Invasive Management Plan for Oubosstrand and Protea farm.

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Executive Summary

The human population is growing rapidly and progressively more natural landscapes are altered to provide area for food production and housing. Only recently scientists and conservationists have come to realise that there is an immediate threat to earth's biodiversity. Invasive aliens are now recognized as the second most significant threat to biodiversity following direct habitat destruction. Most invasive plants were imported for seemingly valid reasons, such as dune stabilization, commercial forestry, horticulture, garden plants and fodder.

The indigenous forests in South Africa, at George and Knysna, were heavily exploited for timber for approximately 200 years. Only later did the government, of the time, realized that the forests were disappearing under the onslaught. There occurred a great need to conserve and effectively manage the remaining forest areas. Thus fast growing alien timber species were planted at large scale to replace the harvesting of indigenous trees. Many of these timber species are now invading the natural areas around the plantations. We are only now starting to identify the consequences of past ignorance and neglect.

Oubos-Grootriver Natuurresevaat Aandeleblok (Pty) Ltd, consists of Oubosstrand (holiday resort) and the farm called Protea. It is situated on the coast of the Eastern Cape Province of South Africa. The Tsitsikamma National Park, boarders on the study site (to the west), and conserves a considerable portion of the natural biota of the Garden Route. The primary vegetation biomes consist of Mountain Fynbos, Coastal Fynbos and Afromontane Forest.

Oubosstand is infested with *Acacia cyclops* (Rooikrans) and Protea farm is invaded by *Acacia mearnsii* (Black Wattle), *Acacia melanoxylon* (Blackwood), *Acacia cyclops* (Rooikrans), *Pinus pinaster* (Cluster Pine) and *Hakea sericea* (Silky Hakea). The integrated method (mechanical, chemical and biological) of controlling invasive alien plants is the most effective way to ensure long-term results.

Acknowledgements

It is with great pleasure that I did this project, for I dearly love the area in which it is situated. I would like to say a special thank you to Mr. Jooste, for answering panicked emails over weekends. Mr. Naudé and Mr. Voges provided me with much needed information that I could not have done without. To the DST-NRF (Centre of Invasion Biology) for the much needed funding and in particular to my supervisor, Prof. McGeoch, thank you for the nudges in the right direction.

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Table of Context

1. Introduction

In this last century invasive, alien organisms have become a major global environmental problem (Higgins & Richardson, 1996). With the human population growing rapidly, progressively more natural landscapes are altered to provide area for food production and housing. There is not a place on earth where humans have not in some way left their mark. Pristine natural environments may be a thing of the past. Only recently scientists and conservationists have come to realise that there is an immediate threat to earth's biodiversity. Invasive aliens are now recognized as the second most significant threat to biodiversity following direct habitat destruction (Dirzo & Raven, 2003). Invasive plants are defined by their ability to invade and disrupt an ecosystem. Most species occurring within an ecosystem have predators or other limitations on their growth, while invasive species tend to overrun the ecosystems they are introduced into due to the lack of these population inhibitors. We are only now starting to identify the consequences of past ignorance and neglect for biodiversity (Van der Heyden, 1998).

There are dozens of examples of plant invasiveness throughout the world. One example is *Bromus tectorum* (Drooping brome grass), which spreads rapidly after burning, and crowds out plants vital to grazing, while itself being of low nutritive value to grazing animals. In the southern United States, *Pueraria lobata* (Kudzu) was originally planted to stop roadside erosion, and now covered large areas with its leafy vines. It has been known to swallow up entire fields and forests if left unchecked. All over the world, invaders are crowding out native species and destroying ecosystems (Daehler & Gordon, 1997).

But why should we be truly concerned about invasive species? Invasive plants have an expensive price tag in terms of management and economic loss. But more importantly, invasive species have the ability to wipe out whole ecosystems, terrestrial and aquatic (Higgins & Richardson, 1996). Though much research has been done, the exact cause of invasion has yet to be pinned down. There are several possible mechanisms by which the invasive species become invasive, and more often than not, it requires a special set of circumstances for an invader to become established, and then reproduce enough to become a threat to the native habitat (Daehler & Gordon, 1997; Gurevitch & Padilla, 2004).

Most invasive plants were imported for seemingly valid reasons (Daehler & Gordon, 1997), such as dune stabilization, commercial forestry, horticulture, garden plants and fodder (Perrings, *et al*., 2005). The indigenous forests in South Africa, at George and Knysna, were heavily exploited for timber for approximately 200 years. Only after a big fire in 1869 between Swellendam in the West and Humansdorp in the East, did the government realize the needed to conserve and effectively manage the remaining forest areas (Winter, 2002). Thus fast growing timber species were planted at large scale.

The first plantations were planted in Worcester (in 1877) for firewood and for the cultivation of sleepers for the railways (Winter, 2002). In 1877, Rooikrans and Port Jackson were planted extensively on the Cape flats in order to control the shifting sand dunes. During the First World War (from 1914 to 1918), a worldwide shortage of timber existed, which led to further large scale plantations in South Africa (Winter, 2002). Plantations of primarily pines and eucalypts have been planted, replaced vast areas of South Africa's natural habitat. These plantations have brought many benefits. Plantation forestry contributes 2% to the GDP and employs over 100,000 people (Le Maitre, *et al*., 2002). Downstream industries, based on forestry, produce products that are exported which further earn valuable foreign exchange (Le Maitre, *et al*., 2002). However, these plantations have not been without cost. Many plantation species are now occurring outside the plantations and spreading further, becoming invasive in the natural ecosystems.

In South Africa invasive alien plants have become established in over 10 million hectares of land (8% of total surface area). It is also estimate that the cost of controlling them is about R600 million a year over 20 years (Le Maitre, *et al*., 2002). According to Van Wilgen *et al* (2001), the negative effects associated with alien vegetation are:

- reduced surface water runoff and groundwater reserves;
- increased biomass and fire intensity;
- destabilized catchment areas with resultant erosion and diminished water quality;
- markedly reduced biodiversity and even extinction of some species;
- seriously affected delivery of ecosystem services; and
- many economic consequences.

In 1995 the Department of Water Affairs and Forestry launched a program to spearhead the fight against invasive aliens called Working for Water. This program works in partnership with Government departments including the Departments of Environmental Affairs and Tourism, Agriculture, and Trade and Industry, Provincial Departments of agriculture, conservation and environment, research foundations, private companies and local communities, to whom it provides jobs. Working for Water currently runs over 300 projects in all nine of South Africa's provinces. The program is globally recognized as one of the most exceptional environmental conservation initiatives on the continent.

2. Study Area

The Eastern Cape

Situated in the south-eastern section of the country, the Eastern Cape is known as the Wild Coast. To the north-west the province borders on KwaZulu-Natal and meets the southern tip of the Drakensberg range; further south, mountains and hills predominate, the northern section in the dry Karoo, being flatter. The long curve of coastline, large area (at nearly 170 000 square kilometres covering 13.9% of the country) and the considerable east-west and north-south distances of the Eastern Cape provides the province with extremely varied vegetation. (Eastern Cape, 2005) The Tsitsikamma National Park on the southern border is home to dense indigenous forest.

Demographically, Port Elizabeth is the largest city and the capital is Bisho. Other important towns include the port of East London and, inland, Umtata, Uitenhage and Grahamstown. The main industrial centres are Port Elizabeth, East London and Uitenhage, the latter known for its automotive manufacturing industry. Fertile land is widespread and agriculture is extensive. Fruit, especially pineapples, form a significant crop; coffee and tea are also cultivated. Maize and sorghum are grown; cattle farming is of particular significance as a subsistence activity; sheep farming predominates in the Karoo.

Very little is known about the first humans that inhabited the Eastern Cape but Early (1 million years ago), Middle (200 000 years ago) and Last Stone Age (30 000 years ago) artifacts have been found, in the Grahamstown and around St Francis Bay, that indicate that they where hunter gatherers. Around the last 2000 years of the Last Stone Age, profound changes occurred and the first herders made their appearance (Hall, 1988). At first the two groups lived in the same area but as competition for land increased the hunter gatherers were displaced and eventually disappeared from the region. Later history called the herders, Hottentots and the hunter gatherers where identified as Bushmen. Around 600 A.D. a third cultural group, the Negroid (Bantu speaking) migrated from across the Limpopo to the Eastern Cape. These people possessed domestic stock, grew crops, smelted iron and lived in settled villages and also exploited the sea shore. They, in part form the forerunners of the Xhosa and caused the first large scale disturbances in the landscape (Hall, 1988).

In an attempt to open the sea route to India, Bartholomew Dias was the first European to sail around the tip of Africa (August, 1487) (Gess & Bell-Cross, 1988). Vasco da Gama successfully finished this journey and the trade route was opened. Between 1500 and 1510 one hundred and thirty-eight ships set sail from Portugal for India, all had to round Africa. A succession of wrecks during this time prompted King Manuel to authorize a detailed survey of the Southern Africa coast. Mesquita Perestrêlo explored the eastern coast line and added a name to the area that survives to this day, that of, St Francis Bay (Gess & Bell-Cross, 1988).

The Portuguese had discovered the Eastern Cape coast (1487-1576) but had little impact upon it. European occupation of the area came, overland from the Western Cape as the "Dutch" spread eastwards from the initial settlement, Table Bay, which was established as a refreshment station in 1652 (Hummel, 1988). The coastal ports of the Eastern Cape were finally developed by the "Dutch" and later more intensively settled by the British rule during the Napoleonic wars (Gess & Bell-Cross, 1988). The Eastern Cape was considered a frontier, where the Cape Colony settlers fought nine frontier wars against the Xhosa nation. These wars were fought intermittently from 1779 to 1879.

Vegetation

The Eastern Cape coast is a transition region where a great complexity of floras and vegetation types converge (Figure 1) because of the transitional nature of the climate, geology and geomorphology (Cowling, 1984; Lubke & Wijk, 1988).

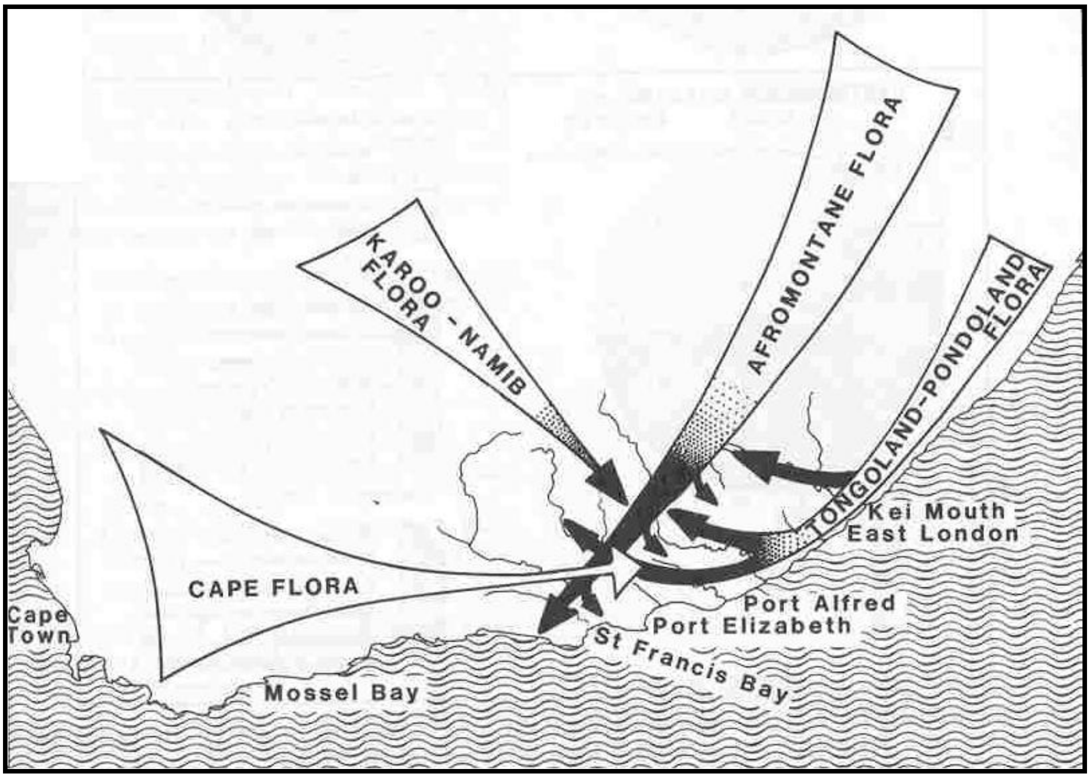

Figure 1. The Convergence of the four major floristic regions in the Eastern Cape (recreated from Lubke & Wijk, (1988))

The Tsitsikamma National Park, which boarders on the study site, conserves a considerable portion of the natural biota of the Garden Route. The primary vegetation biomes consist of Mountain Fynbos, Coastal Fynbos and Afromontane Forest (Cowling, 1984).

Mountain Fynbos is the most widespread vegetation type in the Fynbos Biome, it occurs mainly along the Cape Fold Belt from north of Nieuwoudtville to Cape Town and Cape Agulhas and to near Port Elizabeth. In terms of floristic and structure, Mountain Fynbos has not been rigorously defined. Mountain Fynbos is merely Fynbos on the mountains of the Fynbos Biome (Bredenkamp, *et al.* 1996).

The afromontane vegetation is dominant in the Eastern Cape and KwaZulu-Natal. Afromontane Forests are greatest in stature in the Knysna region. Trees can be up to 30 m or 40 m tall and distinct strata of emergent trees, canopy trees and shrub and herb layers are present (Bredenkamp, *et al.* 1996). Afromontane Forest is well conserved in a number of areas, and many stands are safe from exploitation by their isolation in remote areas.

Plantations of pine threaten the water supply to the indigenous forests in many regions (Cowling, 1984).

Climate

Variations in temperature, rainfall and windiness occur across very short distance in the Eastern Cape. Altitude, mountain orientation and distance from the Indian Ocean are important variables acting on the broad scale. Data for rain, temperature, wind and sunshine are available from several places within the region (Everard, 1987). The Port Elizabeth weather station is the closest to the study area, approximately 180km to the east. Port Elizabeth experiences a maximum winter rainfall; due to its westerly position (where the summer and winter rainfall areas meet) it catches the tail end of the weather fronts that brings winter rain to the Western Cape (Stone, 1988). The study area (Oubosstrand and Protea farm) experiences all year rainfall given that it is located along the coast (Figure 2). The hot temperatures that occur in January and February may be as a result of berg winds (Stone, 1988). Berg winds are hot dry winds which blow seaward from the interior. They can cause temperatures to rise by 10ºC in the space of half an hour. Berg winds occur because of high pressure in the interior and low pressures off shore. Air moving from inland to fill the low pressure moves over the escarpment and descends towards the coast (Stone, 1988). This is often experienced at coastal resorts.

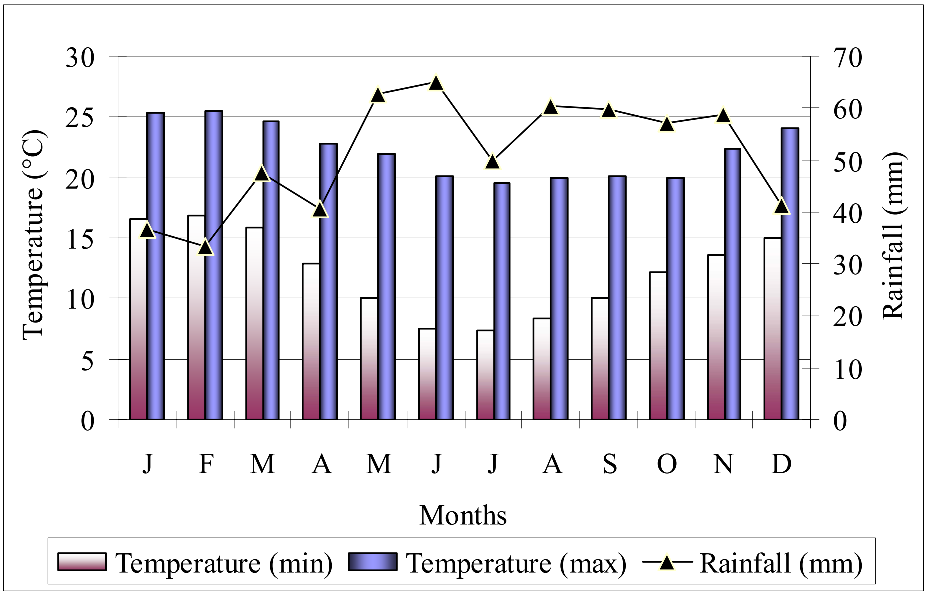

Figure 2. Average monthly values from 1960 to 1980 for Port Elizabeth (recreated from Stone, 1988).

Geology and Geomorphology

The break-up of Gondwanaland which occurred towards the end of the Karoo period in Jurassic time (between approximately 180 and 130 million years ago), caused faulting, uplift and volcanic outpourings and resulted in intrusion of dykes and sills of dolerite. The gross outline of the present Eastern Cape coast was formed at that time (Maker, 1988; Lubke et al., 1986). On land the main process has been that of river erosion. Before the up lift, the rivers meandered across level plains. The up lift caused these rivers to cut down while retaining their meandering pattern. The greater steepness of some valleys results from local differences in rock hardness and weak zones (Plummer, 2000). The fluctuating sea level increased the eroding power of these rivers, allowing them to cut more deeply into the bedrock (Maker, 1988).

With the lower levels of the sea, calcareous sands blew onshore from the exposed floor and were deposited against any uneven ground. These dunes have been hardened by lime cementation to form aeolianite ridges. One of these ridges can be seen on the beach of the holiday resort Eersterivier, next to Oubosstrand. Table Mountain quartzite forms the bedrock of the Tsitsikamma coast line (Plummer, 2000). White quartzite, shales and sandstone can clearly be seen in the rocks that line the coast. Wave action has also had a profound effect on the coastline. Against cliffs or solid rock the water acts hydraulically. There is great evidence of this along the coast in the form of caves and arches (Plummer, 2000).

Oubosstrand and Protea farm

The holiday resort, known as Oubos-Grootriver Natuur resevaat Aandeleblok (Pty) Ltd (Registration number: 60/00245/07), consists of Oubosstrand and the farm called Protea, situated on the coast of the Eastern Cape Province of South Africa (Figure 3). Traditionally the southern Cape coast, from Mosselbay to Port Elizabeth, is known as the Garden Route. Most of the coastal holiday resorts in this area, which have only a few permanent residents, are geographically linked and is served by the larger inland farming town of Humansdorp along the N2 highway.

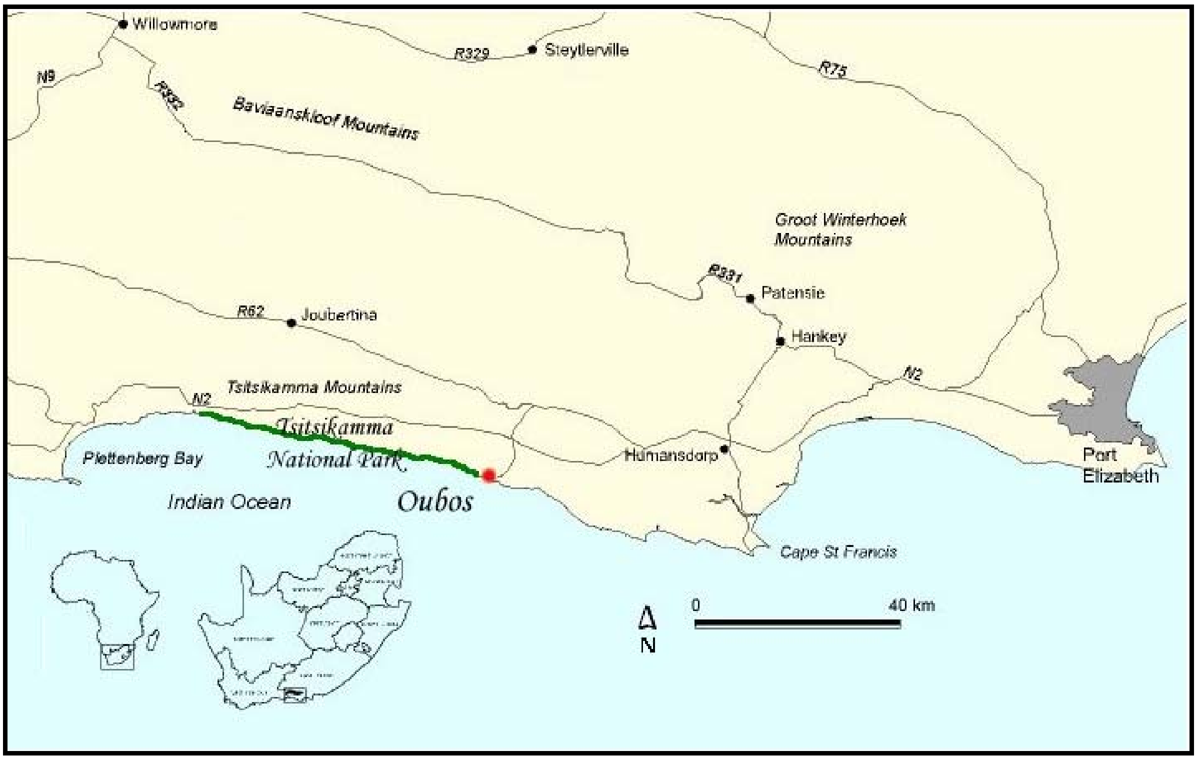

Figure 3. Map of where Oubosstrand and Protea farm are located.

Oubosstrand borders on the Tsitsikamma National Reserve with the Grootriver mouth acting as the boundary. Elevation rises steeply from sea level (about ± 250 meters) until it reaches a plateau (about 125 m a.s.l.) from where the landscape rises gradually in gentle flowing hills (increasing from ± 190 m a.s.l.) inland to the Tsitsikamma Mountains.

Oubosstrand (50.5 ha; Property No. 759) has 39 houses on the property (50 properties ≈ 50 share blocks), that lie between 10 - 25 m a.s.l. A tennis court and a hall are used communally by the holiday makers. One gate grants access to the property, which is strictly controlled; a paved road runs the length of the property (Figure 4). The holiday resort's refuse heap is located near the gate between the road and the sea. The garbage is placed between two sparsely vegetated sand dunes, where it is buried or burned. There is a dam in the catchment area and several reservoirs where water is stored. Holidaymakers utilize the water for household purposes. Water restrictions are often put in place during dry years.

Figure 4. An aerial photograph of Oubosstrand.

Families have been enjoying Oubosstrand during the holidays from before 1957 when fishing cottages were rented from the owner of the Eersteriver farm (Gerber family). Oubosstrand was registered (in 1960) as a Private Share block company by Toby Lochner, Gert van Vollenhoven, Albertus Delport, Hannes Gerber and Philip de Jager (Figure 5). They served as the first board of directors of the Oubosstrand Private Shareblock (PTY) Limited. Name changed in 2005 to Oubos-Grootriver Natuurreservaat Aandeleblok (Pty) Ltd.

Figure 5. Toob Lochner, Gert van Vollenhoven, Albertus Delport, Hannes Gerber, Philip de Jager. The first board of directors of Oubosstrand.

Holiday-makers frequent Oubosstrand in large number during the summer school holidays (December and January), and fewer people during the winter holidays (June and July). Oubosstrand has only one house permanently occupied throughout the year, that of Daphne and Graeme Roberts. They have an established garden which they tend to. Other residents have attempted to cultivate gardens but only the hardiest plants have survived due to the resident's long absences (3 to 9 months absence). The vegetation is mainly coastal shrubs, with natural forest occurring where the elevation is less steep and water flows down from the plateau. A small hiking trail has been cut through the mostly impenetrable vegetation (±45 m a. s. l.).

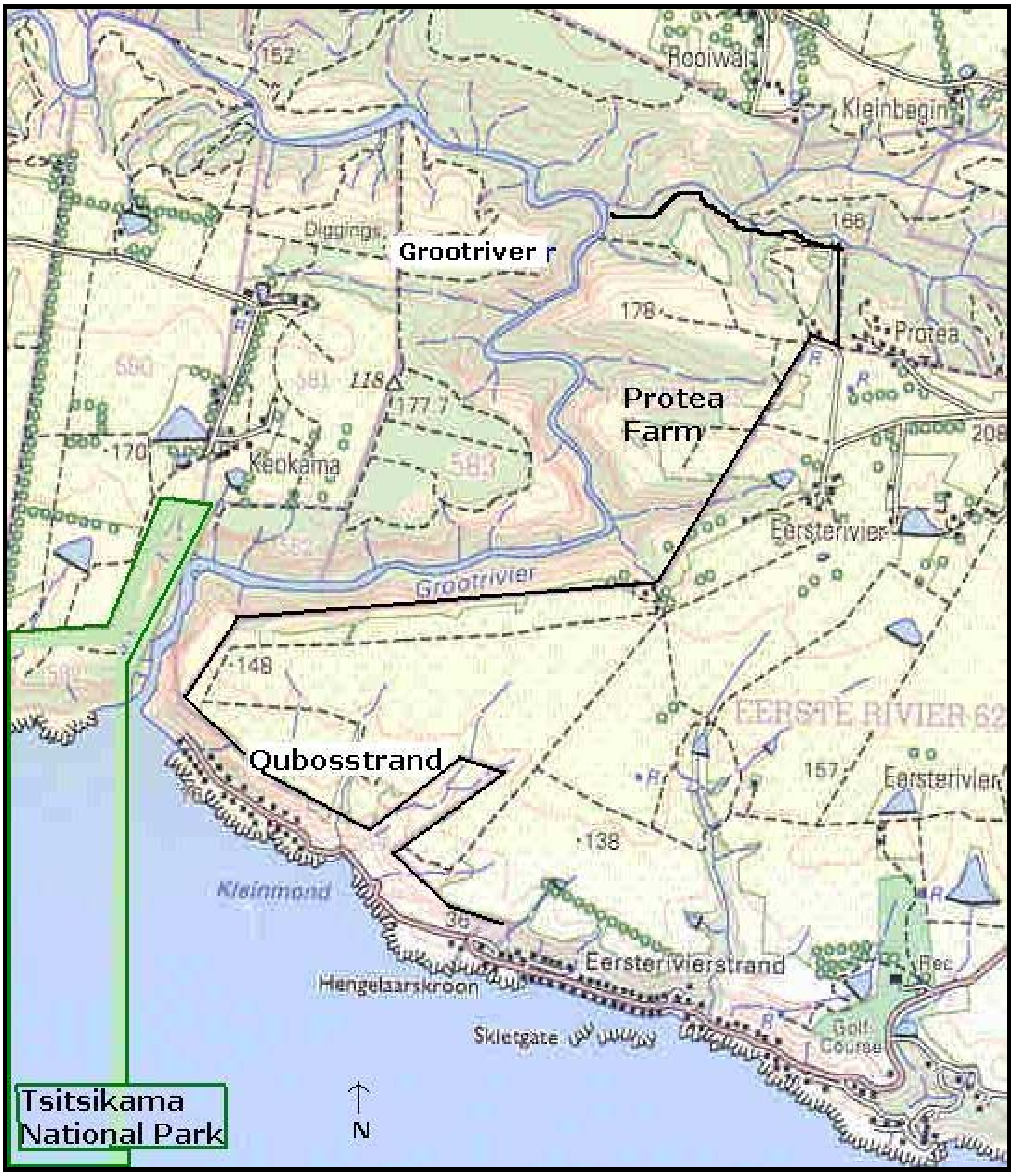

Figure 6. Modified map, 3424AA, Oubosrand (2000). Scale: 1:50 000

Protea farm (238 ha; Property no. 625) is located inland on the plateau with the Grootriver gorge with steep cliffs as a border on the north-west side. A tributary of the Grootriver borders the property on the northern side (Figure 6). The farm has little agricultural value and has been severely neglected by the previous owner. There is very little infrastructure on the farm; it has a borehole, a house and some sheds. The farm is not effectively fenced and has inadequate roads. Eersterivierkruis, an informal settlement, borders on the east side of the property. Some of the fields (on the north-east side) are used by the informal settlement, to graze their livestock (cows). The other fields and the borehole, in the middle of the property, are currently rented by the neighboring farmer, as grazing for his livestock (cows).

There is very little of natural vegetation left on the plateau. Remnants of natural forest remain along the Grootriver gorge where it is not too steep (Figure 7). Although the area is heavily infested with alien invasive plants, the owners have embarked on an intensive plan to eradicate all alien plants. Residents of the holiday resort, Oubosstrand has over the years complied a species lists of vegetation and birds (Appendix A).

Figure 7. The view standing at the edge of the Grootriver gorge, looking north.

3. Invasive Alien Plants

Legislation

South Africa has comprehensive legislation that governs alien plants. Section 29 of the Conservation of Agricultural Resources Act (Act No. 43 of 1983) provides the regulations that apply to the propagation, control and eradication of invasive alien vegetation. Various changes have been made to the act (March 2001). These changes were necessary due to the accelerated deterioration of the country's natural resources (mainly water) due to invasion by alien invasive plants, as well as heightened public awareness with regards to environmental matters (Klein, 2002a). The amendments reclassified problems plants into four groups. The first three groups consist of undesirable alien plants. Category 1 plants are declared weeds (122 species), category 2 and 3 are identified plant invaders (76 species). The forth category deals with bush encroachment. Sound management practices are needed to prevent these indigenous plants from becoming problematic (Klein, 2002a).

Category 1 plants are prohibited plants that will no longer be tolerated on land or on water surfaces, neither in rural nor urban areas. These plant species where included in the list because their harmfulness outweighs any useful properties they might have (Klein, 2002b). Category 2 plants have the potential of becoming invasive, but which nevertheless have certain beneficial properties that warrant their continued presence in certain circumstances. Category 2 plant species may only occur in special demarcated areas, when they appear outside these areas they have to be controlled. The plants in the demarcated area have to serve a commercial or utility purpose, such as a woodlot, shelter belt, building material, animal fodder, soil stabilization and medicinal or personal consumption (Klein, 2002b). Category 3 plants are undesirable because they have the proven potential of becoming invasive, but most of them are nevertheless popular ornamental or shade trees that will take a lone time to replace.

What is the most 'pervasive invader' in South Africa at present? According to Versveld *et al.* (1998) *Acacia mearnsii* is ranked as the number one invader in the country, but infestation various with regional differences. The most important species in terms of total area invaded is *Melia azedarach* and pines (*Pinus pinaster* and *P. patula*). *Acacia cyclops* is first, in terms of condensed area infested, with *Acacia mearnsii* ranking third. 3.37 % of the Eastern Cape (16

986 940 ha) is estimated to be invaded with *Acacia* mixed species (Table 1). This estimation is conservative because it excludes plantations, but not the invaded areas surrounding the plantations areas (Versveld *et al.,* 1998).

Table 1. The most important invader species in the Eastern Cape Province based on condensed invaded area.

Species	Total invaded area (ha)	Density (%)
Acacia mearnsii	344 535	14.23
Acacia melanoxylon	22 151	4.35
Acacia dealbata	65 730	28.72
Acacia saligna	202 952	6.31
Acacia cyclops	212 790	4.05
Acacia longifolia	73 212	9.77
Acacia mixed species	36 640	55.62
Hakea sericea	14 760	13.06
Pinus pinaster	295 346	2.47
Pinus sp.	14 112	9.33
Lantana camera	2 297	50.32
Eucalyptus species	163 121	5.83

recreated from Versveld *et al.*(1998)

Invasive alien plants occurring in study area

The invasive alien plants found at Oubosstrand and Protea farm are: *Acacia cyclops, A. mearnsii, A. melanoxylon, Hakea sericea* and *Pinus pinaster.*

Pinus pinaster Aiton. originated in the Mediterranean basin (common name: Cluster pine) (Figure 8) (Marais, 1998). It is an evergreen coniferous tree, growing 20-35m tall, with 2 needle-shaped leaves per fascicle (leaves usually 15-20 cm long and stiff) (ISSG, 2005; Palgrave, 1981). Its cones are 10-22cm long. Pinus pinaster is well adapted to fire and have relatively small seeds with low seed/wind loading. Pinus *pinaster* has a short juvenile period (ISSG, 2005; Marais, 1998). They can survive in nutrient poor environments and have no natural enemies in South Africa. It is classified as a category 2 invasive alien plant (Klein, 2002b). It was introduced into South Africa for timber production in the 1680's (ISSG, 2005).

All the invasive *Acacia* spp. are from Australia. They release their seeds after fire and have a very short juvenile period. *Acacia* species are well adapted to fire and nutrient poor environments (ISSG, 2005; Richardson, 1998). They thrive after disturbances, such as fire, because it is then able to out compete the natural vegetation. All the *Acacia* species are classified as category 2 invasive alien plants (Marais, 1998).

Figure 8. *Pinus pinaster*

Figure 9. *Acacia mearnsii*

Acacia mearnsii De Wild. (common name: Black wattle) was introduced into botanical gardens in South Africa in 1858. It is grown commercial for its timber and tannin value (Figure 9) (Marais, 1998). Later it was saught for its pulp value, as well as charcoal wood. Many communities in the rural areas of South Africa use the wood for fire wood. It occurs mainly in water rich area (catchments, riverbanks, etc.). It is a fast growing leguminous (nitrogen fixing), unarmed, evergreen tree of 6 – 20 m high (ISSG, 2005; Palgrave, 1981). The branchlets are shallowly ridged and covered with fine hair (Marais, 1998; Palgrave, 1981). There are raised glands occurring at and between the junctions of pinnae pairs. The leaves are dark olive-green and the leaflets are short (1.5 – 4 mm) and crowded (ISSG, 2005). The flowers are pale yellow or cream globular flower heads. Black wattle fruits are dark brown pods and finely hairy (Palgrave, 1981). Black wattle seeds are dispersed by birds, mammals and water (Marais, 1998). The seeds are stored in soil and have a long life time (up to 50 years). Its generation time is 5 years (before it reproduces). It is classified as a category 2 invasive alien plant (Klein, 2002b).

Acacia cyclops A. Cunn. ex G. Don was introduced in 1857 in botanical gardens (common name: Rooikrans) (Figure 10) (Marais, 1998). This was done to explore its timber and sand stabilization properties. It is widely used as fire wood in the Western Cape. Rooikrans is a large shrub or tree 3 to 5 m in height, with phyllodes leaves (Palgrave, 1981). An untidy coiled cluster of pods is characteristic of this species. It has juvenile period of 2 years. The seeds are sorted in the soil, forming large seed banks, and dispersed by birds and mammals (Marais, 1998). South Africa legislation classifies rooikrans as a category 2 invasive alien plant (Klein, 2002b).

Acacia melanoxylon R. Br. was introduced in 1848 into South Africa (common name: Blackwood) (Figure 11) (Marais, 1998). The timber is used for making furniture and is highly saught after. It has a wide ecological tolerance, occurring over an extensive range of soils and climatic conditions, but develops better in colder climates. Blackwood is an unarmed, evergreen tree of 8 -15 (sometimes up to 45) m high (ISSG, 2005; Palgrave, 1981). The trunk is straight with a dense crown that is pyramidal to cylindrical with heavy spreading branches. Seedlings have bipinnate (feathery) leaves and the coppice shoots turn into phyllodes (ISSG, 2005). They grow to be between 7 – 10 cm long, greyish turning dark dull-green. Blackwood flowers are pale yellow and globular (Palgrave, 1981). The fruits are reddish-brown, narrower than the leaves, twisted pods. They are dispersed by birds and mammals (Marais, 1998). The seeds can be stored in the soil for long periods. The plant starts producing long lived seeds after 5 years. They live to be 15 – 50 years (ISSG, 2005). In South Africa it invades forest edges or gaps, wooded kloofs, grassland and watercourses. It replaces native non-tree vegetation, such as grassland and scrubland, and transforms such habitats. It is classified as a category 2 invasive alien plant (Klein, 2002b).

Figure 10. *Acacia cyclops*

Figure 11. *Acacia melanoxylon*

Hakea sericea Schrad. & J. C. Wendl. is a major problem in South Africa (common name: Silky hakea) (Figure 12). It is classified as a category 1 invasive alien plant (Klein, 2002b). It was introduced in 1858 for its potential as a hedge but instead spread rapidly and is now threatening various biomes across South Africa (Marais, 1998). It produces vast amounts of long lived seeds (up to 70 seeds per 100 cm^2) which are dispersed by the wind. The stiff leaves are very sharp and fine, 2-6mm long, 1mm wide, with fine hairs when young. The pale flowers, usually white, can be found clustered in the leaf-joints. The juvenile period is short (1-2 years). They are well adapted to fire and nutrient poor environments.

Figure 12. *Hakea sericea*

4. Material and Methods

Materials used in the study:

1. GPS II PLUS Garmin
2. [1]Maps:
   - 3323DC & 3423BA Nature's Valley (1998). Scale: 1:50 000
   - 3424AA Oubosrand (2000). Scale: 1:50 000

   (Gauss Conform Projection, Central Meridian 23º East. Clarke 1880 Spheroid. Contour interval 20 meters)
3. Orthophoto Map Series (1980):
   - 3424 AA 10 Eersterivierstrand. Scale: 1:10 000
   - 3424 AA 9 Capri. Scale: 1:10 000

   (Contour interval 5 meters Gauss Conform Projection, Central Meridian 25º East)
4. Air photo: No: 0482, Job 1076 Steytlerville, Strip 015. Scale: 1:50 000. Date: 10/12/2003

[1] All maps and air photos are available from: Chief Directorate Surveys and Mapping, Van Der Sterr Building, Rhodes Avenue, Mowbray, Cape Town. Tel: (021) 658 4300

5. Camera and reference books.
6. Measuring tape with which to measure the circumference of the trees.
7. All calculations were done in Microsoft Excel 2003.

Airial photos and maps were studied to familiarise myself with the area. Interviews were conducted with two farmers in the area (Ross Naude and Willie Gerber). Permission was granted to access their property. Any knowledge of the fauna and flora of the area and possible dangers (steep cliffs, aggressive livestock and/or wild animals, etc) that they mentioned were noted. To inform the shareholders (holidaymakers) of the study, a newsletter was distributed during the December holidays 2004 (Appendix B). At which time the annual shareholder meeting took place and permission was granted to initiate the study.

First, a pilot walk was done (a day for both Oubosstrand and Protea farm), to identify the dominante invasive tree species and the layout of the study area. When a tree species was not immediately recognized, a photo was taken and later identified with the help of reference books (Bromilow, 2001; Palgrave, 1981; Stirton, 1978).

The point-center quarter method was used to collect data. It is a time saving way with which to estimate the relative importance of various tree species in a community. In this study, the method was used to determine the infestation of alien invasive tree species in Oubosstrand and Protea farm. Factors that influence the importance of a species in a community is the number of trees of that species (density), the size of the trees (larger size will have more importance) and the distribution if that species within the community (Cottam & Curtis, 1956).

Transects of various lengths were walked. Every 50 steps (30 meters) a sample was taken. The reason samples where taken so far apart was to ensure that the same trees where not measured twice. At the sampling point an imaginary perpendicular line is drawn to the transect. This line and the transect, divide the area into four quarters (Figure 13). One quarter is then selected. In that quarter the nearest invasive tree species is located (sampling point I). The tree species and the circumference, at breast height, is measured and noted. This process was repeated in each quarter (II, III and IV), every 30 m along the transect. GPS readings where taken at random sampling points.

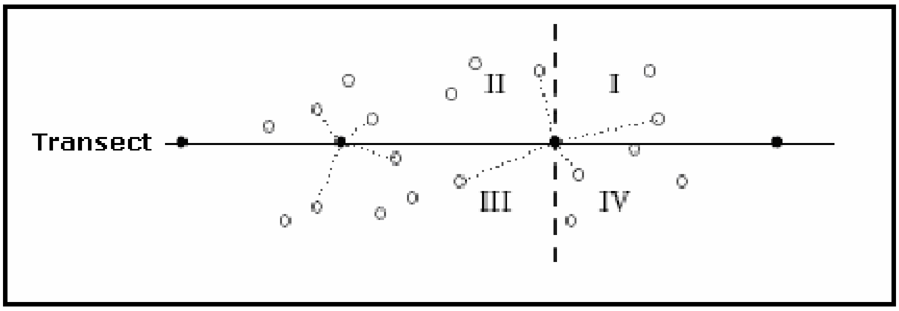

Figure 13. Diagram of the point-center quarter method.

Sampling was done over the June-July university holiday (2005). Oubosstrand was sampled first. A single transect (A; 25 sampling points ≈ 750 m) was walked in the area. The hiking trail was used as the transect line, because the vegetation is impenetrable for most of the area. Four transect lines were walked on Protea farm, transect E (34 sampling points ≈ 1020 m) was first followed by D (11 sampling points ≈ 330 m), C (33 sampling points ≈ 990 m) and finally transect B (42 sampling points ≈ 1260 m) (Figure 14). The transects were used to divide the study area into 5 management blocks (A – E). Block A is representative of Oubosstrand and Blocks B to E, representative of Protea farm. The blocks area's was determined from a digitalized air photo and the use of the program ArcView.

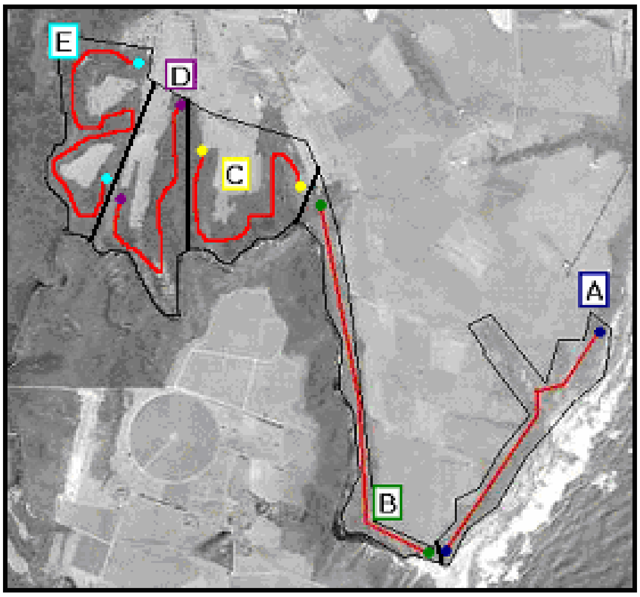

Figure 14. Transect lines walked on the study site. A-E indicating management blocks and transects.

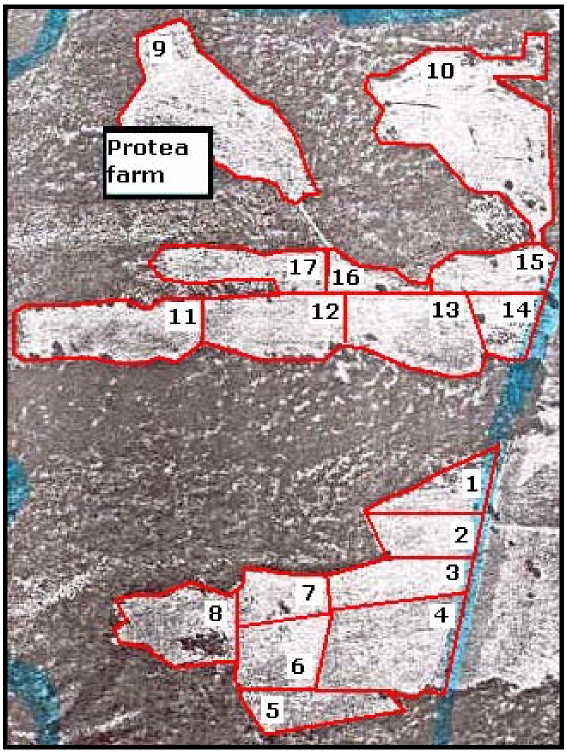

Figure 15. Referenced (1 -17) fields on Protea farm.

The fields on Protea farm were excluded from the transect walks and visually assessed. The fields were placed into categories according to the circumference of the invasive tree species occurring on the specific field. All the fields are allocated reference numbers, as Figure 15 indicates. They where furthermore visually placed in to density classes. Visual density assessments ranged from high to absent (Figure 16 - 18).

Figure 16. An example where there are no invasive alien plants (absent, field 4).

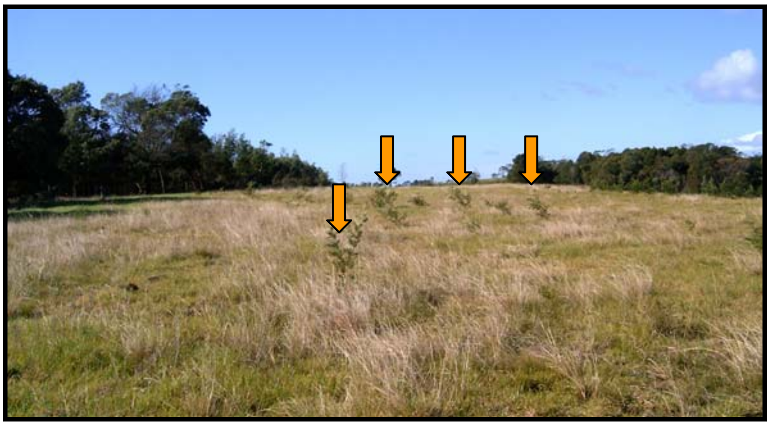

Figure 17. Field 11 is an example of the category, light density (arrows indicating invasive plants).

Figure 18. This is an example of high density (field 10).

The data was modified into size class, age class (seedling, young and adult and density class. This was done according to Le Maitre & Versveld (1994) principles found in Marias (1998). An extract can be found in the Appendix C. The cost was calculated (pers.comm., Voges, 2005[2]) with Working for Water's estimation of clearing effort, in terms of the number of person days it takes to treat one hectare with a specific method (i.e. frill, ring barking, herbicide, etc.), in the Eastern Cape. This effort is determined by what invasive species occur in the area and in what size, age and density class they fall.

Break down of general cost calculations for one clearing method and one density/size class:

Persondays per density/size class/clearing method = **[X]**

- If the terrain is steep:
  [X[3]] + [20% of X] = [Y]
- Invader species that do not require herbicide treatment (*Pinus* and *Hakea*):
  [X] - [20% of X] = [Y]
- Invader species that do require herbicide treatment (composite of rural wages, protective clothing, basic equipment and transportation within a 25 km radius):
  [Y] x [R15] = [TP15].
- Removal methods with simple handheld tools (bow saw and slasher):
  [TP15] + [Y x R95] = COST.
- Removal methods with chainsaw:
  [TP15] + [Y x R110] = COST.

COST can vary greatly as transport cost, labour cost and management costs, etc. can have a huge influence.

Yet

5. Results

Fields

Table 2 indicates the hectares of the different management blocks, as well as the hectares of the fields that occur in them.

[2] Mr. K Voges was a former Working for Water (WfW) project leader in the Tsitsikamma area and is now based in Sedgefield.

[3] WfW estimation of clearing effort, in terms of the number of person days it takes to treat one hectare with a specific method.

Table 2. Management blocks and field areas (ha).

Management block	Total area	Field numbers	Area of fields
Block A	50.5	-	-
Block B	54.3	-	-
Block C	60.1	1 - 8	24.2
Block D	68.3	11 - 17	20.8
Block E	55.5	9 -10	13.93
Total[4]	288.7		58.93

Table 3 illustrates what the density of invasive species are on each field as well as indicating their general circumference. Fields 3, 4 and 6 have no invasive alien species on them and is used for grazing.

Table 3. Circumference and density information for the individual fields.

Circumference	Field	Density	Field
41 - 50 cm	10	High	1, 10
31 - 40 cm	1, 9	Medium to high	2
21 - 30 cm	16	Medium	9, 15, 16
11 - 20 cm	2, 5, 14, 15, 17	Light to medium	5, 8, 11, 12, 14
1 – 10 cm	7, 8, 11, 12, 13	Light	7, 11, 13, 17
Absent	3, 4, 6,	Absent	3, 4, 6

The mean distance as indicated in Table 4, reveals approximately how far the trees are from each other (nearest neighbor). Block D is densely populated and Block A's population of invasive trees are spread out over the area. The high s.d. (standard deviation) further indicates that there is great variation with regards to the distance to the nearest neighbor. The total density for all invasive species is quite low (pers.comm., Voges, 2005).

Table 4. Summary of the mean distance and total density of the management blocks

Management Block	Mean distance (m)	s.d.	Total density (trees/ha)
Block A	8.46	5.47	139.87
Block B	2.64	2.18	1440.12
Block C	3.04	2.33	1078.79
Block D	1.69	0.94	3499.31
Block E	2.56	2.25	1526.05

[4] All calculations: total hectare (of the block) - field hectare.

Block A - Oubosstrand

Acacia cyclops is the only woody invasive sampled in this management block. The mean basal area of the invaders is: 0.000033 ± 0.000045 m^2. The high standard deviation of the basal area indicates that population is comprised of individuals of various sizes. Le Maitre & Versveld (1994) classifies *A. cyclops* as a Medium Tree (Appendix C).

Block B

Acacia cyclops and *Pinus pinaster* is the most abundant invasive alien species occurring in management block. *A. melanoxylon*, *A. mearnsii* and *Hakea sericea* is quite spars (Figure 19). The relative density indicates in what ratio (%) the invasive species occur.

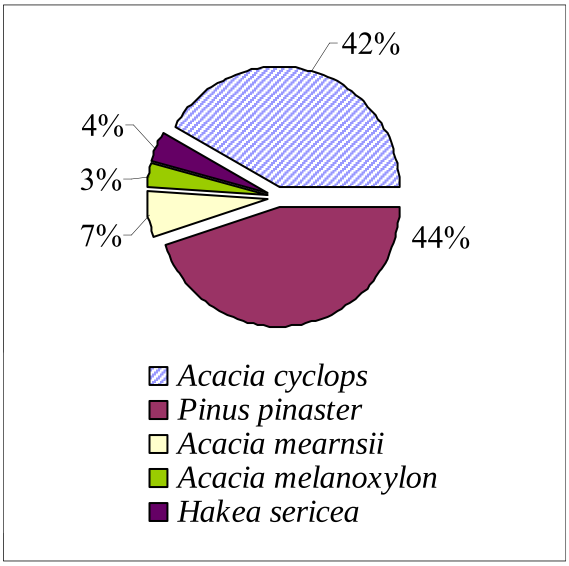

Figure 19. The relative density of each species in Block B.

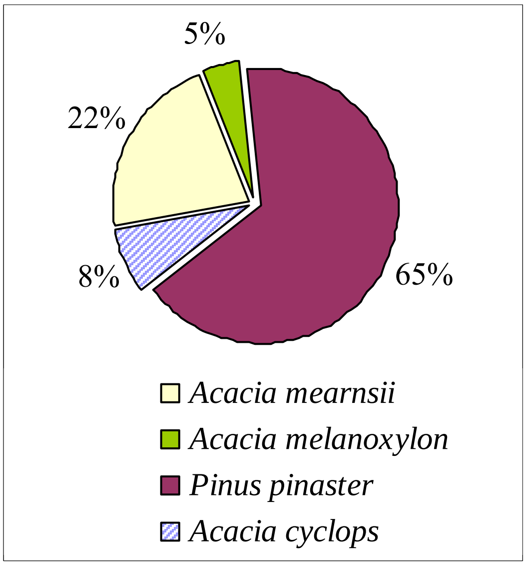

Figure 20. The relative density of each species in Block C.

Block C

Pinus pinaster is the most abundant invasive alien species occurring in management block. *A. melanoxylon*, *A. mearnsii* and *A. cyclops* are also present but to a lesser degree. All these trees are classified as Tall Trees (Appendix C).

Block D

72 % of the invasive aliens occurring in block D are *Pinus pinaster* with *A. mearnsii* making up the last 28 % (Figure 20). *Pinus pinaster* has a mean basal area of 0.09 m^2 and a mean

stem diameter of 0.02 m. According to Le Maitre & Versveld (1994) the age class of the pines is Young (Appendix C).

Block E

Block E is dominated by *A. mearnsii* which is expected due to the fact that the area is surrounded by rivers on two sides (Figure 21). The *Pinus* and the *A. mearnsii* are about the same size and are classified as Young trees (Appendix C)

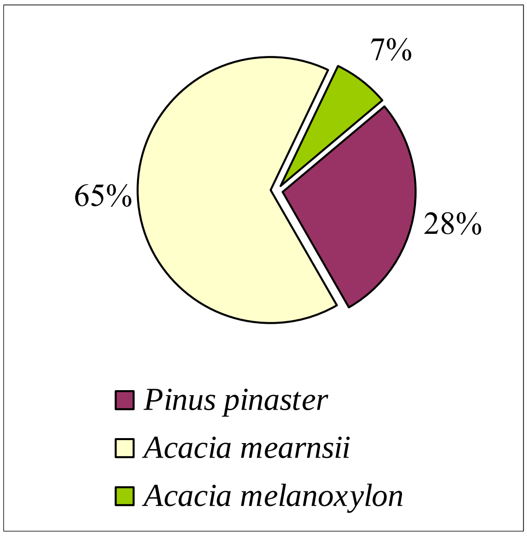

Figure 21. The relative density of each species that occurs in Block E.

Table 5. Mean basal area of trees occurring in management blocks

Management Block	Basal area/tree (m^2)	s.d.
Block A	0.00003	0.00005
Block B	0.00095	0.00051
Block C	0.00221	0.00115
Block D	0.06471	0.00191
Block E	0.00479	0.00222

Table 5 indicates the mean basal area of all the trees (*A. mearnsii, A. melanoxylon, A. cyclops, Hakea sericea* and *Pinus pinaster*), occurring in the different management blocks. Block D has over all the largest trees occurring in it, and Block A the smallest. The high s.d. (standard deviation) indicates that there is great variation between the sizes of the different trees.

6. Managing for Invasive Species

Introduction

The current principle is to clear light infestations first because they pose the biggest threat in terms of invasive potential, yet are the least expensive to control and require no post-clearing restoration actions (Van der Heyden, 1998). Once all the outliers and light infestations have been cleared, dense stands of recent origin should be targeted for clearing as well. The oldest dense stands should cleared last. Factors such as prevailing wind direction following clearing will determine the direction of alien seed dispersal, but accessibility to the site may be the over-riding factor in practice (Van der Heyden, 1998).

The quoted costs for alien plant control can vary wildly. This is to be expected due to the differences in the nature of the problem, accessibility, labor costs, management style, methods used, and accounting methods. As Winter (2002) states in her management plan for the Groenlandberg Conservancy, there are three are three options available to a private landowner:

1) Control of the invasive plant by the landowner at her/his own expense.
2) Making use of an experienced contractor.
3) Working in co-operation with Working for Water (on a shared cost basis).

Private landowners can request assistance from Working for Water by applying for an application for clearing assistance. Applications are evaluated on the basis of clearing and rehabilitation priorities for the programme. Catchment areas are usually high on the priority list. Before the work is started a contract is drawn up between the landowner and the Department of Water Affairs and Forestry (DWAF). Landowners must be patient and keep in mind that South Africa has an immense invasive plant problem and there is currently a lack of suitably trained independent contractors to carry out the work. When signing a contact with WfW, landowners must accept shared responsibility of the clearing costs, either on a 50:50 or 30:70 bases. Once the land is cleared to the satisfaction of both parties, the landowners must sign a commitment which will hold them responsible for maintaining the cleared land, after the initial clearing is completed (Klein, 2002b; Van der Heyden, 1998; Winter, 2002)

Any control programme for alien vegetation must include the following 3 phases (Van der Heyden, 1998):

- Initial control: drastic reduction of existing population.
- Follow-up control: control of seedlings, root suckers and coppice growth.
- Maintenance control: sustain low alien plant numbers with annual control.

If the landowner decides to control the invasive plants themselves, which is highly recommended by Winter (2002), due to the shortage of personnel. There are essentially three methods available to the landowner for the clearing of alien vegetation (Marais, 1998; Winter, 2002).

Control methods

Biological control[5] is the use of host-specific natural enemies (e.g. insects, micro-organisms and diseases) from the alien plant's country of origin to reduce the invasiveness of the specific plant. Indigenous fungi (South Africa) have also been found to be effective when applied directly to the stump. This methods is fairly controversial, particularly where commercial forestry species are concerned (Samways, 2005). The disadvantage to this method is that the natural predator could also become invasive if it was not properly researched before release. It is most likely that it is the only solution that will be both alien-effective and cost-effective in the long run (Winter, 2002).

Chemical Methods (Working for Water, 2004) include herbicides and poisons that can be applied to prevent sprouting of cut stumps, or kill seedlings after felling or burning. The use of herbicides must be restricted to situations where there is no other practical alternative, due to the potential negative environmental impacts. The use of chemical control is regulated by legislation and a relatively high level of training is needed to applying it safely (Winter, 2002). The label on the herbicide provides the user with the information that is needed to use the poison effectively and safely. Care must be taken when selecting an herbicide. The cheapest product might not necessarily be the best suited or the most effective. For more detailed information contact the herbicide manufactures about their product (Appendix D and E).

Mechanical Methods (Working for Water, 2004 & 2005) include physical felling and uprooting of plants, their removal from the site, often in combination with burning. It is a labor-intensive and thus expensive to use in dense infestations or in remote areas. Trees can be felled and removed using chainsaws, bow saws, brush cutters or cane knives. Where trees cannot be removed, due to steep slopes, do not attempt to fell the trees. The following options are available:

- *Basal bark:* Application of suitable herbicide in diesel can be carried out to the bottom 250mm of the stem. Applications should be by means of a low pressure, coarse droplet spray from a narrow angle solid cone nozzle.
- *Hand pull*: Grip the young plant low down and pull out by hand (using gloves).

[5]For more information on biological control: Plant Protection Research Institute: http://www.arc.agric.za/institutes/ppri/main/home.htm

- *Ring barking*: Bark must be removed from the bottom of the stem to a height of 0.75-1.0 m. All bark must be removed to below ground level for good results. Where clean de-barking is not possible due to crevices in the stem or where exposed roots are present, a combination of bark removal and basal stem treatments should be carried out. Bush knives or hatchets should be used for debarking.
- *Frill:* Using an axe or bush knife. Make angled cuts downward into the cambium layer through the bark in a ring. Ensure to affect the cuts around the entire stem and apply herbicide into the cuts (Figure 22).

Figure 22. The Frilling Method (recreated from Working for Water (2005))

Integrated approach is most effective way to remove and control invaders. This approach involves using a combination of at least 2 of the primary elements of control – mechanical and chemical and biological (Winter, 2002).

Use of fire can not be excluded from the control operations. Many natural species that persist in the seedbank of alien infested areas require fire to stimulate germination. It is very important to know which invasive plants seeds are stimulated to germinate by fire, and which are not. Burning will make the follow-up control measures easier.

The selection of appropriate method of control is based on the following criteria (Working for Water, 2004):

- Species to be controlled:

Acacia mearnsii, Acacia melanoxylon, Acacia cyclops, Pinus pinaster and *Hakea sericea*.

- Size of the target plants: seedlings, young trees, adult trees.

- Density of stand: an overall application can be made to dense stands of seedling or young trees. Where there are other vegetation present, use selective herbicides that will not damage the natural vegetation. Where dense stands of big trees occur, mechanical control like ring barking, frill, basal bark or strip barking is used.

- Accessibility of terrain: such as mountainous areas or where roads are bad, methods of control where minimum amount of transportation of equipment and chemicals is possible should be given preference.

- Environmental safety: must be a priority where herbicide control is used. The washing of equipment and disposal of waste spray mixtures is prohibited in or near water courses where contamination of water can occur.

- Disposal of dead vegetation: can occur in three ways. Where the utilization of the wood is an option it (pine and black wattle can be sold), should be removed. Brushwood should be spread over the area rather than stacked, to limit soil damage when it is burned. Where there is a danger of damaging fires the unusable trees should be left standing as this will result in a less intense fire. Felled trees or tree in danger of falling in water courses should be removed as that they do not cause blockages with resulting problems of flooding.

- A cost assessment: must be made before the commencement of any control program. These costs can be based on the following:
    1. cost of herbicides,
    2. quantity to be used (method of application, size and density of target plants, dilution rates),
    3. personnel costs (number of person hours per area/operation),
    4. cost of equipment (spares and maintenance),
    5. coat of transportation and

6. follow-up treatments such as seedling and/or coppice control.

Herbicides

The estimated herbicide use per hectare in the following Tables (6-10) are calculated for closed or dense density stands (classification of density, see Appendix C). Thus the volumes must be reduced for lower infestations. The following formula can be used to calculate the required amount, per density class, of herbicide needed to treat the study area.

The % figure of the dense/closed application rate for the lower infestation groups is calculated at the mid point of the density range (i.e. medium density, 25 - 50%, the mid point is 37.5%). Therefore if the recommended rate is 6 liters of a specific product per hectare, the rate for a medium density will be 37.5% of the 6 liters; in other words, it will be equal to 2.25 l/ha.

MEDUIM	35.5%
SCATTERED	15%
VERY SCATTERED	3%
OCCASIONAL	0.5%
RARE	0.5%

Dye must be added to all herbicide applications to practically identify which areas have been treated:

- Blue dye = approx. 0.1% per liter sprayed.
- White dye = approx. 5% per liter sprayed.
- Red dye (diesel) = approx. 0.1% per liter sprayed.

For water based applications, a suitable adjuvant (wetter) should be added where recommended. The adjuvant quantities can be calculated as a ratio (%) of the herbicide quantity, as the label prescribes.

8. Management Recommendations for Oubosstrand and Protea farm

Fields

- Eradicate the sparsely invaded fields first (see Results, Table 3).

  Infestation: Light to medium density classification; 1-20 cm circumference.

  Recommended Method: Hand pull.

- Then move to the more heavily invaded areas. Through the correct management of livestock grazing, invaders can be kept off the fields permanently.

  Infestation: Medium to high density classification; 21-50 cm circumference.

  Recommended Method: Integrated approach with mechanical (basal bark, ring barking, felling, etc.) and chemical (see Appendix D and E).

Block A - Block E

Tables 6 -10 indicate the infestation of each block, the different methods available for eradication, as well as the general cost of control (not including price of herbicides/ha). I would recommended clearing Block A first then moving to D, E and finally either B or C. Blocks B and C have steep terrain and controlling the invaders from the area will prove to be difficult.

It is recommended that the initial control method for the *Acacia* sp. be integrated (mechanical and chemical) (pers.comm., Voges, 2005). The follow-up treatments should take place twice annually for 5 years; dropping the density classification (Appendix C) a class each year. After initial cutting/felling Pine and Hakea species (density class drops by 2 classes) need follow-up treatments every 2 years.

Action plan in each block (Winter, 2002):

- ✓ Eradicate sparsely invaded areas first.
- ✓ Clear small isolated infestations.
- ✓ Stop the edges of more dense stands from spreading outward.
- ✓ Start to clear from the edges of the denser stands.
- ✓ Follow-up treatments.

Table 6. Total cost of removal of invasive alien plants from **Block A** (50.5 ha):

Species		**Size class**	**Age class**	**Density class**			
Acacia Cyclops		Medium tree	Young	very scattered 1-5 %			
Chemical control		**Product**[6]		**Rate**	**Estimated product/ha**[7]	**Comments**	
Foliar spray		TRICLOPTER ESTER 480g/l TRICLOPYR AMINE SALT 270g/l + CLOPYRALID AMINE SALT 90g/l		50ml/10L water 50ml/10L water	4 L/ha	Apply to young growing trees (2 m)	
Mechanical control				**Cut-stump**	**Fell / stack**	**Cut & remove rip zone**	**Cut / slash**
Mean persondays required per density/size class/clearing method				1.5	1	1	2.3
Total of personday required				**1.8**	**1.2**	**1.2**	**2.7**
Estimated cost of application of herbicide[8]		[sub-total x R15]		R 26.70	R 18.00	R 18.00	R 41.04
TOTAL COST OF REMOVAL (excluding herbicide price/ha)							
Simple hand tools	[sub-total x R95 + herbicide application]			R 9 887.90	R 6 666.00	R 6 666.00	R 15 198.48
Chainsaws	[sub-total x R110 + herbicide application]			R 11 236.25	R 7 575.00	R 7 575.00	R 17 271.00

[6] List of available herbicide brands available in Appendix D.
[7] Estimated product/ha is for calculated dense/closed categories of density. See *Herbicides* to calculate true density class for Estimated product/ha.
[8] Includes: rural wages, protective clothing, basic equipment and transport from nearby (25 km).

Table 7. Total cost of removal of invasive alien plants from **Block B** (54.3 ha):

Species	Control	Product					
Sp: *Acacia cyclops;* **Size:** Medium tree; **Age:** Young; **Density:** Very Scattered 1-5%	**Chemical control**	**Product**	**Rate**	**Estimated product/ha**	**Comments**		
	Foliar spray	TRICLOPTER ESTER 480g/l	50ml/10L water	4 L/ha	Apply to young growing trees (2 m)		
		TRICLOPYR AMINE SALT 270g/l + CLOPYRALID AMINE SALT 90g/l	50ml/10L water				
	Mechanical control		**Cut-stump**	**Fell / stack**	**Cut & remove rip zone**	**Cut / slash**	**Felling**
	Mean persondays required per density/size class/clearing method		1.5	1	1	2.3	0
Sp: *Hakea sericea;* **Size:** Tall shrub; **Age:** Adult; **Density:** Occasional <1%	**Biological control**	Hakea Fruit Weevil (*Erytenna consputa*) available at the Plant Protection Research Institute, Stellenbosch					
	Mechanical control		**Cut-stump**	**Fell / stack**	**Cut & remove rip zone**	**Cut / slash**	**Felling**
	Mean persondays required per density/size class/clearing method		1	0	1	1	2
Sp: *Acacia mearnsii* *Acacia melanoxylon*	**Chemical control**	**Product**	**Rate**	**Estimated product/ha**	**Comments**		
	Foliar spray	TRICLOPTER ESTER 480g/l	75ml/10L water	3 L/ha			
	Frill/Stem application	TRICLOPTER ESTER 480g/l	200ml/10L diesel	1.5 L/ha			
Pinus pinaster **Size:** Tall tree **Age:** Young	**Mechanical control**		**Cut-stump**	**Fell / stack**	**Cut & remove rip zone**	**Cut / slash**	**Felling**

Density: Scattered 5-25%	Mean persondays required per density/size class/clearing method	4.1	4.8	4.8	3.9	0
Total of personday required		**7.1**	**4.8**	**6.8**	**5.9**	**4.6**
Estimated cost of application of herbicide	[sub-total x R15]	R 105.75	R 72.00	R 102.00	R 88.70	R 68.40
TOTAL COST OF REMOVAL (excluding herbicide price/ha)						
Simple hand tools	[sub-total x R95 + herbicide application]	R 42109.65	R 28670.40	R 40616.40	R 35320.34	R 27236.88
Chainsaws	[sub-total x R110 + herbicide application]	R 47851.88	R 32580.00	R 46155.00	R 40136.75	R 30951.00

Table 8. Total cost of removal of invasive alien plants from **Block C** (35.9 ha):

Sp: *Acacia cyclops;* **Size:** Medium tree; **Age:** Young; **Density:** Occasional < 1%	**Chemical control**	**Product**	**Rate**	**Estimated product/ha**	**Comments**		
	Foliar spray	TRICLOPTER ESTER 480g/l	50ml/10L water	4 L/ha	Apply to young growing trees (2 m)		
		TRICLOPYR AMINE SALT 270g/l + CLOPYRALID AMINE SALT 90g/l	50ml/10L water				
	Mechanical control		**Cut-stump**	**Fell / stack**	**Cut & remove rip zone**	**Cut / slash**	**Felling**
	Mean persondays required per density/size class/clearing method		1.48	0	1	1	2.28
Sp: *Acacia mearnsii* *Acacia melanoxylon*	**Chemical control**	**Product**	**Rate**	**Estimated product/ha**	**Comments**		
	Foliar spray	TRICLOPTER ESTER 480g/l	75ml/10L water	3 L/ha			
	Frill/Stem application	TRICLOPTER ESTER 480g/l	200ml/10L diesel	1.5 L/ha			
Pinus pinaster **Size:** Tall tree **Age:** Young	**Mechanical control**		**Cut-stump**	**Fell / stack**	**Cut & remove rip zone**	**Cut / slash**	**Felling**
Density: Scattered 5-25%	Mean persondays required per density/size class/clearing method		4.1	4.8	4.8	3.9	0
Total of personday required			**5.8**	**5.0**	**6.0**	**5.1**	**2.5**
Estimated cost of application of herbicide		[sub-total x R15]	R 86.50	R 75.00	R 90.00	R 76.70	R 37.20

TOTAL COST OF REMOVAL (excluding herbicide price/ha)						
Simple hand tools	[sub-total x R95 + herbicide application]	R 22 772.57	R 19 745.00	R 23 694.00	R 20 192.55	R 9 793.52
Chainsaws	[sub-total x R110 + herbicide application]	R 25 877.92	R 22 437.50	R 26 925.00	R 22 946.08	R 11 129.00

Table 9. Total cost of removal of invasive alien plants from **Block D** (47.5 ha):

Sp:	**Chemical control**	**Product**	**Rate**	**Estimated product/ha**	**Comments**	
Acacia mearnsii	Foliar spray	TRICLOPTER ESTER 480g/l	75ml/10L water	3 L/ha		
Pinus pinaster **Size:** Tall tree **Age:** Young	**Mechanical control**		**Cut-stump**	**Fell / stack**	**Cut & remove rip zone**	**Cut / slash**
Density: Medium 25-50%	Mean persondays required per density/size class/clearing method		9.8	13.2	13.2	8.5
Total of personday required			**5.8**	**5.0**	**6.0**	**5.1**
Estimated cost of application of herbicide		[sub-total x R15]	R 147.50	R 198.00	R 198.00	R 127.10
TOTAL COST OF REMOVAL (excluding herbicide price/ha)						
Simple hand tools	[sub-total x R95 + herbicide application]		R 51 379.17	R 68 970.00	R 68 970.00	R 44 273.17
Chainsaws	[sub-total x R110 + herbicide application]		R 58 385.42	R 78 375.00	R 78 375.00	R 50 310.42

Table 10. Total cost of removal of invasive alien plants from **Block E** (41.6 ha):

Sp:	**Chemical control**	**Product**	**Rate**	**Estimated product/ha**	**Comments**	
Acacia mearnsii	Foliar spray	TRICLOPTER ESTER 480g/l	75ml/10L water	3 L/ha		
Acacia melanoxylon	Frill/Stem application	TRICLOPTER ESTER 480g/l	200ml/10L diesel	1.5 L/ha		
Pinus pinaster **Size:** Tall tree **Age:** Young	**Mechanical control**		**Cut-stump**	**Felling**	**Cut & remove rip zone**	**Fell / stack**
Density: Scattered 5-25%	Mean persondays required per density/size class/clearing method		4.3	5.0	4.1	5.0
Sub-total of personday required			**4.5**	**5**	**4.3**	**5.2**
Estimated cost of application of herbicide		[sub-total x R15]	R 67.25	R 78.00	R 64.70	R 78.00
TOTAL COST OF REMOVAL (excluding herbicide price/ha)						
Simple hand tools	[sub-total x R95 + herbicide application]		R 20 515.73	R 23 795.20	R 19 737.81	R 23 795.20
Chainsaws	[sub-total x R110 + herbicide application]		R 23 313.33	R 27 040.00	R 22 429.33	R 27 040.00

9. Conclusion

Onbosstrand and Protea farm is in a unique position, virtually surrounded by farms and it boarders on the Tsitsikamma National Park. It has the ability to serve as an environmental buffer for the nature reserve and provide more natural habitat for species that live in the surrounding fragmented landscape. The property has the potential to promote biodiversity, sustainability and make the surrounding communities aware of the threat of invasive alien plants. A culture of conservation will then grow and assist in the broader goal of conserving biodiversity in the world.

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11. Appendices

Appendix A – Species List of Oubosstrand

Species list of general indigenous trees
Compiled by holidaymakers over the years.

COMMON NAME – *Scientific name* (Number: South African *National List of Trees*)
MELKHOUTBOOM (WITMELKHOUT) - *Sideroxylon inerme* (579)
KERSHOUT - *Pterocelastris tricuspidatus* (409)
ROOIKERSHOUT - *Pterocelastrus rostratus* (408)
VELDVY - *Ficus burttdavy* (49)
BIETOU - *Chrysanthemoides monilifera* (736.2)
SALIEOUT (KAMFERBOS) -*Tarchonantus camphoratus* (733)
BOKDROL - *Canthuim ventosum* (708)
SEESAFFRAAN (KOEDOEBESSIE) - *Cassine aethiopica* (410)
BASTERSAFFRAAN - *Cassine peragua* (414)
KRUISBESSIE - *Crewia occidentalis* (463)
KUSKIEPERSOL (KIEPERSOLBOS) - *Cussonia thyrsiflora* (565)
SUURBESSIE - *Dovyalis rhamnoides* (509)
KLEINBLAARYSTERHOUT - *Linociera foveolata* (615)
PERDE PRAM - *Fagara davyi* (254)
KEURBOOM - *Virgilia oroboides* (221)
NUM-NUM (ROOI NUM NUM) - *Carissa bispinosa* (640.1)
BOEKENHOUT - *Rapania melanophloeos* (578)
WILDE STOKROOS - Sparmannia africana (457)
BOSTAAIBOS - *Rhus chirindensis* (380)
PERDEPIS - *Clausena anisata* (265)
WIT BOEKENHOUT - *Pittosporum viridiflorum* (139)
ESSENHOUT - *Ekebergia capensis* (298)
VLIER - *Nuxia floribunda* (634)

List of birds: As compiled by holidaymakers sightings (2000).

Name (Afrikaans)/ Number in South Africa

BRILPIKKEWYN	3	VISAREND	148
KLEINDOBBERTJIE	8	BRUINJAKKALSVOËL	149
BLOUBEKMALMOK	11	BERGJAKKALSVOËL	150
WITMALGAS	53	ROOIBORSJAKKALSVOËL	152
WITBORSDUIKER	55	EDELVALK	172
TREKDUIKER	56	KRANSVALK	181
RIETDUIKER	58	KAAPSE FISANT	195
SLANGHALSVOËL	60	ROOIKEELFISANT	198
BLOUREIER	62	GEWONE TARENTAAL	203
SWARTKOPREIER	63	WATERHOENDER	226
GROOTWITREIER	66	BLESHOENDER	228
KLEINWITREIER	67	VELDPOU	231
VEE-REIER	71	BONTTOBIE	243
HAMERKOP	81	SWARTTOBIE	244
WITOOIEVAAR	83	VAALSTRANDKIEWIET	246
SKOORSTEENVEËR	91	KROONKIEWIET	255
GLANSIBIS	93	GROOTSWARTVLERKKIEWIET	257
HADEDA	94	BONTKIEWIET	258
LEPELAAR	95	GEWONE RUITER	264
GROOTFLAMINK	96	WATERDIKKOP	298
KLEINFLAMINK	97	SWARTRUGMEEU	312
KOLGANS	102	GRYSKOPMEEU	315
GEELBEKEEND	104	REUSE STERRETJIE	322
BRUINEEND	113	GEELBEKSTERRETJIE	324
WILDEMAKOU	116	GEWONE STERRETJIE	327
BLOUVALK	127	KRANSDUIF	349
WITKRUISAREND	131	GEELBEKBOSDUIF	350
BRUINSLANGAREND	142	GEWONE TORTELDUIF	354

ROOIBORSDUIFIE	355
KANEELDUIFIE	360
KNYSNA LOERIE	370
MOOIMEISIE	384
MEITJIE	385
GEWONE VLEILOERIE	391
NONNETJIE-UIL	392
BOSUIL	394
KAAPSE OORUIL	400
AFRIKAANSE NAGUIL	405
WITKRUISWINDSWAEL	415
KLEINWINDSWAEL	417
WITPENSWINDSWAEL	418
GEVLEKTE MUISVOËL	424
WITKRUISMUISVOËL	425
ROOIWANGMUISVOËL	426
BONTVISVANGER	428
REUSE VISVANGER	429
BLOUVISVANGER	430
KUIFKOPVISVANGER	431
HOEPHOEP	451
GEWONE KAKELAAR	452
BONTHOUTKAPPER	465
KLEINHEUNINGWYSER	476
GRONDSPEG	480
GRYSKOPSPEG	488
DRAAIHALS	489
EUROPESE SWAEL	518
WITKEELSWAEL	520
KLEINSTREEPSWAEL	527
KRANSSWAEL	529
HUISSWAEL	530
SWARTSSAAGVLERKSWAEL	536
SWARTKATAKOEROE	538
BLOUKATAKOEROE	540
MIKSTERTBYEVANGER	541
SWARTKOPWIELEWAAL	545
SWARTKRAAI	547
WITBORSKRAAI	548
WITHALSKRAAI	550
KAAPSE TIPTOL	566
GEWONE WILLIE	572
OLYFLYSTER	577
GEWONE BONTROKKIE	596
GEWONE JANFREDERIK	601
WITKOLJANFREDERIK	606
BRUINWIPSTERT	616
KNYSNARUIGTESANGER	640
HOFSANGER	643
BANDKEELKLEINJANTJIE	645
GRASVOËL	661
GRYSRUGTINKTINKIE	669
VLEITINKTINKIE	677
LUITINKTINKIE	679
NEDDIKKIE	681
KAROOLANGSTERTJIE	686
EUROPESE VLIEËVANGER	689
FISKAALVLIEËVANGER	698
KAAPSE BOSBONTROKKIE	700
PARADYSVLIEËVANGER	710
GEWONE KWIKKIE	713
DONKERKOESTER	718

ORANJEKEELKALKOENJIE	727	KAALWANGVALK	***
FISKAALLAKSMAN	732		
SUIDELIKE WATERFISKAAL	736		
SNEEUBAL	740		
GRYSBORSTJAGRA	742		
BOKMAKIERIE	746		
EUROPESE SPREEU	757		
WITGATSPREEU	759		
ROOIVLERKSPREEU	769		
KAAPSE SUIKERVOËL	773		
JANGROENTJIE	775		
KLEINROOIBORS			
(BAND)SUIKERBEKKIE	783		
GROOTROOIBORS(BAND)			
SUIKERBEKKIE	785		
SWARTSUIKERBEKKIE	792		
KORTBEKSUIKERBEKKIE	793		
KAAPSE GLASOGIE	796		
HUISMOSSIE	801		
GEWONE MOSSIE	803		
KAAPSE WEWER	813		
ROOIVINK	824		
KAAPSE FLAP	827		
SUIDELIKE SWIE	850		
KONINGROOIBEKKIE	860		
GEELOOGKANARIE	869		
KAAPSE KANARIE	872		
GESTREEPTE KANARIE	873		
DIKBEKKANARIE	877		
GEELKANARIE	878		
STREEPKOPKANARIE	881		

Appendix B – Newsletter (study aims where changed early 2005)

NEWS LETTER/NUUS BRIEF

With the changing political climate in South Africa the basic principals of nature conservation and protected areas are drastically changing. Nature must now pay its way (be functional in some way) or be lost in the encroaching mass of humanity

I am currently studying BSc. Conservation Ecology at the University of Stellenbosch. In my fourth year (2005) I have to write up a "thesis". I have decided to put together a management plan for Oubos. I am designing this Management Plan as if Oubos is making the transition from holiday resort to private nature reserve.

If anybody has any information about how Oubos was founded, the fauna, flora and animals or just information that they think I should take into account please let me know.

Die politieke klimaat van Suid Afrika is aan die verander en daarmee saam die basiese boustene van bewaring en beskermde areas. Die natuur moet nou funksioneel wees en 'n doel dien, anders sal dit verdwyn onder die toenemende getalle mense wat 'n eie stukkie aarde soek.

Ek is tans besig om BSc. Bewarings Ekologie te studeer by die Universiteit van Stellenbosch. In my vierde jaar (2005) moet ek 'n "thesis" skryf. Ek het besluit om 'n bestuursplan op te stel vir Oubos. Dit doen ek met die aanname dat Oubos van vakansie-oord na privaat natuurreservaat geregistreer word.

Enige inligting ten op sigte van Oubos se ontstaan, die fauna en flora of enige ander ligting wat u dink ek dalk sou kon gebruik, sal baie waardeer word.

Thank You
Baie Dankie

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Appendix C - Le Maitre & Versveld (1994) density conversions found in Marias (1998).

1.2.2 Age (Size)

The age or size of invasive alien plants can have a substantial impact on the cost of treatment and the type of treatment required. The age or size of alien vegetation should be captured using the following codes/classes:

- m – mature
- a – adult
- y – young
- s – seedling
- x – mixed ages

Table 1.2.2a provides a summary of the characteristics of different size classes for a selection of vegetation types. Vegetation should be judged based on its visual appearance and reproductive maturity. Typically, the vegetation height is the most appropriate characteristic for establishing age, but the canopy diameter and stem diameter can also be used.

Table 1.2.2a Characteristics of different size classes for selected types of vegetation

CHARACTERISTIC	TALL SHRUBS	MEDIUM TREES	TALL TREES	SIZE CLASS
	HAKEA SPECIES	*ACACIA CYCLOPS*, *A. LONGIFOLIA*, *A. SALIGNA*, *LEPTOSPERMUM* SPECIES	*PINUS* SPECIES, *ACACIA MEARNSII*, *A. MELANOXYLON*	
HEIGHT (M)	≤0.5	≤0.5	≤0.5	Seedling
	0.5-1.5	0.5-2.0	1.0-4.0	Young
	≥1.5	≥2.0	≥8.0	Adult
CANOPY DIAMETER (M)	≤0.3	≤0.5	≤0.5	Seedling
	0.3-1.0	0.5-1.5	0.5-2.0	Young
	≥1.0	≥1.5	≥2.0	Adult
STEM DIAMETER (CM)	<1	<2	<2	Seedling
	1 - 4	2 - 8	2 - 8	Young
	>4	>8	>8	Adult

Where possible, the use of the mixed age class should be avoided.

1.2.3 Density

For report purposes the total density of a polygon will be classified according to the following density classes:

- Rare: 0.01%
- Occasional: 0.02 – 1%
- Very scattered: 1.1 – 5%
- Scattered: 5.1 – 25%
- Medium: 25.1 – 50%
- Dense: 50.1 – 75%
- Closed: 75.1 – 100%

Table 1.2.3a provides some guidelines for the classification of different types of vegetation (shrubs, medium sized trees, tall trees) into these density classes based on age and stems per hectare.

Table 1.2.3a: Classification of different types of vegetation into density classes based on age and stems per hectare

		TALL SHRUBS	MEDIUM TREES	TALL TREES
	SIZE CLASS	HAKEA	ACACIA CYCLOPS, A. LONGIFOLIA, A. SALIGNA	PINE BLACKWATTLE BLACKWOOD
Rare				
Individuals are known to occur in the area, but are few and far between				
Occasional <1% cover				
Density (/ha)	Seedling	≤1 100	≤400	≤400
	young	≤240	≤100	≤60
	adult	≤100	≤40	≤25
Very scattered 1-5% cover				
Density (/ha)	Seedling	1 100-10 000	400-3 600	400-3 600
	Young	240-2 200	100-900	60-600
	Adult	100-900	40-400	25-225
Scattered 5-25% cover				
Density (/ha)	Seedling	10 000-55 000	3 600-20 000	3 600-20 000
	Young	2 200-12 000	900-5 000	600-3 200
	Adult	900-5 500	400-2 200	225-1 200
Medium 25-50% cover				
Density (/ha)	Seedling	55 000 -200 000	20 000 -70 000	20 000 -70 000
	Young	12 000-40 000	5 000 -17 000	3 200-11 000
	Adult	5 500-17 000	2 200-7 600	1 200-4 300
Dense 50-75% cover				
Density (/ha)	Seedling	200 000 -340 000	70 000 -120 000	70 000 -120 000
	Young	40 000 -70 000	17 000 -30 000	11 000 -20 000
	Adult	17 000 -30 000	7 600-20 000	4 300-7 600
Closed > 75% cover				
Density (/ha)	Seedling	≥340 000	≥120 000	≥120 000
	Young	≥70 000	≥30 000	≥20 000
	Adult	≥30 000	≥20 000	≥ 7 600

Appendix D - Registered Herbicides for the control of alien plants (recreated from Winter, 2002)

Active ingredient	**Trade Name**
***Acacia mearnsii* (Black wattle)**	
2,4-D/picloram	Tordon 101
Cylindrobasiduim laeve live spores	Stumpout
bromacil	Bushwacker
bromacil/tebuthiuron	Savana
clopyralid	Lotrel
glyphosate 144 AL	Stirrup
glyphosate 240 SL	Tumbleweed
glyphosate 360 AL	Clear Out
	Glifogarde
	Glyphogan
	Kleen Up
	Mamba
	Profit
	Roundup /Ultra
	Sunup
glyphosate trimesium	Muster
	Touchdown /Plus
	Wipe-Out
triclopyr	Garlon
***Pinus pinaster* (Cluster Pine)/ *Hakea sericea* (Sliky Hakea)**	
tebuthiuron	Molopo

Appendix E - Guild to further control method and herbicide selection for alien vegetation occurring on Oubosstrand and Protea farm (Winter, 2002; Working for Water, 2004)