and nitrogen content was conducted as well as the analysis of the soil size particles in order to determine the texture.

pH and Electric conductivity (EC)

A 1:2,5 soil:water suspension was made for all 13 soil samples (10 g of each soil sample were suspended in 25 mL distilled water) and each container was shaken for 30 min to make the solution homogenous. The pH was measured with a handheld pH-meter and the EC was measured using a handheld EC-meter.

Phosphorous

The phosphor in the soil was carried out according to Olsen's phosphorous test on all 13 soil samples.

Particle size analysis/mechanical analysis

This was carried out for all 13 soil samples using the hydrometer (Bouyoucos) method.

Nitrogen and carbon test

All the soil samples were prepared in small tinfoil containers for measurement, using flow injection analysis (Lachat 8000 series). After, it was handed to the lab personnel and the carbon and nitrogen content were measured.

Germination tests

This test was conducted in the field using three different soils: under the dense wattle stands, from the grassland and from areas cleared of wattle. The soil was transferred to vessels, and four zones were marked for planting the seeds of dwarf beans (5 seeds), cabbage (10 seeds), egg plants (10 seeds) and garden radish (10 seeds).

The soil in the vessels was watered and then covered with plastic film with holes in.

At the third day of the test the stage of the germination was noted, and from there on germination was noted everyday for 5 days. The aim is to find out if wattle has any allelopathic effect on the soil where it grows.

Alellopathy tests

Two different allelopathy tests were carried out that differ on the means by which the possible to test if allelopathic substances are present in the wattle leaves and if they are carried through air or water.

In both of the tests, seeds of dwarf beans, cabbage, garden radish, egg plants and swiss chard were used. Jars (ca.1L) with lids, lented in the village, were used to maintain a climate with constant humidity for germination. The plant material was harvested leaves that we macerated to release allelopathic chemicals from the cellular vacuoles. About 10 mL of water were added to maintain humidity. In each test one series with *A. dealbata* material, one with *A. mearnsii* material and one reference were carried out. The vessels were left closed for one week and the germination of the seeds was observed every morning from the third day of the test (appendix 2 for pictures)

The test for water as allelopathic medium was carried out with the plant material in the bottom of the jar, above this gaze with the seeds on it (Dwarf beans - 3 seeds, swiss chard – 6 seeds, garden radish - 10 seeds, cabbage – 10 seeds, egg plants – 10 seeds).

The test for air as allelopathic medium was carried out with the plant material in the bottom of the jar. To avoid contact between the seeds and the solution with the plant material, the seeds (dwarf

beans – 3 seeds, garden radish – 5 seeds, swiss chard – 5 seeds, cabbage – 6 seeds, egg plants – 10 seeds) were placed in beer capsules on top of cotton wool and watered separately (appendix 2 for pictures)

Landscape Observation

Several field walks were conducted in order to evaluate the status of the landscape in relation to the effects of the clearings and the spread of wattle.

Semi-structured interviews with key informants

Table 2: Semi structured interviews with Key informants.

Aim	Key informants
Gather information about wattle economic dynamics	Chiefs from Madlangala, Pontseng and Thotameng
	Responsible for the control of community stands in Madlangala
	Wattle sellers
	Wattle buyers
	Wattle transporter
Analysing functioning of the WfWP	Former Project Area manager
	Former and current contracters
	Workers
Analysing the use and management of wattle on Site E	Villagers around wattle stand that cut it for private use

Questionnaires

A questionnaire was made with four close-ended questions and one open-ended question (box 1), and asked to 103 people in four villages, namely Pepela, Makomereng, Sira and Thotameng. This was done to investigate their perception and the influence of the wattle on their lives. The choice of the four villages aims at making a comparison between the results and the accessibility of each village to wattle.

Box 1:

1. Do you use wattle?
2. Are you aware of the problems associated with the wattle?
3. How does the wattle affect your life as an individual (positively or negatively)?
4. Do you agree or disagree to the eradication of the wattle, (WfWP)? And why?

Participatory Rural Appraisal (PRA) exercises

To gain data about the villagers' perception of wattle and their opinion and problems connected to it, different PRA sessions in Pepela and Makomereng were set up.

The aims, methods and expected outcome of every exercise are shown in table 3.

The PRA Pepela 2 and the PRA Makomereng were laid-out to be able to compare different age groups, gender and WfWP workers with villagers who do or did not work for the programme. Representatives of each of these groups were chosen as participants.

Table 3: PRA sessions from Pepela and Makomereng

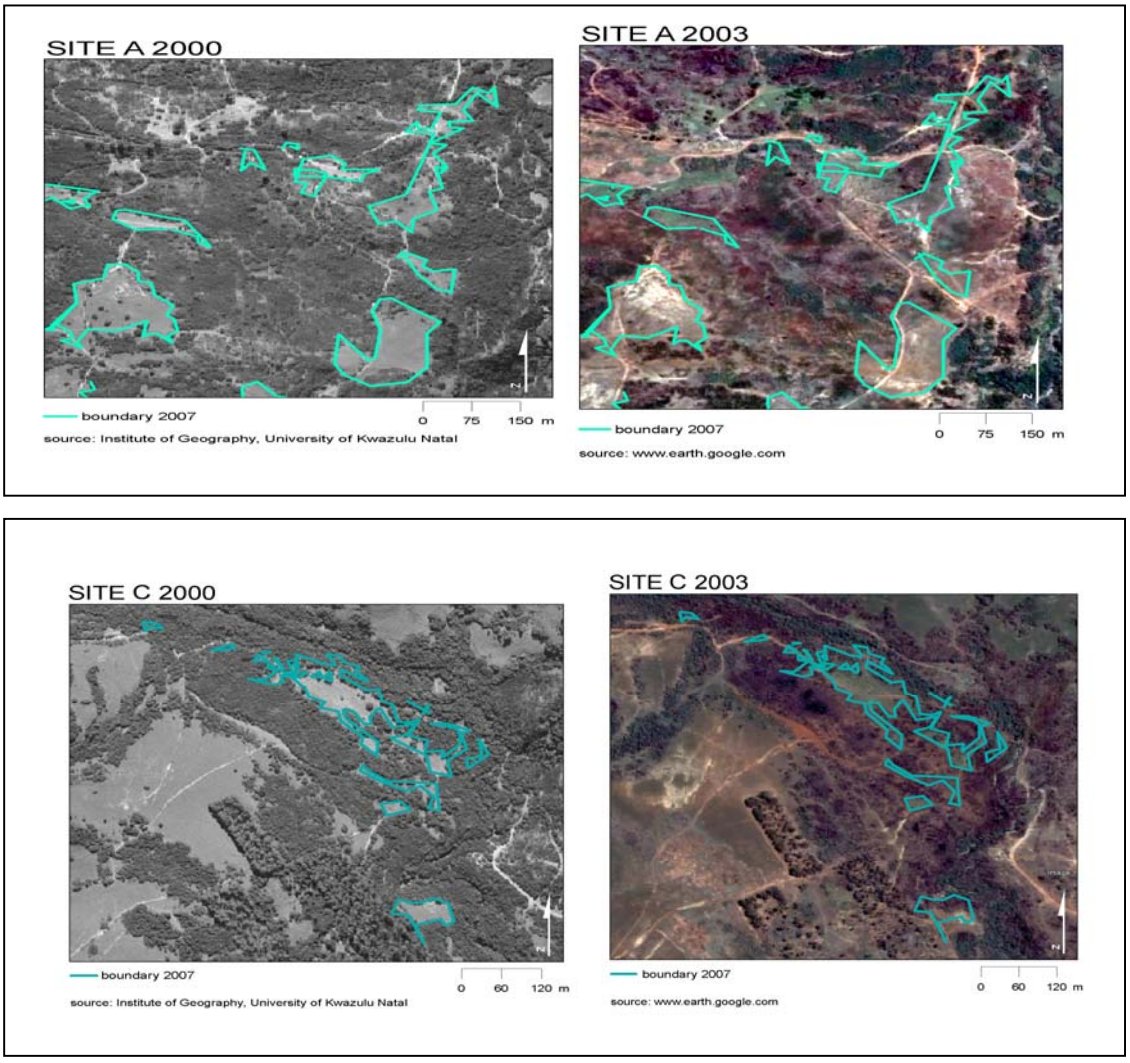
Working title	Number of participants	Exercise nr.	Aim	Method	Expected outcome
PRA Pepela 1	10	1	Acquiring a map with participants view on their village	Participatory mapping	Map of whole village
		2	Examination of the connection of wealth distribution and the WfWP.	Wealth ranking: map showing who is rich, who is poor and who works for the WfWP	Verification that poor villagers work for WfWP
		3	Time spent on collecting wattle and frequency	Seasonal calendar (monthly and weekly)	Different collecting patterns
		4	Importance of different tree species for different purposes	Matrix ranking	High importance of wattle compared to other species
PRA Pepela 2	20	5	Find out the preferred spatial distribution of wattle for the villagers	Participatory mapping	Different opinions for different gender, age groups and different opinions of WfWP-workers and non-workers
PRA Makomereng	9	6	Relation of wattle and other trees, finding out if wattle can be replaced by other trees	Mind map	High importance of wattle compared to other species
		7	Villagers perception of wattle	Drawing a wattle tree	Different levels of detail
		5	Find out the preferred spatial distribution of wattle for the villagers	Participatory mapping	Different opinions for different gender and age groups and different opinions of WfWP-workers and non-workers
		8	Importance of different tree species	Matrix ranking	High importance of wattle compared to other species
Schoolworksh op Pepela	50 (age 12-13)	9	Importance of wattle in relationship to nature	Mind map	Lists of words the schoolkids connect with nature
		10	Schoolchildrens perception of landscape and wattle	Participatory mapping	Maps indicating the importance of trees
		11	Favorite tree of the children	Matrix ranking	Consensus about one or two favourite trees

Results and discussion

The status of wattle distribution in 2007

According to a study from de Neergaard *et al*. (2005) in the Drakensberg region, the cover of wattle increased from 7% and 20% in 1953, over 21% and 33% in 1975, to 48% and 58% in 2000 on two sample plots. Following up on this study the recent spread was investigated on three sites (A, B and C, map 2). For each of them the aerial picture from 2000 and the reference pictures from 2003 have been overlaid with the mapped boundaries between wattle and grassland in March 2007.

Map 2: Site A and C 2000 and 2003.



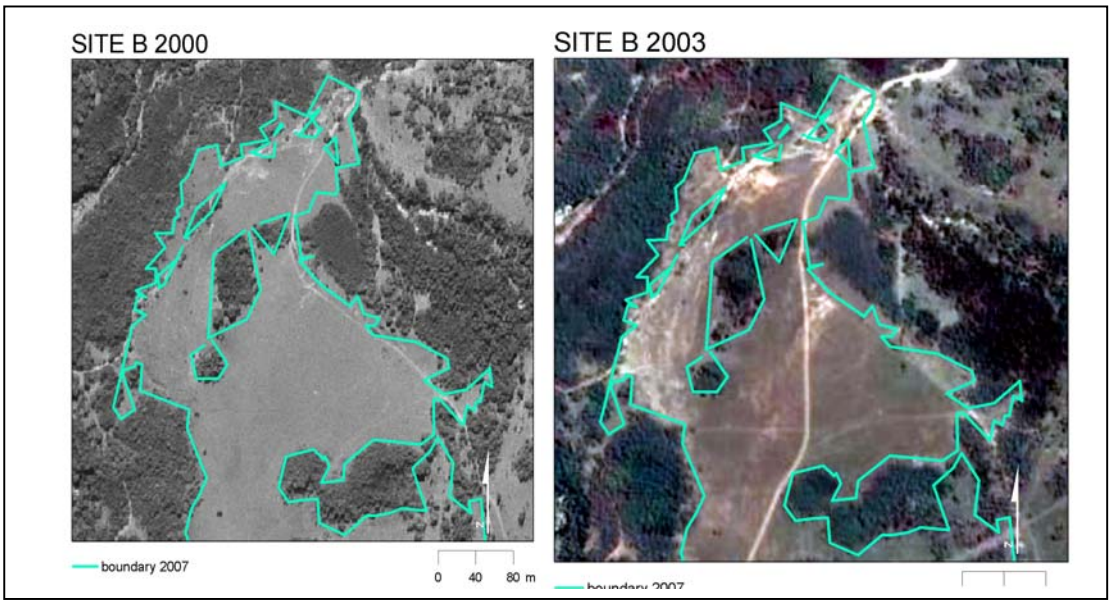
At sites A and C clearings have been taken place between 2000 and 2003 within the WfW-woodlot program. On the reference picture from 2003 the cleared areas can be recognised in reddish colours (map 2). The polygons from the mapping in 2007 show the patches of opened grassland which were found in this site ("islands").

The comparison between 2000 and 2007 shows that, except from some small parts, the boundaries of 2007 reappear nearly in the same shapes as in 2000. The boundary of 2007 indicates that wattle was regenerating everywhere on this site. Wattle was regenerating densely outside the „islands".

There is no independent, freestanding patch of grassland within the wattle stands which has not been a patch of grassland in 2000. Wattle was therefore regrowing everywhere where is has been cut. Despite the efforts of the eradication programs and private use by the villagers Wattle has been successfully regenerated into the state of 2000.

This shows the wattle's huge potential of regenerating its extent within a short period of time.

Map 3. Site B 2000 and 2003.



The map of site B shows the northern part of the 10ha big patch of grassland which is surrounded by wattle. Unlike site A and C, there are hardly any big-scale clearings recognizable on the reference picture from 2003. The boundaries of 2007 are almost identical with the boundaries of 2000. Thus the extent of those wattle stands remained more or less the same as in 2000. The

western edge of this patch of grassland is formed by a stone cliff which serves as a physical barrier against the wattle invasion. While mapping young wattle trees growing over the edge of this cliff were observed. The assumption is made that the spread might be faster onto the grassland once the wattle passed this obstacle.

The impact on the livelihoods and perception of wattle

Despite being an invasive species and effecting ecology, wattle has a great impact on the livelihood of the invaded villages. The positive and negative impacts and the perception of the villagers will be discussed in the following section.

Impact

During the study a wide variety of uses for wattle species was found (box 2).

Box 2: Utilty of wattle in the Madlangala region.

Utility of wattle in the Madlangala region
Firewood, building material, garden fence, cattle fence (kraal), to build the toilet, to build the traditional sled, to build the clothes dryer, stick for the herdsmen, furniture(chair, bed, table), to make a football goal, beating stick for pupils, to make a spoon, as plough, for cooking, for the roofing, for protecting young lettuce plants (sources: interviews, observation, PRA-exercises 6 and 9)

Matrix rankings (table 3; exercises 4, 6 and 8) showed that the main uses of wattle in the Madlangala region are firewood and building material. Other benefits are the possibility to create income by selling wattle or by working for the WfWP.

Box 2: Benefits and costs from the wattle.

Benefits	Costs
Firewood: An important fuel source for rural communities	Fear of cattle thieves hiding in the wattle
Building materials: Used as brandering, laths and poles by rural communities.	Wattle roots regenerating inside the house and damaging the walls of the house
Nitrogen fixation: Addition of nitrogen through fixation by roots could be regarded as a benefit or a cost in some areas.	Nitrogen pollution: Increases in soil nitrogen levels in nutrient-poor environments can make habitats unsuitable for indigenous plants and more susceptible to invasion by other species, reducing biodiversity
Medicinal products: Possible use as styptics or astringents.	Loss of biodiversity: Displacement of species-rich indigenous plant communities by single-species wattle stands, and disruption of important ecosystem processes and threat to the local biodiversity.
Combating erosion: Planting wattles can decrease erosion in severely degraded sites away from river courses.	Dragging of harvested trees by sleds promote erosion.

C.M. Shackleton *et al* (2007) states that *"…rural communities adapt to IAS as long as it does not become a problem for them*". From the cost benefit table (box 2) one can observe there is a cost associated with wattle in terms it impact on the ecology of the place. Despite of the costs associated with wattle people view it as a resource, as seen by the results of the questionnaires.

These benefits are shared by all the neighbouring villages where interviews where carried out. As the chief Victoria stated, since a recent change in the program policy, more workers from the neighbouring villages are called for working. This is also supported by the interviews on the clearing site. None of the 13 interviewees were from Madlangala. Another aspect is the existence of wattle sellers on other villagers that make an income from it. On this case, also Madlangala benefits from this, because the sellers have to pay a fee to the chief (source: interviews with different sellers and the responsible for wattle control).

The influence on the daily live (quantity of time spend on collecting) was examined by a seasonal calendar (table 3; exercise 3). It shows that there are different collection patterns. Depending on the resources the villagers have, some need to collect everyday and carry a bunch of wattle on their head, whereas the ones who have a tractor or cattle only collect every two or three month. Villagers in Pepela and Makomereng who are not capable of collecting wattle by themselves, normally get it from their relatives.

Villagers from Pontseng and Thotameng who do not have access to wattle receive wattle every second or third month. These villagers spend less time but more money on achieving wattle.

Perception

In all villages that are included in this study more people considered wattle as a resource then a problem. This is not surprising as everybody who lives in the villages uses wattle and grew up with having it as a resource. Nevertheless in Sira and Thotameng more villagers saw wattle as a problem (still only 12-13%). One reason might be that their accessibility to wattle is reduced.

Table 4: Perception chart

Village	Sira	Thotameng	Pepela	Makomereng
Resource	86,9	87,5	100	96,4
Problem	13,1	12,5	0	3,6

In the matrix ranking (table 3; exercise 4) wattle and protea are stated as the most used trees, even though protea is a protected species. This shows the extreme importance of the wattle tree for the villagers in Pepela. The participants were also asked which tree they like or dislike. Wattle was the only tree that was not only liked, but also disliked at the same time. This shows that the villagers are probably aware of several problems wattle causes and also know about the WfWP as some of the participants of the exercise work for the programme.

At the mind mapping (table 3; exercise 6) 42 different trees and uses were mentioned all together. The most frequently mentioned ones were wattle (11 times), gum tree and pine tree (9 times each) and protea (7 times). Willow tree was mentioned 6 times and 5 participants wrote down Ikatsiyoni and Intshitshi ("smelly tree"). The frequency with which wattle is mentioned shows the presence of it in people's minds. The connection of these trees and their uses (exercise 8, table xx) shows that wattle was not only mentioned the most often in the mind maps because it grows in large numbers in the region, but also because it is used a lot.

Table 5: Results from exercise 8 from PRA in Makomereng

Use	Tree species
Building	Pine + black wattle
Roofing	Gum tree + Popple
Selling	All trees
Kraal	Yintshatshi + black wattle + silver wattle
Cooking	Silver wattle

The positive perception of wattle is also supported by a workshop at the school in Pepela. The associative exercises and the drawing exercises suggest that trees are an important part of the childrens perception of their surroundings (landscape). Trees were mentioned by 23 of 50 children as part of „indalo" (Xhosa word for „nature, surrounding, environment") and trees have been identified in all maps where the children drew their own villages. Concerning wattle, the associative exercise shows a wide variety of uses (table 3). Wattle (Xhosa="indwabaseli") was referred to as "natural tree" (Xhosa "imthindalo"). In the ranking exercise all of the children were choosing wattle as their favourite one.

As the impact of wattle already indicates the perception of wattle is not only positive. In an exercise aiming at the spatial preferences of the wattle by the villagers the difference between different gender and ages was examined.

For exercise 5 (table 3), participants were asked to point out on a sketch whether they prefer wattle in the mountains, foothills or in the village and where they do not want wattle to grow.

Analysing the answers from the participants no age group wants wattle to grow in the villages. Nevertheless older participants prefer the wattle to grow in the hills whereas younger people want the wattle to be as far away from the village as possible (table 6A).

The reason for old people preferring to have the wattle growing closer to the village is probably that in that way they can go and collect it themselves. Younger people on the other hand are not depended on a short distance but might be afraid of thieves hiding in the wattle stands. This could lead to the younger participants' preference of wattle in the mountains.

Table 6. A. Result from PRA in Makomereng and Pepela 2. **B.** Results from PRA in Makomereng

A. PRA Makomereng and Pepela 2						
Age group	**<25** (6)		**25 - 50** (13)		**> 50** (10)	
	Do	Don't	Do	Don't	Do	Don't
Village	1	5	0	13	1	9
Foothills	2	4	4	9	5	5
Mountains	4	2	7	6	3	7

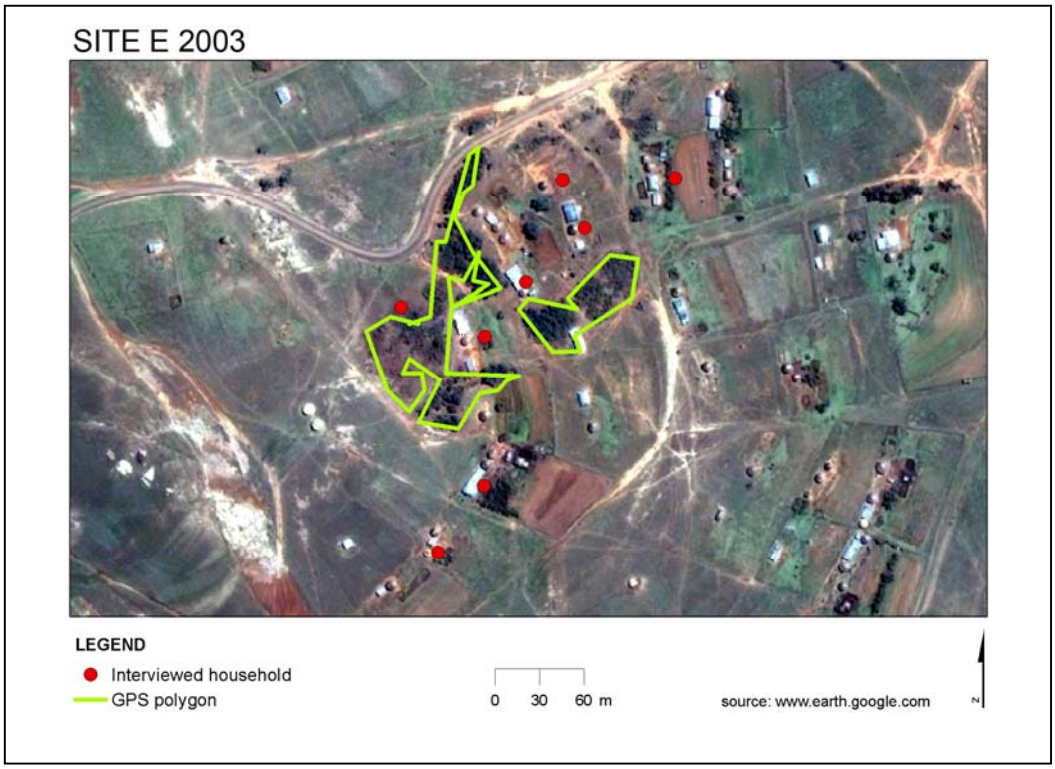
B. PRA Makomereng				
Gender	**F** (5)		**M** (4)	
	Do	Don't	Do	Don't
Village	1	5	0	4
Foothills	3	2	4	0
Mountains	2	3	4	0

From the results of the PRA in Makomereng a comparison between male and female was made. This indicated that males want the wattle in the hills and mountains but not in the village.

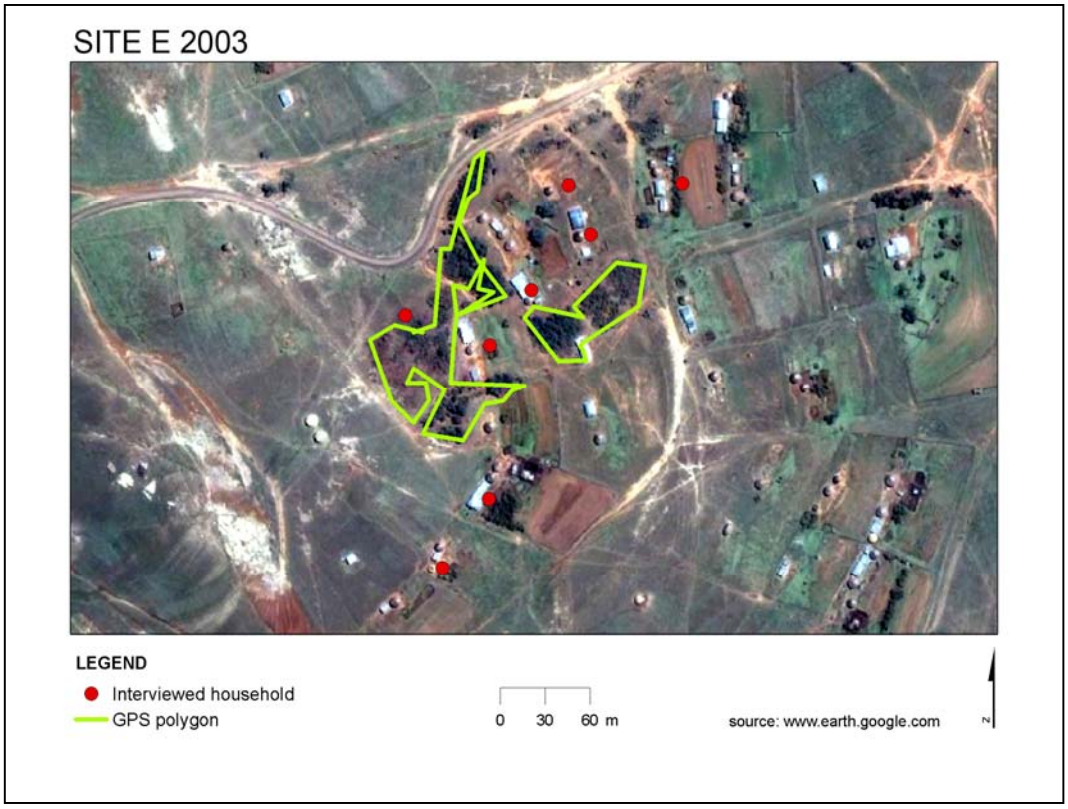
Among females there are different opinions: some want wattle in the hills whereas others prefer wattle to grow in the hills (table 6). Reasons for the different opinions among females can be that on one hand they are afraid of people hiding in the dense wattle stands, but on the other hand they would like to be able to collect the wattle close by.

The explanation that the participating males do not want wattle in the foothills or the mountains to be eradicated might point to the fact that they are not as afraid of people hiding in it as women, maybe due to rapists.

Map 1: Site E as on 2000



Map 2: Site E as on 2003



Box 4: Case of how people manage wattle inside the village stands

Results:

The comparison between the extent of the wattle stand of 2000 shows some clearings within the wattle stand at the north-western edge. In the reference picture from 2003 one clearing on the western edge of the polygon is recognizable and another clearing outside the polygons. Compared to the patch dimension of 2007, the wattle has been regenerated at the spot on the western edge. The wattle stand on the north-east of our polygons has not been found in 2007. These wattle stand seems to be relatively stable, in its core capable to restore soon after clearing.

Interviews

Results:

All the households surveyed use wattle along with paraffin for fuelwood and heating purposes. One household only harvests wattle from site E. Three households harvest wattle from site E and the hills. The rest uses wattle from outside site E. All respondents agreed that wattle near the households helps them as a windbreak to protect their houses from strong wind and do not cut it because of that.

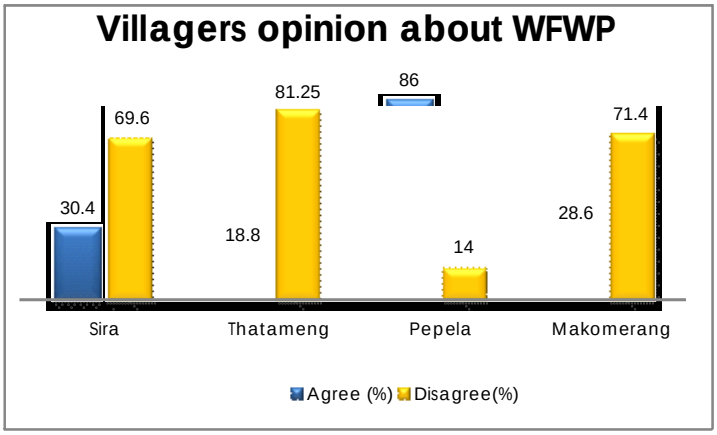
Half of the households do not harvest wattle due to the fear of wattle regenerating faster when it is cut.

Single statements that were made during the interviews were:

- Cutting of wattle stimulates the wattle suckers to grow inside the house, damaging the walls.
- Vegetables grow smaller next to the wattle.
- Wattle germinates profusely during the rainy season. This villager therefore uproots young plants during that period.

The impact of the WfW Program on the communities and its organization as a system

Figure 1: Villagers opinion about WFWP



In Pepela, 86% of the interviewees agree with the WfWP, while in Makomereng the percentage is 28,6%. In Pepela, the most part of the villagers expressed that the reason for desiring the removal of wattle is the crime associated with wattle stands. Namely, harm caused by thieves and rapists hidden in the dense wattle.

In Makomereng, on the other hand, the utility of the wood and the high cost of the alternative, paraffin, justifies that 28,6% of the respondents do not agree with the WfWP. The big difference between Pepela and Makomereng might seem surprising as both villages have the same accessibility to wattle. A possible explanation can be that Pepela lies closer to the mountains which form the border to Lesotho. To support this hypothesis, only one person in Makomereng referred crime as a reason for agreeing with the removal of wattle and a villager from Pepela referred five murders in wattle stands.

Thotameng and Sira are two villages were the WfWP was working in 2003 but that is currently finished. In Thotameng, 81,25% of the respondents disagree with the eradication of wattle, mainly due to the utility of wattle as a fuel wood and the high cost of the alternative, paraffin. On the other hand, in Sira the percentage is a little bit lower, 69,6%. The reason for

Most of the people are unemployed after exiting from the programme

"They should not only remove wattle but substitute it a suitable trees and a change of policy is needed for making the program is success"

-Victoria Spambo

disagreeing with the program is the fact that they have a positive attitude towards wattle.

On these two villages, none of the villagers expressed the wish of securing a job at the WfWP, which it can be explained by the distance to the current clearing sites and the high percentage of disagreement towards the program. It does not seem to be a significant correlation between the the perception of the program by the different villages and their different accessibility to wattle. The results seemed to be better explained by the occurrence of crime referred by villagers from Pepela.

How do the chiefs from the villages perceive the WfW

The three chiefs interviewed had different levels of knowledge about the program. The chiefteess of Madlangala (Victoria Spambo) is one that seems to have a better understanding of the program, probably because it is the only place where the program is running at the moment. Her opinion about wattle changed after she attended a workshop carried out by WfWP on wattle. Before, she did not know about the environmental impact of wattle on the decrease of stream flow. So, she agrees with the eradication of the species in the region, due to the environmental impact and due to the job creation. The job issue is her main concern about the program. She complained about a change on the policy of the program that decreased the number of villagers employed from her community by increasing the number of villagers employed from other villages. This change was also referred by some of the contractors and villagers that were interviewed. Victoria informed that the selection of the workers for the program is made by a committee composed by people from the community, which was also referred by the chief of Thotameng.

However, the extent of the involvement of the community on the program is unclear. Victoria Spambo expressed her dissatisfaction about the working relationship with the contractors she claimed not to be aware of the current status of the programme and not having contact with the contractor even though she preferred to “work hand in hand with them”.

On the contrary, the contractors claimed that they had good working relationship with the chiefteess. This unclear situation can be seen as a lack of communication between the leader and the contractors, which is not favourable to the success of the program. The community leaders could be involved in the planning of the programme to make it more participatory and meet the needs of the local people at the grass root level.

“I have no contact with the contractor,, I don’t know what is happening,, I prefer working hand in hand with the contractors”
-Victoria Spambo

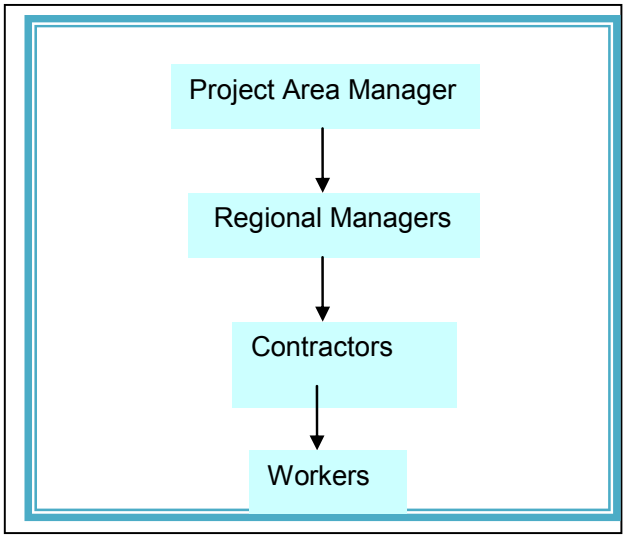
The chiefs from the other villages, where the program is no longer active, find the program good for different reasons.

For the chief of Pontseng, the eradication is necessary due to the uptake of water performed by wattle. For the chief of Thotameng, his community changed for better with the program because people had jobs. He referred that the wattle is coming back on the area where it was removed, and that nobody came back from the program to do the follow up. However, this information is merely indicative, since it was not possible to confirm it with the personnel from the program.

The Hierarchy

Based on the interviews with the key informants it is possible to draw the hierarchy of organization of the program on the lowest level – under the Regional Programme Leaders (figure 2).

Figure 2: Working for Water Programme Hierarchy



Administrative issues

The way the different levels interact is not effective. In general the contractors have a feeling that the planning and area demarcation for clearing of wattle was based on the map and excluding the limitations of the field. The planning resulted in unacceptable deadlines for the clearing contractors. From the interviews with the contractors it is evident that the managers are not regular in inspecting the areas under their supervision. This is also echoed by a senior official of the programme that denounces that laziness exists within the managers. This could be a major set back to the efficiency of the programme in terms of reducing the contractor's morale.

On three of the villages where the interviews and questionnaires where conducted, the villagers expressed their disagreement towards the eradication of wattle. This confirms that this IAS control program is not supported by studies on the needs of the affected populations, as stated by Shackleton (2007).

On the other hand, from the interviews with the chief Victoria, it is possible to see that the relationship between the program and the communities is not functioning as stated on the WfW objectives. In addition, the workers are not receiving their wages on time. For all this, it is possible to extract that the aims of increasing community spirit and empowerment are not being accomplished at their full extent.

Finally, by analysing the functioning of the diferent levels on the program, one can relaize that the relation between them is not working. The lack of supervision of the field work by the regional managers might jeopardize the project, by inhibiting the cross of information between the contractors and the Project Area Manager.

The effectiveness of the WfW Program on wattle eradication and its environmental impact

To evaluate the effectiveness of the WfWP a regeneration survey was made and the growing stock density was estimated. To investigate the impact on the environment soil from different areas was analysed.

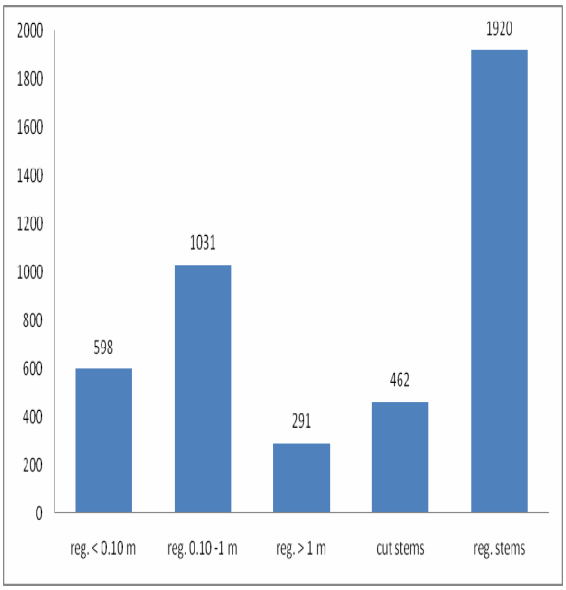


Figure 3. Status of regeneration.

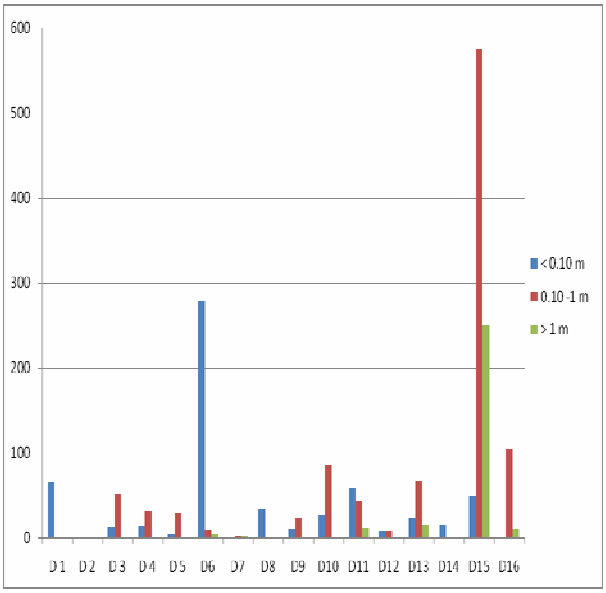


Figure 4. Height of regenerated stumps.

Regeneration survey

Site D was cleared in 2001. The regeneration survey of 2007 shows that the number of regenerating of wattle is four times higher than the number of stumps cut. More than half of the regenerated trees were between 0,1 and 1 m. Almost 1/3 of the regenerated trees are smaller than 0,1 m and 291 plants are bigger than one meter (figure 3).

Figure 4 shows the heterogeneity within the regenerating plants. Important is the presence of plants smaller than 0,1 meter in almost every plot, which suggest the beginning of wattle growth.

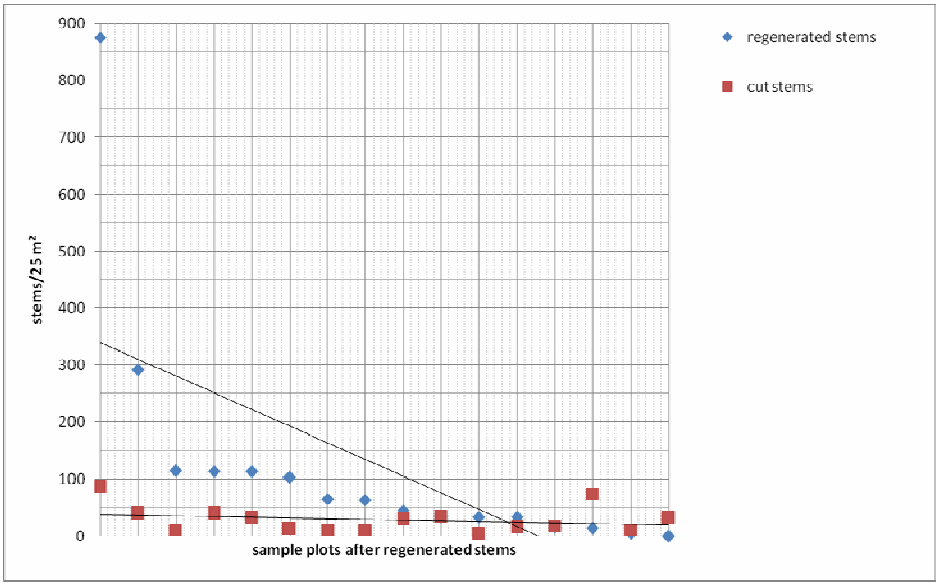


Figure 5. Sample plots arranged after the number of regenerated wattle trees.

Figure 5 shows the sample plots arranged after the number of regenerated trees. Wattle was regenerating on 15 of 16 plots. The number of regenerated wattle trees is in 11 of 16 plots higher than the number of cut stems.

The WfWP can be assessed as not successful in eradicating the wattle on site D because wattle was regenerating since 2003 on almost all plots. The regrowth on the whole study site was very heterogenous, maybe due to differences in pre-existing vegetation, methods of treatment and follow-up procedures.

On several plots young, grazed wattle trees were observed (see figure 6). Although the amount of wattle trees under 10 cm is very high, the sample site is not controlled by grazing cattle.

Figure 6: Grazed wattles.

Growing stock density

The quantity of the regenerating wattle is shown by measuring the growing stock density. From page 16 it can be seen, that site A was cleared of wattle in 2003. In 2007 the woody biomass of wattle covers 50 m^3 in 20 m^2 of site A. The trees were more or less evenly spaced and as the trees were at different regeneration stages, it was difficult to make a complete enumeration. Taking into account the open spaces and the continuous harvesting of wattle from these plots, the measurements can not be used as a final result, due to the harvesting.

Having stated that the wattle is re-growing in at least the two studied sties (A and E), further research was made on the effect of wattle on the soil.

Soil Analysis

The 13 soil samples were analysed for pH, phosphor (P), nitrogen (N) and carbon (C) and electrical conductivity (EC) (table 7).

The pH was found to vary from low/acid (pH <5,5) to medium (5,5-7,0) – most of the samples were acid. An acid soil can indicate that there can be an excess of some micronutrients (Co, Fe, Mn, Cu, Zn, Cl) but also a deficiency of other micronutrients (Mg^{2+}, Ca^{2+}, K^{+}, Mo, B) and macronutrients (P, S, N) (Landon, J.R)

The pH affects the composition and activity of the microbes and the soil fauna, and through this the mineralization processes (e.g. the nitrification).

As there is no significant variety within the pH in the different areas, a comparison of the areas will give no meaning.

It was found that the P content in all of the samples was low, described as deficient (< 4 ppm) in Booker Tropical Soil Manual (Landon, J.R.). At pH ≤ 5 the P tends to make poorly soluble compounds with the minerals iron (Fe), manganese (Mn) or aluminium (Al), compounds that are useless for plant growth. The available P in the soil is thereby decreased (Petersen & Vestergaard, 2006; Landon, J.R.; and-Jensen, 2000). This low content of P in the soil is though the suitable demand for the growth of grass (Landon, J.R.), and as it can be seen in table 8 the P content in the soil in Makomereng (MKM), Grassland, Open Cleared Pepela and in two of the plots from Dense Pepela is very low.

Even though the soil is low on P, and should only be suitable for grass, wattle is able to grow in these areas.

There was a great variety in the N content between the different areas varying from a very low (< 0,1% of soil by weight) N content to a high (0,5-1,0 % of soil by weight) N content (table 8).

Because of the low pH in most of the plots, the available N in the soil is reduced. The acid soil influences the enzyme activity in the microbes in the soil, and thereby their degrading of the organic matter to ammonium (NH_4^+) and nitrate (NO_3^-) (Petersen & Vestergaard, 2006; Landon, J.R.;Sand-Jensen, 2000). The wattles capability of fixating N and thereby contributing to a higher N content in the soil can be seen in the samples from Dense Pepela (table 7; table 8), the average content of N in these samples is higher than the average of the soil from the other areas.

For all of our soil samples the level of N can be less than in real life, because the N content changes due to storage time, temperature and moist content (Landon, J.R.)

Table 7: Summary of the results from the soil analysis

Sample plots	Soil analysis
MKM (Makomereng)	Acid pH; deficient/low P; low N; very low C
Grassland	Acid pH; deficient/low P; 2x low N; 2x medium N; 3x low C; 1x very low C
Dense Pepela	Acid pH; deficient/low P; 2x medium N; 2x high N; medium C
Open Cleared Pepela	Acid pH; deficient/low P; very low N; very low C

All but the soil taken from the dense wattle stands had a carbon content going from very low (< 2% of soil by weight) to low (2-4 % of soil by weight). This indicates that there is a very little decomposition activity. This is probably due to the low pH, P and N.

The dense wattle stand (Dense Pepela) has medium carbon content (4-10 % of soil by weight) (table 8). As far as remembered, there was no litter on the forest soil, probably because wattle is an evergreen, so the medium content of C can not be explained.

Referring to table 8 and Appendix 5 (Amount of Nitrogen, Organic matter and the C:N.), it was clear that all the soils tested had a C:N ratio that exceeded 10 (the critical value), an indication that the decomposition processes are not functioning well. This situation could be due to the low pH, N, P or maybe temperature. There is perhaps an effect of the organic carbon on the nitrification process or perhaps there is the competition between the ammonia oxidizing bacteria and the heterotrophic bacteria for the available $NH4^{+}$.

Electrical conductivity (EC) is used for measuring the soil salinity. Different factors contribute to the variability in soil EC, this is the amount and connectivity of soil water, soil aggregation, electrolytes in soil water and the conductivity of the mineral phase.

All the sample plots had a salt content on 0-2 mS cm^{-1}, which indicates that the soil is salt free (table 8) (U.S. Department of Agriculture, 1969; Hartsock *et l.*2000)

Table 8: Result from the soil analysis

Sample plots	pH pHCaCl$_2$	EC mS cm $^{-1}$	P mg P g-1 soil	N %	C %	C:N
Makomereng (MKM 1) (grassland)	5,6	0,50	0,11	0,1068	1,691	15,83
MKM 2 (near wattle stand)	3,7	0,07	0,11	0,1101	1,594	14,48
MKM3 VS (inside wattle stand)	3,6	0,43	0,045	0,2005	2,877	14,35
Grassland	4,7	0,43	0,08	0,2689	3,386	12,59
Grassland Pepela 1	4,3	0,65	0,08	0,1998	2,822	14,12
Grassland Pepela 2	4,1	0,22	0,06	0,2074	2,591	12,49
Grassland Pepela	3,9	1,15	0,08	0,1637	1,938	11,84
Dense Pepela 1	5,6	0,86	0,08	0,3852	4,961	12,88
Dense Pepela 2	4,4	0,94	0,015	0,7782	9,862	12,67
Dense Pepela 3	4,3	0,36	0,45	0,3455	4,598	13,31
Dense Pepela 4	3,8	0,65	0,45	0,6139	8,246	13,43
Open Cleared Pepela	4,3	0,36	0,11	0,05564	0,7382	13,27
Open Cleared Pepela 2	4,1	0,43	0,03	0,04148	0,4795	11,56

Given the knowledge from the results, Open Cleared Pepela has the least amount of C and N of the four areas. P and pH are also deficient (as for all of the areas). This might refer to the fact that the area has been cleared in 2003. Due to the clearing nutrients and organic matter could have been carried away by rain flush or the removal of biomass.

Particle size analysis/mechanical analysis

As can be seen from table 9, all the samples collected are a silt loam soil. Loam is composed by 40-40-20% (respectively) sand, silt and clay composition, the soil being a silt loam means that the proportion of the components is slightly different, with a bit more silt in. Loam has an ability to both retain water and let I flow freely (http://en.wikipedia.org/wiki/Loam).

Table 9: Results on the soil texture

	Soil texture				Soil type
Sample plots	**4 min**	**8 min**	**2 h**	**16 h**	
Makomereng (MKM 1) (grassland)	11	10	6	5	silt loam
MKM 2 (near wattle stand)	16	13	10	7	silt loam
MKM3 VS (inside wattle stand)	16	14	9	7	silt loam
Grassland	21	18	12	10	silt loam
Grassland Pepela 1	23	20	13	10	silt loam
Grassland Pepela 2	23	20	14	11	silt loam
No label (Grassland Pepela 3)	18	17	12	11	silt loam
Dense Pepela 1	17	14	7	4	silt loam/silt
Dense Pepela 2	17	14	8	7	silt loam
Dense Pepela 3	14	12	8	6	silt loam
Dense Pepela 4	19	17	10	7	silt loam
Open Cleared Pepela	18	16	12	10	silt loam
Open Cleared Pepela 2	18	17	12	9	silt loam

Box 5: Wattle Ecology

- Extreme water use compared to native species (literature)
- Fast spreading and growing (regeneration survey)
- Nitrogen fixating (soil analysis)
- Suspected allelopathic effect (germination test + allelopathic test)

Germination tests

As stated the synopsis it should be tested if there was any possible allelopathic effect from the wattle on the growth on different species.

There is no big difference in the germination of the seeds between the three areas (Appendix 1).

After field walks within the wattle stands, the assumption was made, that the lack of vegetation underneath the trees was maybe not only due to a possible allelopathic effect, but more to the lack of light coming through the canopy.

Allelopathy

To test if the allelopathy effect can come from other parts than the roots of the wattle a test was set up to see if the air and water can be a possible carrier of the allelopathic substances.

The results for both aerial and water tests can not be used for stating that there is an allelopathic effect from the black- and silver wattle (appendix 3;figure 7 and 8).

The only seeds not germinating were, as in the germination tests, the egg plant. We assume that this is not connected to the allelopathic effect, but more to the fact that a slow germinating seed was chosen.

In the water test the swiss chard was the only one where all the seeds germinated. Around half of the other seeds germinated. There was no difference in the end result of black- or silver wattle, except for the germination of the dwarf bean and swiss chard where the results show a slower germination in the black wattle jar than in the silver wattle jar (figure 7).

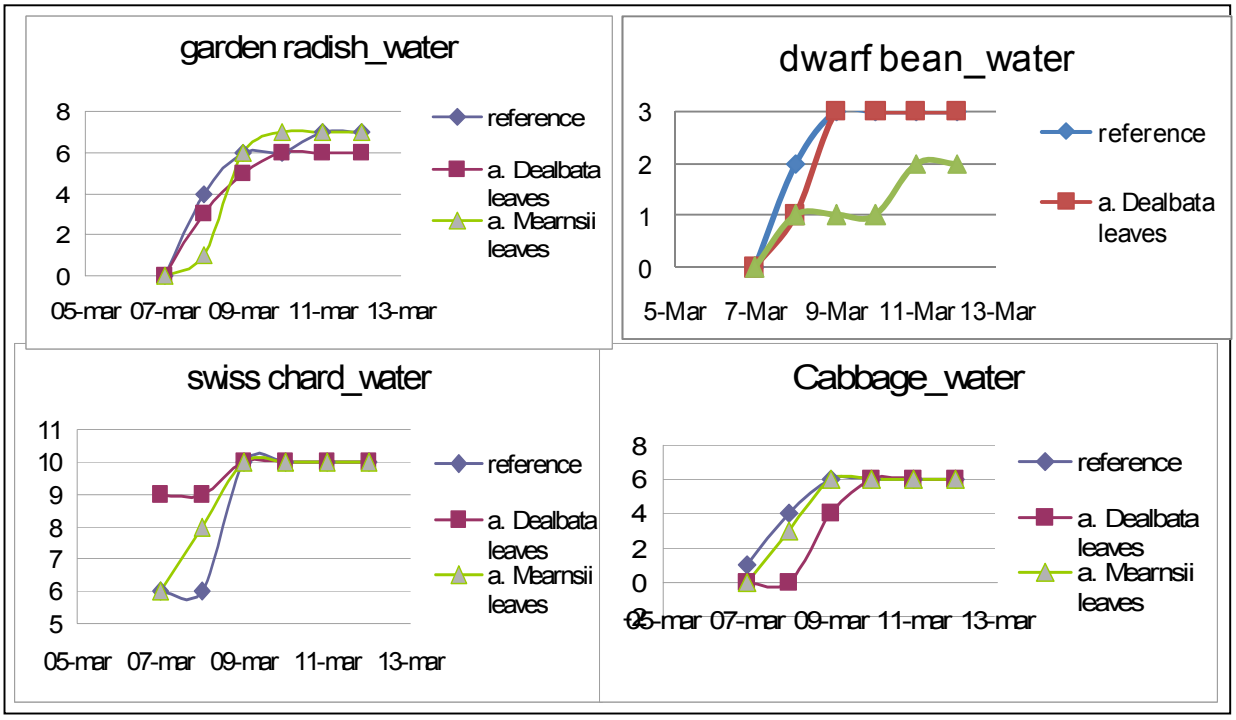


Figure 7: Water allelopathic tests on four different seeds.

In the aerial tests the end result of the germination is the same for all of the seeds, around half of the seeds germinated. In three of the tests (except cabbage) the reference was germinating slower and fewer than seeds germinated when exposed to wattle (figure 8).

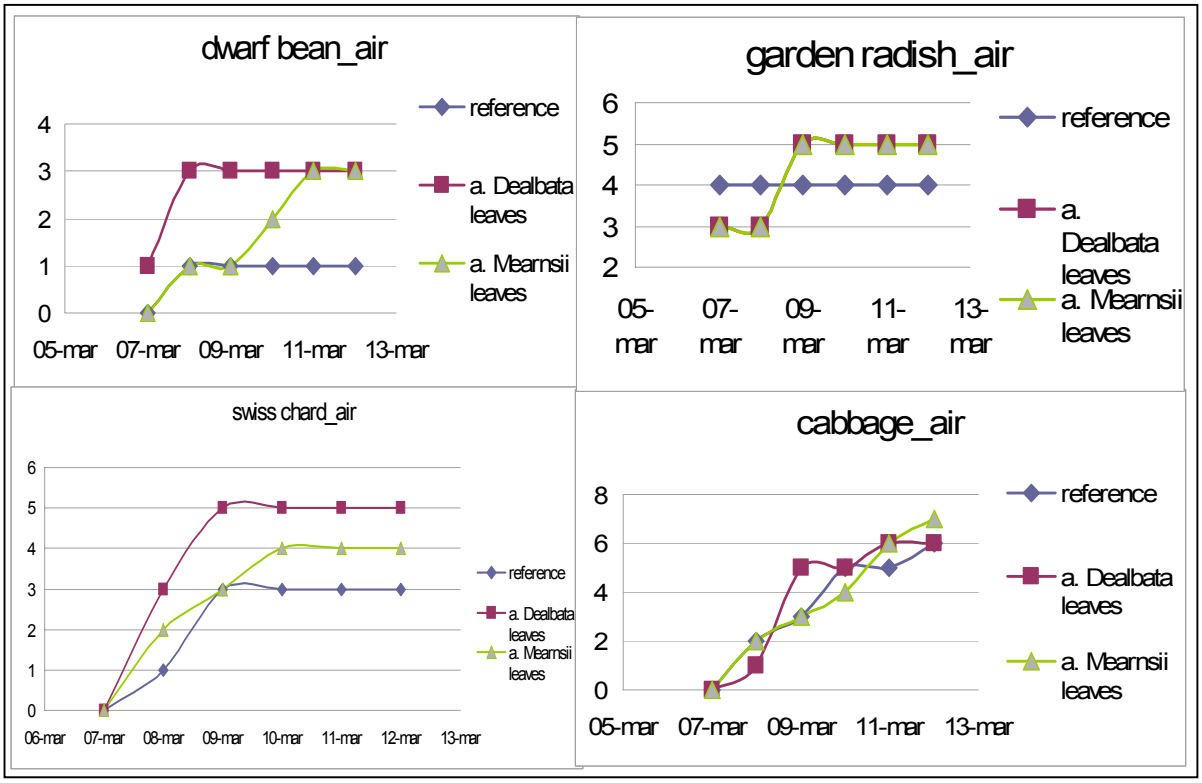


Figure 8: Aerial allelopathic tests on four different seeds.

Vegetation sampling

Although the sampling is not very representative – only one plot in each place was surveyed-, it is possible to observe that the biodiversity is lower inside the wattle stand and that the value increases with the increase of the distance from the wattle stand.

For further studies we suggest to investigate biodiversity in terms of ecosystem functions.

The status of landscape in relation to the wattle invasion and the impact of the clearing program

The impact of the invasion of wattle on the landscape can be seen in two different scales which will in the following be referred to as macro and micro scale.

The macro scale can mainly be grasped from the top of the hills and has also an indirect influence on the overview from the village. Wattle is spreading in high extends, forming big stands with open areas in between that can only be seen from above (see mapping). Dense patterns of wattle

can be observed along the streams. The visual axes are progressively blocked, which results on the sense of insecurity, referred several times by villagers.

On the micro scale, the disturbance of the ecosystems results also on a change of its functions, which can be noticed by the decrease of the number of species (appendix 4). This loss of biodiversity caused the progressive expansion of wattle can, in the long term, decrease the plant diversity in the area. This might bring irreversible consequences: the disturbed ecosystems will have difficulties to support the natural vegetation, and prevents further succession to natural forest (Le Maitre et al., 2002). Since the wattle seeds are resistant to fire, this practice supports the establishment of wattle forests. Furthermore, the biologic characteristics of wattle make them a very resistant species to cut since it regenerates very easily, as it can be seen by the regeneration survey. For the same reason, the inefficiency of the follow ups expands the invasion.

The cultural landscape is, to a certain extent, endangered by the spread of wattle. However, it would be needed to do a further research on landscape changes to assess the real risk.

At this point, it seems that without the invasion of wattle the land use would be mainly grassland. At the moment, the image of the cleared areas is very disagreeable: dead stumps in the middle of grasslands or “forests” of dead ring barked trees. This can have a negative impact on the touristy potential of the region.

Reflection on the methods and on the field work

Biophysical

A higher sample density would have given more conclusive results for the computation of growing density and vegetation sampling. More effort was given on the mapping of the wattle so little effort and time was put into the study of the growing density and vegetation sampling.

Mapping

The method of mapping patches of open grassland seems to be a comprehensive methodology to map the spread of wattle species. If done in a group the methodology has to be accorded and adapted to the later digital work with GIS. To use portable GPS devices and the „Area Calculation“ function was useful for obtaining fast datasets. For future mapping we suggest to work with a higher frequency of waypoints in order to obtain polygons with a more exact outline.

Vegetation sampling

Individual species identification was not achieved for each species due to the lack of resource base and personnel.

Mapping

These reference pictures cannot be used to map any spread of wattle exactly because of the uncertainty of the rectification.

Soil analysis

Soil texture

The soil texture was measured for all our samples. One problem with our soil samples was that there was a lot of organic material in them. By sieving the samples we tried to remove the largest roots and leaves, but there was still a lot left in the sample. This organic material was weighted together with the sand larger than 0,2 mm. This makes the end results of the soil type biased/wrong. We should have burned the soil samples before using them, by doing so we would have gotten rid of the organic material.

Electric conductivity (EC)

According to Booker Tropical Soil Manual (Landon, J.R.), the most preferable way of measuring EC is “on undiluted soil solution extracted from soils containing water held at the normal plant-available water potential (about -0,1 to -15 bar)”. But that was not possible in our field lab, because of the instruments available.

Apparent profile soil EC is one sensor-based measurement that can provide indirect indicator of important soil physical and chemical properties and it is affected by soil salinity, clay content, cation exchange capacity (CEC), clay mineralogy, soil pore size and distribution, soil moisture content and temperature (McNeill, 1992; Rhoades *et al,.* 1999)

In saline soils, most of the variations in EC can be related to salt concentration (Williams & Baker, 1982)

In non-saline soils, conductivity variations are primarily a function of the soil texture, moisture content and CEC (Rhoades *et al*,. 1976 ; Kachaoski *et al*,. 1988)

In the Dense Pepela 2 was recorded as having a EC of 0,13 ds/m whereas MKM2 recorded a EC of 0,01 (lowest) a variation that is not too significant. (hasty, perhaps. –to be analyzed later)

Phosphorous

According to Booker Tropical Soil Manual (Landon, J.R.) this test it though most preferable for soil with a pH >7, but the easiest test to carry out in the field. For acid soil the methods by Bray, Truog or Morgan should be used. I

Germination test

Because of the small sample size in the experiment, different sizes of vessels (seeds were exposed to different light conditions) the very small degree of standardisation, the short period of testing and problems with counting (difficulties to see the germinated seeds through the film covering the vessel because of the condense water) the results cannot serve as basis for statistics.

Egg plants were not useful for any of the tests (appendix 1 and 3). The different seeds that we chose might not have been the most preferable ones. They were selected on how fast they were to germinate. Maybe we should have used seeds similar to those planted in the home gardens, so that we knew that they were suitable for the temperature conditions.

The experiment could have been carried out by removing a "piece" of soil with small wattle trees to the lab. Thereby a natural "environment" could have been maintained, avoiding problems like flushing and animals removing seeds that would have to be faced conducting the tests *ex situ*. This should again have been tested with both light and lack of light, imitating the conditions under the canopy.

This would be one possibility avoid the decrease of the allelopathic effect by removing the soil from the wattle stand which is stated by Carballeira & Reigosa (1999).

Allelopathy

The jars were not suitable for the test. As they were too high it was difficult to see the seeds in the bottom of the jar. For the aerial test, we could not remove the lid, and the condense water made it even more difficult to count the seeds.

Social (PRA, questionnaire, interviews)

"*Local knowledge is increasingly valued by research community in the developing world.*" (Dougill *et al.*, 2006, p.260). During the fieldwork "technical" analysis was combined with social studies/methods to include the needs and the attitude of the local people.

The different hierarchies of the WfWP were analysed by involving representants of each level. This is of great importance to gain an overall picture of the situation and would be a necessary step for further development plans. There is a *"…need for social network analysis at an early stage to provide information on existing conflicts between stakeholders, to identify marginalised groups and to provide guidance to policy-makers on how best to structure stakeholder engagement.*" (Dougill *et al.*, 2006, p.273).

The questionnaire survey was carried out based on the short questionnaire, but on the field the questionnaire was modified to suit the person being interviewed. The process generated a lot of data that could bring in interesting factors about the topic. On the contrary this process generated broad qualitative data that can not be categorized.

"*.....experimental learning theory suggests that it is necessary to reflect on and learn from past experiences to ensure that planning captures the complexity of a multi-stakeholder world.*" (Dougill *et al.*, 2006, p.263)

A learning experience was made from the first PRA session in Pepela. As it did not lead to the expected outcome the problems were analysed afterwards. A reason that was figured out was the insufficient introduction. For two further sessions a greater effort was put introducing our work and explaining the purposes of the exercises. Awareness was also gained about the fact that, working with a group of people, there is often one person with a strong opinion other groupmembers just follow/copy. This awareness was included in the further work and if the aim was to obtain individual opinions (to be able to examine gender and age differences) like in exercise 5 people were seated seperatly.

Conclusions

On the following of the discussion, it is possible to conclude that the program is not effective at its full extent on the area. Authors stated that the WfWP is less effective in managing the wattle than in poverty eradication (de Neergaard *et al.,* 2005). Concerning the social impacts on individuals, we conclude that there are benefits such as temporarily raised standard of life and empowerment by the WfWP. In terms of its impacts on the community, the WfWP can have, although temporarily, a strong positive influence. But we would regard these benefits as not sustainable due to the poor communication between communities and these agencies as well as the uncertainties in funding, which is translated into the inefficiency of the follow up treatments and the delay of the payments. An example in our case is the woodlot project where the community would be ready for a (more sustainable) project but is relying on external support.

Our assessment of the effectiveness of the WfWP suggests that the methods and the planning of the wattle eradication will have to be optimised to be successful in removing the wattle. We therefore recommend to optimise the clearing methods to the ecology of the wattle invasion (spatial and temporal), integrate biological control mechanisms and to change the way how the different levels of the WfWP organization interact with each other. Following the concept from (Holling, 2001) the WfWP organization can be seen as a “panarchy” or a hierarchy as a nested set of adaptive cycles; on a system, the functioning of these adaptive cycles and communication between them on will determine its sustainability. There is a big lack of knowledge on the site conditions and on the real performance of the clearings, and a big communication gap between the upper and lower levels of the program. It seems thus that this change within the current structure of the WfWP is needed to address the problem of IAS in a more realistic way. As Shackleton sets in a recent study, “the design and implementation of IAS control programmes are informed by the long-term costs of IAS for broader society and ecosystems and are rarely informed by the current needs of the rural people“ (Shackleton *et al.,* 2007). This is creating a conflict of interest between the reality of the rural livelihoods and the IAS control programs such as the WFWP. To address this, we support de Neergard *et al.* (2005) who ask to develop an “economically and ecologically sustainable land management or land stewardship founded on ownership, involvement and management by local communities“.

We add that the management of areas affected by IAS and the implementation of the clearing processes must be adaptive to the reality of the local livelihoods and the biology of Acacia species. Furthermore, in order to become sustainable, the management strategies have to

become more integrated (into the reality of the community), flexible (in their ways of addressing management issues) and resilient (concerning their management aims), and will have to resemble a continuous 'learning-by-doing' process to meet environmental uncertainty. (Bagheri & Hjorth, 2007). A sustainable management system of IAS will have to integrate social and environmental change (Moberg & Galaz, 2005) and foster public participation and collaborative learning (Bagheri & Hjorth, 2007). In this way it can be possible to address both the need of the community for a sustainable development perspective and the need of the society for secured water supply. In order to achieve this, the communities on whose land wattle is invading are an essential part of a management concept. Knowledge about the utility and management strategies of wattle within these rural communities can be integrated into such a concept. Through empowering the local people to manage wattle in a sustainable way it can be possible to achieve a sustainable development perspective for the communities. The aim for this management plan would be to accomplish a "cultural landscape", managed by the local people with help from external agencies, where wattle is managed and water resources are secured.

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Appendix

Appendix 1: Germination tests

Grass land		07-Mar	08-Mar	09-Mar	10-Mar	11-Mar
1	Radish	1	1	2	3	3
	Bean	1	1	2	4	4
	Cabbage	0	0	1	1	2
	Eggplant	0	0	0	0	0
2	Radish	0	2	2	2	2
	Bean	0	1	2	2	2
	Cabbage	0	0	1	1	2
	Eggplant	0	0	0	0	0
3	Radish	1	5	5	4	4
	Bean	0	1	3	4	4
	Cabbage	0	0	0	0	0
	Eggplant	0	0	0	0	0

Dense Wattle		07-Mar	08-Mar	09-Mar	10-Mar	11-Mar
1	Radish	1	2	2	2	3
	Bean	0	0	0	0	1
	Cabbage	0	0	0	1	1
	Eggplant	0	0	0	0	0
2	Radish	0	1	1	2	5
	Bean	1	3	4	4	4
	Cabbage	0	0	0	1	1
	Eggplant	0	0	0	0	0
3	Radish	3	3	5	5	5
	Bean	1	2	3	3	4
	Cabbage	0	0	0	1	1
	Eggplant	0	0	0	0	0

Open cleared land		07-Mar	08-Mar	09-Mar	10-Mar	11-Mar
1	Radish	2	2	2	2	2
	Bean	1	2	2	2	2
	Cabbage	0	0	0	0	0
	Eggplant	0	0	0	0	0
2	Radish	0	0	0	0	1
	Bean	2	3	3	3	3
	Cabbage	0	0	0	0	0
	Eggplant	0	0	0	0	0
3	Radish	0	1	1	3	4
	Bean	0	1	2	2	3
	Cabbage	0	0	0	0	0
	Eggplant	0	0	0	0	0

Appendix 2: Pictures of germination test and allelopathic tests.

Germination Test

Allelopathy test

Appendix 3: Allelopathy

Aerial allelopathy						
corrected	**Dwarf bean**	**07-Mar**	**08-Mar**	**09-Mar**	**10-Mar**	**11-Mar**
	Reference	0	1	1	1	1
	A. dealbata leaves	1	3	3	3	3
	A. mearnsii leaves	0	1	1	2	3
	Garden radish	**07-Mar**	**08-Mar**	**09-Mar**	**10-Mar**	**11-Mar**
	Reference	4	4	4	4	4
	A. dealbata leaves	3	3	5	5	5
	A. mearnsii leaves	3	3	5	5	5
	Swiss chard	**07-Mar**	**08-Mar**	**09-Mar**	**10-Mar**	**11-Mar**
	Reference	0	1	3	3	3
	A. dealbata leaves	0	3	5	5	5
	A. mearnsii leaves	0	2	3	4	4
	Cabbage	**07-Mar**	**08-Mar**	**09-Mar**	**10-Mar**	**11-Mar**
	Reference	0	2	3	5	5
	A. dealbata leaves	0	1	5	5	6
	A. mearnsii leaves	0	2	3	4	6

Appendix 3: Allelopathy continued

Water allelopathy						
corrected	**Dwarf bean**	**07-Mar**	**08-Mar**	**09-Mar**	**10-Mar**	**11-Mar**
	Reference	0	2	3	3	3
	A. dealbata leaves	0	1	3	3	3
	A. mearnsii leaves	0	1	1	1	2
	Cabbage	**07-Mar**	**08-Mar**	**09-Mar**	**10-Mar**	**11-Mar**
	Reference	0	4	6	6	7
	A. dealbata leaves	0	3	5	6	6
	A. mearnsii leaves	0	1	6	7	7
	Garden radish	**07-Mar**	**08-Mar**	**09-Mar**	**10-Mar**	**11-Mar**
	Reference	6	6	10	10	10
	A. dealbata leaves	9	9	10	10	10
	A. mearnsii leaves	6	8	10	10	10
	Swiss chard	**07-Mar**	**08-Mar**	**09-Mar**	**10-Mar**	**11-Mar**
	Reference	1	4	6	6	6
	A. dealbata leaves	0	0	4	6	6
	A. mearnsii leaves	0	3	6	6	6

Appendix 4: Vegetation sampling

Open grass land	**Open grass land next to wattle**	**Inside wattle**
Gladiolus crassifolium - Thick-Leaved Gladiolus	*Helichrysum herbaceum* - Monkey-Tail Everlasting	*Berkheya* sp.
Gladiolus sp.	*Hermannia woodii*	Senecio *sp.*
Stoebe vulgaris - Zigzag Bush	*Cliffortia* sp.	*Helichrysum* sp. x 4
Faml. *Scrophulaniaceae*	*Helichrysum* sp. x 2	Grasses x 2
Faml. *Leguminosa* x 3	Grasses x 5	Moss x 1
Indigofera longobarbata - Blue long-bearded	Unknown x 11	Unknown x 8
Dicoma anomala		
Helichrysum herbaceum - Monkey-Tail Everlasting		
Helichrysum sp. x 7		
Scilla nervosa - White Scilla		
Hypoxis rigidula - Silver-Leaved Star-flower		
Grasses x 4		
Unknown x 7		
TOTAL: 30 species	**TOTAL: 21 species**	**TOTAL: 17 species**

Appendix 5: Amount of nitrogen, organic matter and the C:N.

No.	Name	Weight(	%Nitro	N(kg)	Atom%	N15 excess	%Carb	C (kg)	%OM	C/N
1.	Reference 1.	1,122	10,36	0,1162392	0,365775	0	71,09	0,7976298	41,2322	6,861969
2.	Reference2	1,002	10,3	0,103206	0,365636	0	71,05	0,711921	41,209	6,898058
3.	Reference 3	1,195	10,31	0,1232045	0,365654	0	70,62	0,843909	40,9596	6,849661
4.	Reference 4.	1,028	10,48	0,1077344	0,365873	0	71,7	0,737076	41,586	6,841603
5.	Reference 5	0,947	10,36	0,0981092	0,365775	0	71,7	0,678999	41,586	6,920849
6.	Reference 6.	0,956	10,34	0,0988504	0,365939	0	71,41	0,6826796	41,4178	6,90619
7.	Reference 7.	1,163	10,36	0,1204868	0,365775	0	71,09	0,8267767	41,2322	6,861969
8.	Dense pepala 1.	26,4	0,385	0,1016928	0,367388	0,001388	4,961	1,309704	2,87738	12,87902
9.	Dense pepala 2.	33,793	0,778	0,26297713	0,36695	0,00095	9,862	3,3326657	5,71996	12,67283
10.	Dense pepala 3.	28,296	0,346	0,09776268	0,36053	-0,00547	4,598	1,3010501	2,66684	13,30825
11.	Dense pepala 4.	26,75	0,614	0,16421825	0,367204	0,001204	8,246	2,205805	4,78268	13,43216
12.	Grassland Pepela 1.	30,475	0,2	0,06088905	0,367799	0,001799	2,822	0,8600045	1,63676	14,12412
13.	Grassland Pepela 2	25,988	0,207	0,05389911	0,367869	0,001869	2,591	0,6733491	1,50278	12,49277
14.	Grassland Pepela 3.	33,548	0,164	0,05491808	0,368282	0,002282	1,938	0,6501602	1,12404	11,83873
15.	Grassland	30,638	0,269	0,08238558	0,368109	0,002109	3,386	1,0374027	1,96388	12,59204
16.	OLCleared Pepela	25,444	0,056	0,01415704	0,368231	0,002231	0,738	0,1878276	0,428156	13,26743
17.	Ocleared L Pepela	25,39	0,041	0,01053177	0,369469	0,003469	0,48	0,1217451	0,27811	11,55979
18.	MKM 1.	33,703	0,107	0,0359948	0,369545	0,003545	1,691	0,5699177	0,98078	15,83333
19.	MKM 2.	33,045	0,11	0,03638255	0,368519	0,002519	1,594	0,5267373	0,92452	14,47775
20.	MKM 3.	30,572	0,201	0,06129686	0,365939	-6,1E-05	2,877	0,8795564	1,66866	14,34913
			100	N14	0,366		100	0,58		

refe	dense pepela	grasslanc	OLC clea	MKM
6,9	12,87902388	14,1241	13,267	15,83
6,9	12,67283475	12,4928	11,56	14,48
6,8	13,30824891	11,8387		14,35
6,8	13,43215507	12,592		
6,9				
6,9				
6,9				
10	0,3852	0,1998	0,0556	0,107
10	0,7782	0,2074	0,0415	0,11
10	0,3455	0,1637		0,201
10	0,6139	0,2689		
10				
10				

Anova: Single Factor

SUMMARY

Groups	Count	Variance
Column 1	7	9E-04
Column 2	4	0,127
Column 3	4	0,936
Column 4	2	1,458
Column 5	3	0,676

there

ANOVA

Source of Variatic	SS	F	P-value	F crit
Between Group	197,8609068	123,5	2,741E-11	3,055568
Within Groups	6,007314461			
Total	203,8682213			

Anova: Single Factor %N

t0,025

SUMMARY

Groups	Count	Sum	Average	Variance
Column 1	7	72,51	10,36	0,00348095
Column 2	4	2,1228	0,531	0,04121593
Column 3	4	0,8398	0,21	0,0019079
Column 4	2	0,0971	0,049	0,00010025
Column 5	3	0,4174	0,139	0,00282712

reference	
dense pepela	0,321
grassland pepela	
OCL cleared pepela	
MKM	

ANOVA

Source of Variati	SS	df	MS	F	P-value	F crit
Between Grou	463,764	4	115,9	11147,3279	7,57963E-26	3,055568276
Within Groups	0,15601	15	0,01			
Total	463,92	19				

Appendix 6: Interview with Rob Adams, 6th March

Question 1: How were you involved in the Working for Water project?

- Rob Adams was the extension officer/area manager for the Northern Eastern Cape catchment area from 2000. Because of the change from catchment boundaries to provincial boundaries he is now limited to KZN. He is in charge of 4 managers, who each supervise 5 contractors. Each contractor is responsible for 15 workers.

Question 2: Can you please tell us about the project in Madlangala?

- The Madlangala region has a total of 3 contractors who each have 15 workers. The area is currently involved in a 5 year plan which includes initial treatment and a further 2 follow up procedures.

Question 3: How many people are employed in the Madlangala region by WFW?

- 1 manager, 3 contractors, 45 workers

Question 4: What salaries are being paid?

- Old: Contractors - R160 per day; Herbicide Applicators – R 51 per day; General worker – R47.80 per day
New (as of 1st April '07): Contractors – R170.32 per day; Herbicide Applicators – R54.20 per day; General worker – R50.33 per day

Question 5: How does the project select those employed either as workers or contractors?

- Contractors: Apply through application of CV. Paid approximately R6000 per month plus benefits such as a car allowance. 20% of their salary is saved for them and then paid out to them in a lump sum at the end of their 2 year contract. This will help them to invest in something (e.g.: buying a tractor?).
Workers: contractors select the workers with the help of the community committee. Workers are selected form the nearest villages. Only 1 worker per household is allowed, and the poorest households get 1st priority.

Question 6: Do employees receive any training?

- Yes (see printed pages for Contractors training programme). Workers receive 2 days of training per month (48 days over a 2 year period). Training for workers not only includes health and safety with handling chemicals etc, but also personal finance to help them with money management.

Question 7: How does the project select areas for eradication?

- Mostly catchment areas are targeted. Heavily invaded sites areidentified with aerial photography then assigned to individual managers who form 5 year plans for wattle removal in those areas.

Question 8: What methods are used for clearing wattle?

- Old methods: bruch cutters and chainsaws were used to cut down the wattle trees and then poison/chemicals/herbicide was applied to the stumps. Too little training resulted in equipment being used incorrectly and accidents because of people working in close proximity to each other with powertools.
New methods: ring barking/frilling with a machete close to the ground followed with herbicide (mix-

ture of Garlon and Lontrill) to the exposed wood. This method allows soil to be protected against erosion because grasses are able to establish before the trees die/are removed, therefore is more ecologically friendly.

Question 9: Are there any follow-up treatments after areas are “cleared”?

- After the initial treatment, the site is revisited twice and sprayed with herbicide, which may destroy other plants.

Question 10: Have you had success in controlling wattle spread in some areas and not in others, in particular between private and communal land?

- Without a timber permit, wattle growth on private land is illegal. Overgrazing over-resting or fire can cause grasslands to be invaded. Therefore private land is generally better managed therefore wattle invasion is usually less extensive on privately owned land. Local people are quite protective over the wattle because the use it for firewood, building materials and shade for cattle, therefore sometimes cause issues when WFW try clear communal land.

Question 11: How much pressure does wattle spread put on land-uses such as grazing?

- There is a definite impact however ore research needs to be done on which land-uses are more prone to invasion.

Question 12: If the wattle were to be completely eradicated what would replace that resource for local people?

- In the past, people used to burn cow dung for heat. There is also the possibility of creating a woodlot that is fenced and controlled to service local needs.

Question 13: What impacts will there be when the project is handed over to the Eastern Cape?

- Budget cuts

Notes:

- Work teams must consist of 60% woman 40% men
- Issues with managers such as laziness exist
- Contracts for contractors and workers only last for 2 years after which they must be “exited”
- Cost for clearing = R6000 per hectare
- Follow-up procedures should include helping workers and contractors with income/livelihood activities after their contracts end. Also, grazing management should contribute to follow-up procedures.
- Other environmental problems should be solved through similar poverty alleviation projects (e.g.: soil erosion)

Appendix 7: Activity sheets

Date	**Activity sheet Aadarsh**
Saturday 03.03	• Field walk in Pepela in 5 year old WfW cleared area (entire group). • Field walk in Makomereng in former cleared area (entire group). • Pre-test and discussion of interview questions with interpreters (entire group). • Group meeting/triangulation in the evening – planning for the next day
Sunday 04.03	• Church • Collection of soil samples from 9 sites in Pepela • Triangulation in the evening – planning for the next day
Monday 05.03	• Mapping at site A • Interview with a WfW worker • Triangulation in the evening – planning for the next day
Tuesday 06.03	• Mapping at site B • Mapping at site E • Interviews at homes around site E • Interview with chieftess of Makomereng • Triangulation in the evening – planning for the next day
Wednesday 07.03	• Vegetation, soil sampling on site B • Interview on the site E continued • Triangulation in the evening – planning for the next day
Thursday 08.03	• Interview with a working for water contractor • Hiked for 5 hours totally • Triangulation in the evening – planning for the next day
Friday 09.03	• Interviews in Pontseng with the villagers • Interview around the wattle stand site E in Pepela • Key informant interview with former woodlot contractor • Presentation for the other groups in Makomereng
Saturday 10.03	• Interview with contractor Mr. Ndaba and interviews at site E in village (Pepela) • Regeneration survey • PRA in Makomereng • Triangulation in the evening – planning for the next day
Sunday 11.03	• Regeneration survey • Questionnaires in Thuthaneng • Triangulation in the evening – planning for the next day
Monday 12.03	• Hiking to the WfW area 2h from Pepela – interviews with workers and the contractor there • Presentation in Makomereng for the villagers • Get together after presentation at Makomereng

Appendix 7: Activitysheet (continued)

Date	Activity sheet Ana
Saturday 03.03	• Field walk in Pepela in 5 year old WfW cleared area (entire group). • Field walk in Makomereng in former cleared area (entire group). • Pre-test and discussion of interview questions with interpreters (entire group). • Group meeting/triangulation in the evening – planning for the next day
Sunday 04.03	• Church • Preparation of next day's PRA • Triangulation in the evening – planning for the next day
Monday 05.03	• PRA in Pepela (Ana, Loren and Therese) • Triangulation in the evening – planning for the next day
Tuesday 06.03	• Mapping of site B (Ash, Ana, Anita, Flo, and Therese) • Interview with chieftess of Makomereng (Ash, Ana, Flo) • Triangulation in the evening – planning for the next day
Wednesday 07.03	• Mapping of site B (Ana, John, Keagan and Loren) • Triangulation in the evening – planning for the next day
Thursday 08.03	• Mapping of site C (Ana, Flo, Keagan and Therese). • Triangulation in the evening – planning for the next day
Friday 09.03	• Interview of Mr. Kuboni´s wattle driver • Making of slides for the presentation in the evening (Anita, Loren, Flo, Ana and Therese) • Interviews in Pontseng with the villagers • Presentation for the other groups in Makomereng
Saturday 10.03	• Interviews in Pontseng with villagers about use of wattle (Loren, John, Ana, Anita and Therese). • Interview with Mr. Marareni • Interview with the wattle responsible person in Pepela • Regeneration survey • Triangulation in the evening – planning for the next day
Sunday 11.03	• Regeneration survey • Interview with Thuthaneng chief • Questionnaires in Thuthaneng (Ash, Ana, Flo, Kojo and Therese) • Triangulation in the evening – planning for the next day
Monday 12.03	• Hiking to the WfW area 2h from Pepela – interviews with workers and the contractor there (Anita, Flo, Ash, Ana, Keagan and Therese). • Presentation in Makomerang for the villagers

Date	Activity sheet Florian Lorenz
Saturday 03.03	• Field walk in Pepela in a 5 year old WfW cleared area. • Field walk in Makomereng in the woodlot area. • Group meeting/triangulation in the evening – planning for the next day
Sunday 04.03	• Ill at home • Interview with two villagers • Triangulation in the evening – planning for the next day
Monday 05.03	• School workshop in pepela about nature and landscape perception • Germination test initialized • Triangulation in the evening – planning for the next day
Tuesday 06.03	• Mapping on site B • Mapping at site E • Interviews at homes around site E • Interview with chieftess of Makomereng • Triangulation in the evening – planning for the next day
Wednesday 07.03	• Vegetation, soil sampling on site B • Interview on the site E continued • Triangulation in the evening – planning for the next day
Thursday 08.03	• Mapping of site C • Interview with the sangoma of pepela • Triangulation in the evening – planning for the next day
Friday 09.03	• Prepared the PRA for Saturday and made slides for the presentation in the evening • Interview at homes around site E in Pepela • Key informant interview (Oriana -woodlot) • Presentation for the other groups in Makomereng
Saturday 10.03	• Interview with contractor Mr. Ndaba interviews at site E Pepela • Key informant interviews in Makomereng (wattle drivers, officer) • Regeneration survey started • Triangulation in the evening – planning for the next day
Sunday 11.03	• Regeneration survey continued • In Thuthaneng for interviews concerning the living without wattle • Triangulation in the evening – planning for the next day
Monday 12.03	• Hike to the area 2h from Pepela where WfW is clearing wattle. Interviews with workers and the contractor. • Presentation in Makomerang for the villagers

Appendix 7: Activitysheet (continued)

Date	Activity sheet Therese
Saturday 03.03	• Field walk in Pepela in 5 year old WfW cleared area (entire group) • Field walk in Makomereng in former cleared area (entire group) • Pre-test and discussion of interview questions with interpreters (entire group) • Group meeting/triangulation in the evening – planning for the next day
Sunday 04.03	• Recasted the interview questions (with Loren and Therese) • Church • Interview with two villagers – one former WfW worker and one present WfW worker (with Loren, Flo and Therese) • Triangulation in the evening – planning for the next day
Monday 05.03	• Mapping at site A (with John, Kojo and Aadarsh) • Interview with a WfW worker (with Ash and Therese) • Triangulation in the evening – planning for the next day
Tuesday 06.03	• Mapping at site B (with Aadarsh, Ana, Therese, Flo and Keagan) • Triangulation in the evening – planning for the next day
Wednesday 07.03	• Drawings for the PRA for Thursday (with Therese) • Counting germinated seeds (with Therese) • Interviews with different villagers in Pepela and Goxe (with Therese) • Summarized the answers from the interviews that had been done so far (with Therese). • Triangulation in the evening – planning for the next day
Thursday 08.03	• Counting germinated seeds (with Therese) • PRA in Pepela (with Loren and Kojo) • 4-question survey and interview with former contractor (with Kojo) • Triangulation in the evening – planning for the next day
Friday 09.03	• Counting germinated seeds (with Therese) • Prepared PRA for Saturday in Makomereng (with Therese) • Interview of Mr. Kuboni´s wattle driver (with Ana) • Presentation for the other groups in Makomereng (entire group)
Saturday 10.03	• Counting germinated seeds (with Therese) • Interviews in Pontseng with the villagers (with Loren, John, Ana and Therse) • PRA in Makomereng (with Aadarsh, Loren and Therese) • 4-question survey in Makomereng (with Loren and Therese) • Triangulation in the evening – planning for the next day
Sunday 11.03	• Counting germinated seeds (with Therese) • Measured pH, EC and phosphor in the soil samples (with Loren, John, Kojo and Therese) • Ultimatefrisbee with villagers • Triangulation in the evening – planning for the next day
Monday 12.03	• Hike to the WfW area 2h from Pepela – interviews with workers and the contractor there (with Flo, Ash, Ana, Keagan and Therese) • Presentation in Makomereng for the villagers

Appendix 7: Activitysheet (continued)

Date	Activity sheet for Anita
Saturday 03.03	• Field walk with colleagues to study the village • (Grp. Meeting)
Sunday 04.03	• A walk into the mountains at Pepela to examine the spread of the wattle and it's establishment • A slight study of the morphology/physiology of the species. • Collection of thesoil samples for the germination test. • (Grp. Meeting)
Monday 05.03	Went with Ash, John, and Anita to map Islands without wattle at site A and also did some vegetation sampling. • (Grp. Meeting)
Tuesday 06.03	• Went to Kokstad with John, Loren, and Andreas to have an interview with Rob Adams. Continued though to a wattle eradication site to have an interview with both a manager and a worker. • (Grp. Meeting)
Wednesday 07.03	• Walked to SIRA to find the responsible for the eradication program in the village. Met his absence, and started an interview with the villagers to find out about their perception of the wattle and how it is impacting their livelihood. • (Grp. Meeting)
Thursday 08.03	• Conducted a PRA session with Anita and Loren at Pepala and continued with questionnaire in the afternoon. • (Grp. Meeting)
Friday 09.03	• Continuation of the interviews in Thuthameng and the rest of Pepela. • (Grp. Meeting)
Saturday 10.03	• Soil sampling with John and Andreas • Helped with the PRA session at Makomerang • (Grp. Meeting)
Sunday 11.03	• Conducted experiments on the soils to determine the pH, EC and the phosphate. • Continued with the interviews. Germination inspection. • Soil sampling in the afternoon. • (Grp. Meeting)
Monday 12.03	• In the morning, cleaning up after the germinating test to give the people their borrowed items. Presentation in Makomereng for the villagers.
Tuesday 13.03.	• Cleaning and parking of all our items with Andreas and John and departure afterwards.

Appendix 7: Activitysheet (continued)

Date	Activity sheet Kojo
Saturday 03.03	• Field walk with colleagues to study the village • (Grp. Meeting)
Sunday 04.03	• A walk into the mountains at Pepela to examine the spread of the wattle and it's establishment • A slight study of the morphology/physiology of the species. • Collection of thesoil samples for the germination test. • (Grp. Meeting)
Monday 05.03	Went with Ash, John, and Anita to map Islands without wattle at site A and also did some vegetation sampling. • (Grp. Meeting)
Tuesday 06.03	• Went to Kokstad with John, Loren, and Andreas to have an interview with Rob Adams. Continued though to a wattle eradication site to have an interview with both a manager and a worker. • (Grp. Meeting)
Wednesday 07.03	• Walked to SIRA to find the responsible for the eradication program in the village. Met his absence, and started an interview with the villagers to find out about their perception of the wattle and how it is impacting their livelihood. • (Grp. Meeting)
Thursday 08.03	• Conducted a PRA session with Anita and Loren at Pepala and continued with questionnaire in the afternoon. • (Grp. Meeting)
Friday 09.03	• Continuation of the interviews in Thuthameng and the rest of Pepela. • (Grp. Meeting)
Saturday 10.03	• Soil sampling with John and Andreas • Helped with the PRA session at Makomerang • (Grp. Meeting)
Sunday 11.03	• Conducted experiments on the soils to determine the pH, EC and the phosphate. • Continued with the interviews. Germination inspection. • Soil sampling in the afternoon. • (Grp. Meeting)
Monday 12.03	• In the morning, cleaning up after the germinating test to give the people their borrowed items. Presentation in Makomereng for the villagers.
Tuesday 13.03.	• Cleaning and parking of all our items with Andreas and John and departure afterwards.

Appendix 8: Synopsis

Spatial, ecological and socio-economic dynamics of the Wattle invasion in the Madlangala region.

Mohandas Aadarsh Ana Braganca Florian Lorenz Therese Nissen Anita Rohwer Francis Kojo Yeboah **Supervisors:** Andreas de Neergaard Torben Birch-Thomsen Interdisciplinary Land Use and

Natural Resource Management Faculty of Life Sciences, Copenhagen University, Denmark February 22, 2007

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Background

Introduction

Alien plants invasions are generating a great concern in terms of environmental impacts (Binns et al., 2001). The distribution of invasive alien plant species, which is recorded in the South African Plant Invaders Atlas (SAPIA), shows that the greatest number of invading plants occurs in the Western Cape, along the eastern seaboard and into the eastern interior. The main invaders are trees and shrubs in the genera Acacia, Hakea and Pinus (Richardson & van Wilgen, 2004). Acacia species are fast growing, and their extensive spread over South Africa since 1900 has diminished the indigenous vegetation, like fynbos and grassland, and thereby causing a decline of biodiversity (Dye & Jarmain, 2004). In 1998 the black wattle (*Acacia mearnsii*) covered 2,5 million ha (Binns et al., 2001). The spread has mainly been in water catchments and riparian zones, where it is affecting the water discharge because of reduced stream flow (Richardson & van Wilgen, 2004). According to Le Maitre *et al*. (2002) almost 7% of the country's water run-off is estimated to be used by these invaders. Acacia species are evergreen, permit transpiration all year long, consuming considerable amounts of water (Dye & Jarmain, 2004). Water is considered a key constraint to economic growth in South Africa and there is an urge for efficient and sustainable use of it (Le Maitre *et al*., 2002). Due to this threat to the South African water resources, a nation-wide program to eradicate wattle has been introduced in 1995 – the Working for Water programme (WfWP). The multiple environmental and social developmental objectives of the Working for Water programme have been described internationally as being without precedent (Preston et al. 2000).

The Working for Water Programme (WfWP)

Since 1930 there have been several research programmes on alien plant invasions in South Africa. In 1995 the Department of Water Affairs and Forestry launched the Working for Water programme which includes the first countrywide assessment of the extent of woody plant invasions (Richardson & van Wilgen, 2004). The WfWP aims at the eradication of invasive species, especially wattle, by working together with the local communities, using local contractors and paying the locals for eradicating the wattle (Binns et al., 2001). It can be seen as a dual purpose of protecting water resources (through controlling invasive alien plants), and of job creation (through employment of poor people in control projects) (van Wilgen et al., 2001).

WfWP in the Eastern Cape Province

In the Eastern Cape Province the main invasive species is black wattle (*Acacia mearnsii*). The aim of the WfWP program is to replace this species by indigenous vegetation. Therefore various steps are being followed: first, the wattle is being mapped. Sequentially meetings are held with private landowners who have invasive species on their land. Afterwards the workload is defined and the area which is supposed to be cleared is divided into blocks. One year after clearing there is a follow-up treatment and the area is reseeded with indigenous vegetation. Moreover the cut timber is being removed and the timber for charcoal making is being stacked (Binns el al., 2001).

Ecological aspects
There is no consensus among scientists regarding the issue of the ecological benefits of the WfWP. It is stated by some authors that the main ecological benefits are: prevention of the loss of biodiversity, reduction of fire hazard, stabilization of catchment areas, and prevention of erosion. (Le Maitre *et al*., 2002). Nevertheless, others point to the fact that the ecological succession must be considered, and that the WfWP brings along the problem of an erosion threat between clearance and the establishment of indigenous vegetation (Binns et al., 2001). Furthermore, Anon (2002) states that although the programme has been proposed during the last 20 years, the progress towards achieving the goal of clearing major infestations within that period has not yet been assessed.

Social aspects
According to Le Maitre et al (2002) the social role of the WfWP is very important due to job creation, gender and racial equity, opportunities for the youth, the disabled and the single parents, training and empowerment and environmental awareness. For Binns et al., 2001, the job creation helps to reduce poverty, leading to further positive social effects as the job training includes, for example life-skill courses. Apart from that the community spirit might increase and especially women acquire empowerment (Binns et al., 2001). By addressing unemployment, transformation issues, the HIV/AIDS pandemic, skills training as well as empowerment the programme gained political support and secured significant funding (Magadlela & Mdzeke, 2004). Despite the opinions of these authors, Anon (2003) states that although most of the program's social development interventions were aimed at improving economic conditions in poor rural communities, the implications for the lives of the affected people are not fully investigated. It should also be taken into account that one of the reasons for villagers to eradicate the wattle is that the dense wattle stands provide a hiding place for thieves and criminals (de Neeregaard et. al., 2005). Some authors already point towards weaknesses of the programme. For Magadlela & Mdzeke (2004), the exit strategy for the workers has not been developed so far, and preliminary findings in 2002 revealed that most workers and contractors leaving the program were not fully equipped to secure work outside it (although this situation also reflects the general economic depression in rural areas). It is possible to presume then, that the programme is not really building up capacity. On their turn, de Neergaard et al. (2005) stress a potential conflict between the perceived interests of society (control of the wattle) and local communities (a continued resource of woody species).

Economical aspects
Some studies conclude that the clearing of the trees was justified because the cost of clearing was much less than the value of benefits from the improved water supply (van Wilgen et al. 1996) and that clearing programmes are a wise and cost-effective method of protecting vital water resources in South Africa. (Le Maitre *et al*., 2002). Economists are claiming that benefits of alien plant clearing programs have been underestimated which leads Turpie (2004) to suggest that further ecological research will be needed to underpin reliable economic analysis of the problem. Binns et al. (2001) adds that this cash-flow created by the program can give uplift to poor rural communities. Having a completely opposite position, other authors state that the WfWP program in the Madlangala area is unsustainable due to that fact that it relies on external funding (de Neergard,et al. 2005). Furthermore the economical benefits from alien species must not be forgotten. These are not restricted to the ones of commercial plantations; in rural communities, they also provide fuel and other products; they provide land restoration and the development of agro-forestry (Le Maitre *et al*., 2002).

Towards our objective
There is no consensus among authors who conducted research concerning the wattle invasion and the role of the WfWP program in South Africa. Furthermore the literature review shows that the spatial,

social-economical and ecological aspects of both the Acacia sp. and the WfWP are not well explored. At the moment our understanding of a number of important aspects of the dynamics of the wattle invasion remains relatively poor (Magadlela & Mdzeke, 2004). For our research we aim to acquire new knowledge concerning the ecological effects of wattle, its invasive dynamics and its impact on the local people. Furthermore the impacts of the WfWP on the rural livelihoods and the wattle distribution are core areas of our interest. Following the suggestion of some authors, we will focus on a more holistic scientific approach and an interdisciplinary agenda for our research (van Wilgen, 2004), and formulate the right questions, addressing ecological and economic topics in a dynamic research concept (Turpie, 2004).

Objectives

To study about spatial, ecological and socio-economic aspects of the Wattle invasion and governmental sponsored eradication programs in the Madlangala region. To make a comparison of the social-economics and the landscape-perception in three villages of the Madlangala region.

Main research questions:

- **Which socio-economic, ecological and spatial effects did the Wattle invasion have since 1953 in the Madlangala region?**
- **What are the effects of the WfWP on the distribution of Wattle and the rural livelihoods since 1999 in the Madlangala region?**

Sub-research questions:

Wattle:

What is the distribution of wattle since 1953? Which areas have been cleared from wattle since the program started in the Madlangala region? What is the impact of wattle on biodiversity and soil quality?

WfWP:

What effects does the wattle removal have on biodiversity and soil quality? What is the status of the current WfWP in terms of spatial mapping and state of vegetation? How are areas cleared from wattle within the WfWP? Is the technique of eradication adapted to Acacia ecology? What is happening with the wood from areas cleared within the WfWP? Are there other incentives than the WfWP for people to eradicate wattle?

Local communities:

Where and how is wattle used? Where is the locally sold wood being harvested? What is the perception of the wattle problem by the villagers? What is the role of wattle in the villagers' perception of landscape? Do the local people have their own suggestions to solve the wattle problem?

Socio-economics:

What are the dynamics of the wattle economics in the villages? Which socio-economic dynamics do areas show where wattle has been removed? What is the potential of a local agro-forestry or industry with wattle?

Methodology

Structure of working groups

The working group consists of two landscape architects, one biologist, one ecologist, one forester and one agronomist. We will split in two groups, collecting data independently. One team will focus on the socio economic dynamics of wattle, the other one on the spatial and ecological aspects of wattle. We are aware of our role as strangers coming into the reality of the people in the villages where we conduct our research (see research framework, appendix 1). The triangulation of the collected data is a key element of the presented methodology. Data triangulation meetings of the entire group will be held every evening, promoting interdisciplinary discussions, data collection and interpretation within the two teams.

Field walk and sample plots demarcation

Field walks will help us to get familiar with the surroundings and to identify and mark locations for soil samples and vegetation analysis. (compare appendix 2) The sample plots within the Wattle stands will be chosen by the time when clearing has been taken place. We will mark plots in a range from undisturbed Wattle stand to ones recently cleared. Furthermore sample plots will be indentified on natural fynbos grassland close to the wattle stands so the soil quality is comparable to a non-invaded state.

Soil sampling and analysis

Soil will be collected from the marked spots and used to conduct different soil experiments like determination of soil pH, EC and organic carbon estimation, to examine the effect of Wattle on soil fertility and biodiversity. The locations of these sampling plots will be clustered and results compared within these clusters to minimize local differences in soil composition.

Germination test

A germination test will be included to collect data concerning possible allelopathic effects of wattle. These will be conducted on site and in the laboratory back in Copenhagen. To acquire results on site in Madlangala it will be necessary to use fast germinating species for the experiment. Results from germination experiments can support us to understand the inventory of vegetation on cleared areas.

Vegetation sampling

On GPS marked plots of 1*1 meters, plant species and their spatial distribution will be documented. The plots will be the same or adjacent to the sample plots of the soil analysis, chosen after different stages of clearing. The absolute species richness and species coverage will be documented. By using the Shannon weaver index for species richness we can thus compare numbers for biodiversity (alpha diversity) on the examined plots. Therefore the examined plot must have a homogenous character.

GIS Wattle mapping 1953-2003

To obtain spatial data of the historical spread of Wattle, we will make a GIS analysis of aerial pictures from 1953, 1975, 2000 and 2003. The mapped area will contain the villages chosen for detailed field work.

This mapping will provide us a spatial reference to compare the distribution of Wattle in the region in 2007 and the historical spread. It will be furthermore interesting how the spread of Wattle has changed since the WfWPstarted in the region. Therefore we need to understand the historical context of the Wattle invasion in the Madlangala region.

GPS mapping of Wattle distribution

We will define sampling areas close to the villages with a relative high cover of *Acacia mearnsii* and *A. dealbata*. Within these areas the actual distribution and succession state of the vegetation will be documented according to the different stages of clearing. This information will be complemented with data from the local contractors working for the WfWP. The documentation of the different stages of clearing and the documentation of successive growth in these areas will allow us to interpret the effectiveness of the eradication methods used within the WfWP and the impacts of the WfWP on biodiversity.

Semi structured interviews

Interviews will be held in three villages: Makomereng, Pepela and a village where wattle has been eradicated. Within these villages people will be interviewed; who are either using wattle in their own household, who make an income from selling it or who earn money from working within the WfWP. To get variance within the interviewed people, clusters will be made within the villages. Within each cluster, random sample household will be conducted and followed by interviews.

Key informant interviews

Heads of the WfWP, scientists (Pietermaritzburg) and some villagers with a special social role in the village (chief, head-man, the village's WfW committee) will be interviewed independently using specific questions.

Mind maps on Wattle

To understand the perception of wattle by the villagers and the attitudes towards Wattle and the WfWP mind maps will help us to gain more information than the interviews can provide us with. Villagers will be asked to draw and write about their attitudes and the importance of wattle for their everyday life. The mind maps will be grouped after age, gender and background to be comparable.

Compilation of data and presentation of results

The last days in Pietermaritzburg will be used for compilation of all the data collected on the field and on the last days there will be a presentation of the results.

Time schedule

February 26th to March 17th 4 days at the university at Pietermaritzburg 12 days in field collecting data 2 days at the university for data processing and reporting

Timetable wattle group

	feb																	**march**
26	**27**	**28**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
P-burg							Field							P-burg					
Presentation of synopsis																			
Editing and presentation of final synopsis																			
Preparing for field trip																			
Field walk																			
Sample plot demarcation																			
Soil collection Makomerang																			
Soil collection Pepela																			
Soil collection in wattle eradicated village																			
Germination test Makomerang																			
Germination test Pepela																			
Germination test wattle eradicated village																			
Wattle inventory Makomerang																			
Wattle inventory Pepela																			
Vegetation analysis Makomerang																			
Vegetation analysis Pepela																			

Local preparation of interviews
Interviews Makomerang
Interviews Pepela
Interviews in Wattle eradicated village
Interview of W4W personnel
Triangulation meetings after dinner
Compilation of data
Presentation of results
wattle team
village team
entire group

Table 1: Timeline of the wattle group
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Info	**Methods**	**Location**	**Inventory**	**Conclusions towards**
wattle inventory 1953-2003	GIS-mapping	CPH and pietermaritzburg	maps, aerial pics, geo referenced	historical background
extend of spread of wattle				
spatial distribution 2007	GPS-referencing	pepela and makomerang	maps, aerial pics, geo referenced	impact of W4WP on distribution
Mapping	wattle eradicated village	GPS	of wattle.	
ecological effects	soil sampling	pepela and makomerang	soil samples, GPS, plant guides	correlating ecological data
analysis of allelopathic effects	germination tests	wattle eradicated village	germination trays, seeds	to W4W, wattle dynamics and
soil quality	erosion quantifying	use by villagers.		
vegetation sampling	wattle impact on biodiversity			
benefits of wattle, socio-economic data	S.S interview	pepela and makomerang	questionnaires, transalator,	socio-economic dynamics of wattle
W4W personnel and contractors	key informant interview	wattle eradicated village	voice recorder	impact of the W4WP
progress and process of WfW	mind maps on wattle	madlangala region	paper, drawing material	perception , landscape
perception of wattle		pietermaritzburg		

Table 2: Plan of action for the wattle group (feb. 22 2007)

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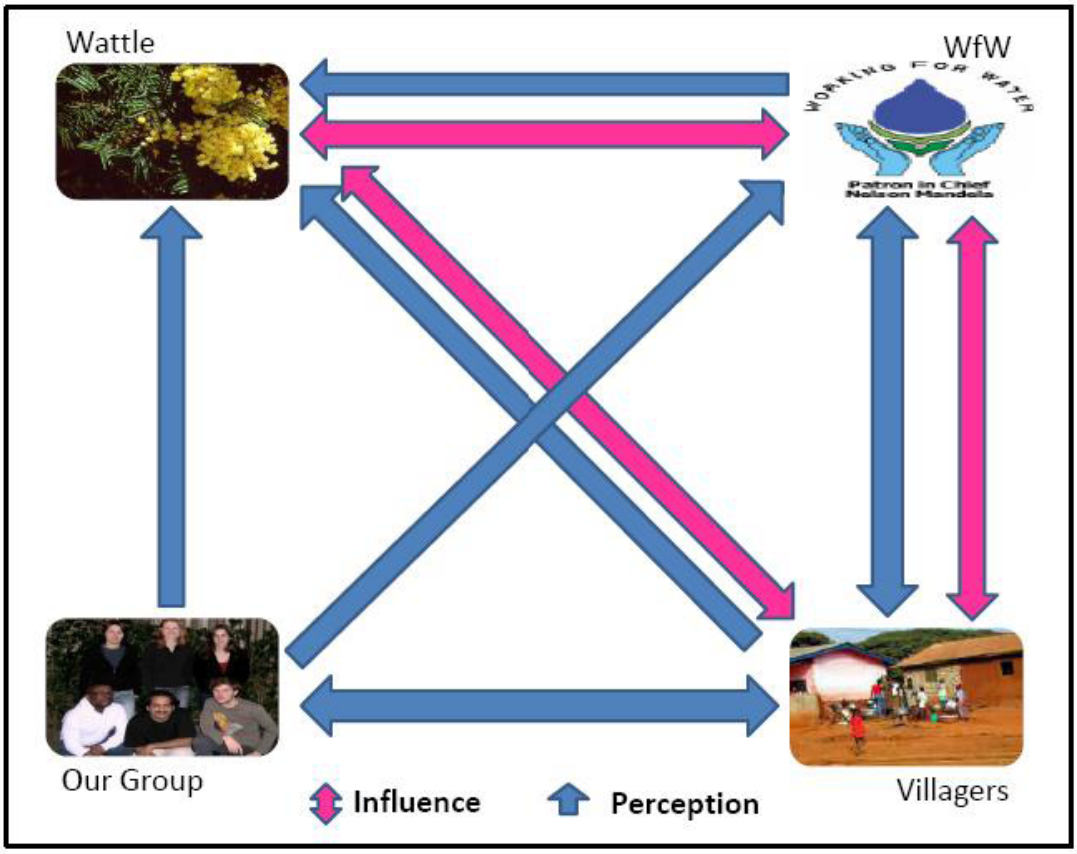
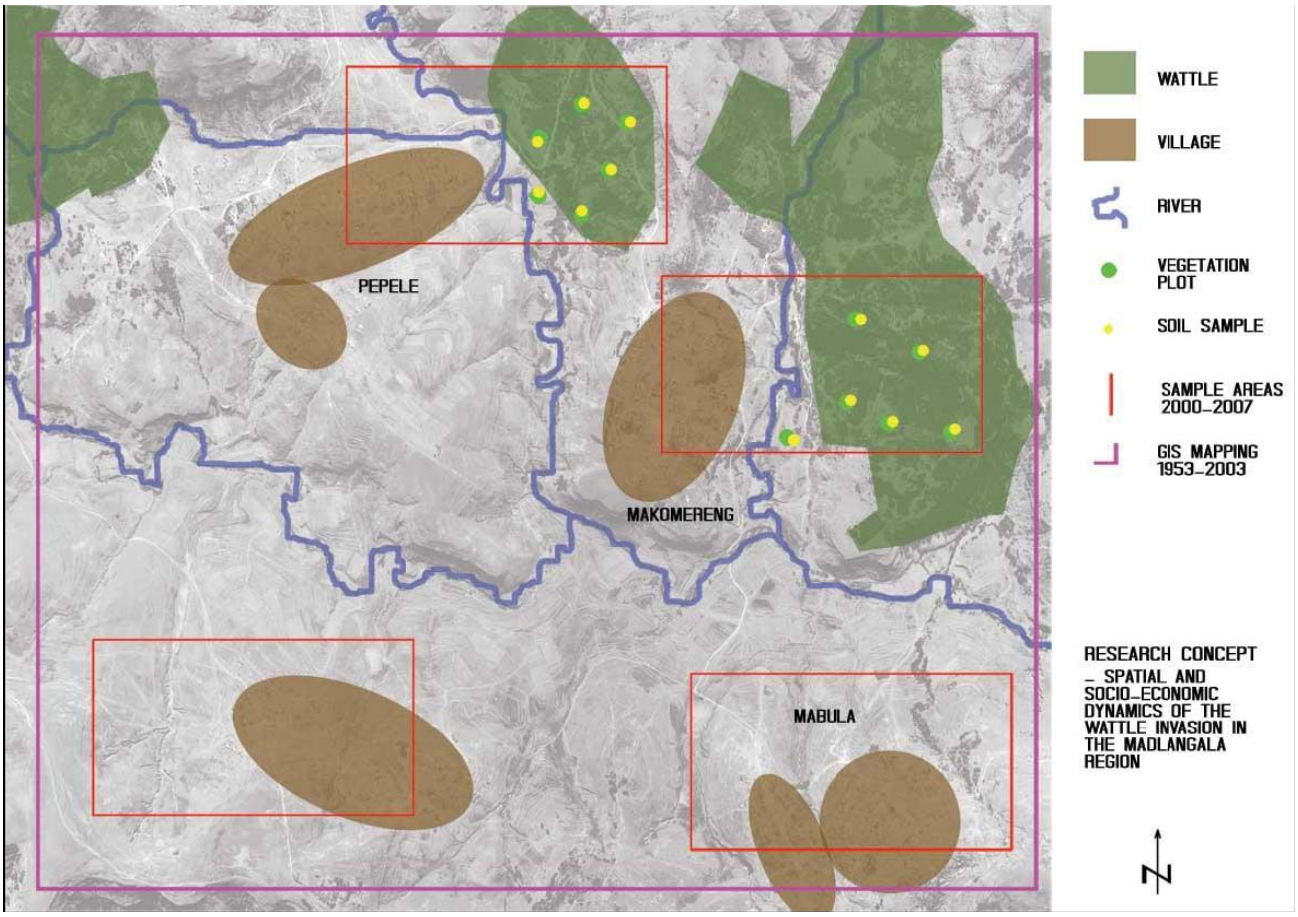
Appendix 1.

Figure 1: Research framework



Appendix 2.

Figure 2: Spatial research concept.



Appendix 3.

Villagers – (draft)

We are studying the spread of wattle in the Madlangala region. We would like to ask you some questions to help us to understand what wattle means to your village. Questions for the chief?

1. What is the main source of income in your village?
2. Who is making an income from wattle?
3. How many people do earn money from Wattle?
4. What is the importance of the WfW program for the village
5. What will come after the WfW program?

To all villagers / one household

1. How many people live with you?
2. How many do permanently live there/slept there last night?
3. What is your households' main source of income?
4. Do you gain money from selling wattle or the WfW programme?
5. Which other sources of income does your household have?
6. What does your household use wattle for? Private use – income – both – no use of wattle
7. How much wattle do you cut? How can we measure this? Do we need to know this?

To all villagers (maybe at the end of the interview)

1. Does wattle cause any problems for you? What kind of?
2. What are your suggestions to solve these problems?
3. What are incentives for you to eradicate wattle?
4. (consider this too:-- what incentives are derived from eradicating the wattle?)

To the villagers who use wattle for private purpose

1. What are the private purposes you use wattle for? (what purposes does the wattle serve for you,privately?)
2. Where do you cut the wattle for your private use?

To the villagers who use wattle as a source of income

1. Where do you cut the wattle you sell?
2. Where do you sell the wattle?

Are you working for the WfW Programme? *To the villagers working for the WfW programme*

1. How long have you been working for the WfW programme?
2. How long are you going to work for the WfW programme?
3. Are you working for the WfW programme through the whole year? (Do you expect to work on the WFW programme the whole year?)
4. How many hours per day do you work on the WfW programme? Can you describe your activities during a workday?
5. How much do you earn from this work? (or is it enough to know if it's the main source of income?)
6. How did you get employed on the WfW programme? What are the conditions to get employed?
7. What is happening to the wood from areas cleared within the WfW programme?

To Villagers from a village where wattle has been removed successfully

1. What is the main source of income in your village?

2. What do you use for your fuel and heating purpose?
3. Where do you procure the wood from?
4. How much money do you spend on wood? Is it a main factor compared to your other expenses?
5. Where did wattle grow before the eradication? How do these areas look like now? What are they used for?
6. When was the wattle eradicated?
7. Did your daily activities change due to the eradication of wattle? What changes do you find in your daily activities after the eradication of wattle?

Apendix 4

WfW staff (draft)

We are studying the invasion of wattle in the Madlangala region and its spatial, ecological and socio-economic effects. A main part of our study is to look into the influence of the WfW programme. We would like to ask you some questions to give us an insight into this programme.
Facts about the person we are talking to:

1. What is your function in the WfW programme?
2. How long have you been working on this job?

Spatial aspects:

1. According to our findings the programme startet in 1999 in this area. Is that right?
2. In which area did the program start?
3. Where (location) was wattle cleared first?
4. Where did it continue?
5. Where is it operating now? (show on a map! Our map or own one? Get the maps!)
6. Which areas have been successfully cleared of Wattle since the program started in the Madlangala region? (also to be located on map.)

Socio-economic:

1. How many people do you employ in the Madlangala region?
2. For how long are people employed in total?
3. How many hours per day do they work?
4. Are there different contracts?
5. How much are the workers paid (per hour?)?
6. What is the procedure for employment on the WfW programme?
7. Who is choosing the people?
8. Do they need a certain qualification?
9. What kind of training do the workers for the WfW programme get?
10. Is there any insurance when working for the WfW programme?

Process of eradication:

1. How are areas cleared from wattle within the WfW programme?
2. Which technique is used?
3. Are the methods of eradication changing?
4. What are the different steps adopted until an efficient eradication achieved?
5. How/when do you check the efficiency of the eradication?
6. What are your facilities if wattle spreads again on a cleared area?
7. Is the W4W programme operational through the whole year? If not: when is the season, when are the break periods?

After eradication:

1. What is happening with the wood from areas cleared within the WfW programme?
2. Is wood, cut within the WfW sold? Where is it sold?
3. Who gains money from that?
4. Are you still in contact with the villages where wattle has been removed successfully?
5. Do you know who provides them with firewood now?
6. Which sources do they have to gain income now that they do not have the possibility of working for the WfW programme anymore?

Activity sheet for Anita