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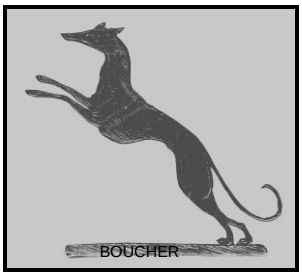

ASSESSMENT OF THE BOTANICAL FEATURES OF THE PARADYSKLOOF GOLF ESTATE, INCORPORATING FARM 366 AND THE REMAINDER OF FARM 369, STELLENBOSCH

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The section of the Paradyskloof Golf Estate linked to the Hottentots Holland Nature Reserve serves as a near-pristine catchment area for streams originating here. Helderberg Mountain is prominent in the far distance.

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Executive summary

The proposed Paradyskloof Golf Estate and associated developments covers approximately 277 ha located 5 km south west of Stellenbosch town centre. It has an northern and a southern section with a narrow linking corridor along the Paradyskloof River. The area has mainly been used for pine silviculture, water catchment area and for recreation (walking and shooting).

The site has a Mediterranean climate on shales and alluvium with two major streams, which are tributaries of the Eerste River, flowing through the site in an east-west direction. It is located within the Fynbos Biome and supports Swartland Shale Renosterveld, Sandstone Fynbos and Azonal Alluvium Thicket vegetation.

Three main plant communities are described, together with further subdivisions as follows:

A *Pteridium aquilinum–Cliffortia odorata* Stream Community
- A1 *Pteridium aquilinum–Ischyrolepis subverticillata* Stream Thicket
- A2 *Pteridium aquilinum–Rubus fruticosus* Exotic Stream Forest

B *Typicum Elytropappus rhinocerotis* Shale Renosterveld Shrublands
- B1 *Elytropappus rhinocerotis–Erica imbricata* Foothill Shale Renosterveld
- B2 *Elytropappus rhinocerotis–Felicia filifolia* Mountain Slope Shale Renosterveld

C *Anthospermum aethiopicum–Wachendorfia paniculata* Colluvium Sandstone Fynbos

The Swartland Shale Renosterveld is Critically Endangered, one of two most endangered vegetation types in South Africa, with high priority being placed for the conservation of all remaining patches. Rivers have recently been identified as the most threatened ecosystems in South Africa. **High priority is placed on the conservation of the rivers flowing through the Paradyskloof site**, together with a surrounding buffer zone varying between 30—50 m, depending on location. **Maintenance of biodiversity also requires that linkages be maintained between ecosystems**, hence the near-pristine Colluvium Sandstone Fynbos adjoining the Hottentots Holland Nature Reserve, which serves as catchment area for the rivers flowing through the Paradyskloof site and is also of recreational and educational importance, is identified as being necessary to provide a functioning system for the area.

A total of 374 species, including 34 introduced alien plants, have been recorded from the site. Two threatened Red Data Book species were recorded, namely *Theiranthus racemosus* (Klatt) G.J.Lewis (rarity category = Rare) and *Xiphotheca lanceolata* (rarity

category = Indeterminate). A map is presented indicating the distribution of *Xiphotheca lanceolata*, which was recorded at 765 locations through the site, with concentrations in some disturbed areas.

Fire and alien vegetation management plans are the two most important aspects requiring attention within the context of development on site. These, together with conservation of the areas identified here, will require a considerable financial support base.

1. Introduction

1.1 Objectives

The brief for this study, identified as the Paradyskloof Golf Estate Development (also called mountain course @ Stellenbosch), located on Farm 366 and the remainder of Farm 369, Stellenbosch (Figure 1), was to examine the botanical environment, particularly to determine the composition of the vegetation, whether the vegetation has any conservation value and whether any threatened plant species are present and to comment on management issues in respect of the vegetation.

Detailed objectives for the botanical investigation are:-

A. Vegetation (the last two bullets to be addressed at later stages)

- Identify and describe the natural vegetation including the potential vegetation under the pine plantations
- Assign botanical sensitivity rankings to the different vegetation units on the property
- Suggest potential uses of different areas with natural vegetation
- Develop a vegetation and flora conservation plan
- Advise on the rehabilitation of natural vegetation areas
- Prepare vegetation management guidelines

B. Flora (the last two bullets to be addressed at a later stage)

- Compile a reasonably comprehensive list of the flora and determine the rarity status of the plants collected
- Advise on search and rescue procedures in the areas to be developed
- Advise on the indigenous flora to be used around the golf course (and housing if required)

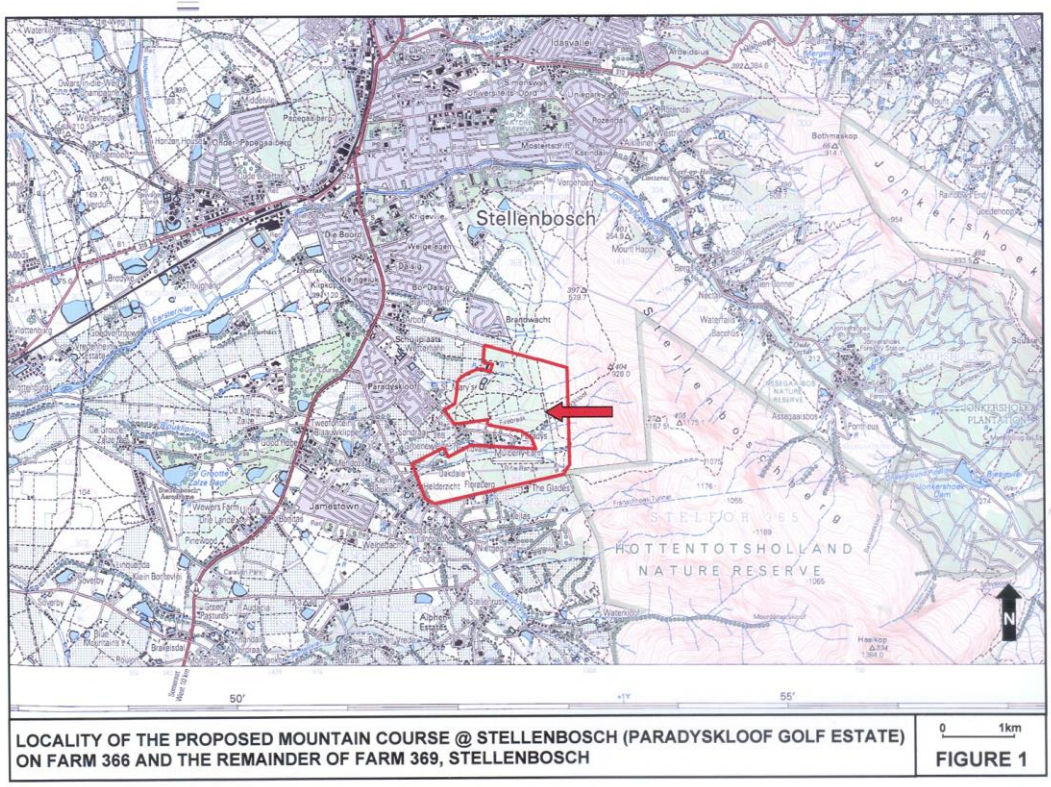

Figure 1: General location map of the Paradyskloof Golf Estate in relation to Stellenbosch.

1.2 Description of area

1.2.1 Location

The proposed Paradyskloof Golf Estate development is located approximately 5 km to the south west of the centre of Stellenbosch town on Farm 366 and the remainder of Farm 369 (Figure 1). The site covers approximately 277 ha and adjoins the Hottentots Holland Nature Reserve to the east and south east respectively of the residential suburbs of Paradyskloof and Brandwacht. The site is divided into two distinct sections (Figure 2) that will be referred to as the northern and the southern sections in this report. The sections are separated by the wine farm, Vriesenhof and the small holdings, Mulberry Farm and Paradys. Municipal land adjoining the site is leased to the wineries, Blaauwklippen, KWV and Vriesenhof.

The gradient of the property varies from approximately 1:10 in the lower-lying western portion to 1:6 along the foothills of Stellenbosch Mountain. Three stream courses (Blaauwklippen, Paradyskloof and Kaffirskuil (Skuilplaats) Rivers), tributaries of the Eerste River, flow through the site in a general east-west direction and are all sourced in Stellenbosch Mountain (Figure 2). Gale (1998) notes that the upper reaches of the Paradyskloof and Kaffirskuil Rivers are in very good condition despite invasion by alien trees in the catchment area.

Figure 2. Locality plan of area showing place names.

Some of the downstream farmers have water extraction rights on the Paradyskloof Stream, with the result that it tends to dry up entirely in late summer although there is irrigation return flow downstream. The riparian vegetation has a good representation of indigenous trees and shrubs and has been identified by Helme (1997) as being sensitive. Vegetation and water quality degradation starts from the farms and increases further downstream. Pine plantations cover most of the terrestrial areas on the site (Withers Environmental Consultants (2004).

The Paradyskloof Water Purification Works and reservoirs are situated in the northern part of the site. A pipeline and associated powerline connected to the Theewaterskloof-Cape Town water supply cross the southern section of the property. Two decommissioned shooting ranges are located on the site, one in each section (Figure 2).

1.2.2 Geology & soils

The geological features of the area are illustrated in Figure 3. Stellenbosch Mountain, on the eastern edge of the site, is composed of quartzitic sandstones (Table Mountain Group). This is underlain by Malmesbury Group shales that have been intruded in places by Cape Granites of the Stellenbosch-Kuilsriver and Helderberg Plutons (Withers Environmental Consultants 2004).

At Paradyskloof, colluvial sandstone derived material, varying in thickness from thicker deposits on the upper footslopes of Stellenbosch Mountain to shallow deposits on the lower footslopes occur. The colluvial deposits overlay Malmesbury Group shales and phyllites.

The description and distribution of the substrates (Figure 4) on site are presented by Mountain & Partners (1997). Dryland area soils are described as talus gravels overlying completely weathered phyllite or greywacke (Malmesbury Group sediments). Alluvial soils of silts, sands, gravels and boulders in the streams through the area with the interface between the wetlands and drylands being alluvial terrace silts nearer the rivers and colluvium overlying completely weathered phyllite or greywacke fringing the dryland areas.

A lateritic horizon (oubank) of variable thickness has developed at the interface of transported hillwash and *in situ* weathered shales and phyllites. These lateritic gravels assist in the drainage of the hillwash during the wet winter period (A. Withers pers. comm.).

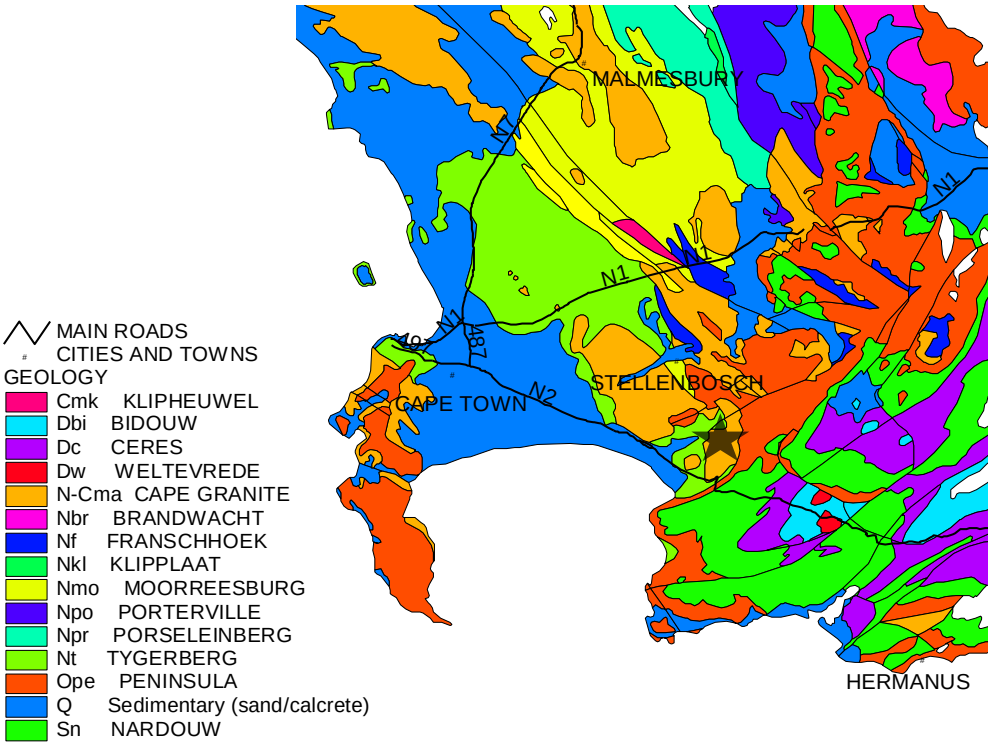

Figure 3. Geological Map of the Western Cape. (Star indicates the location of the Paradyskloof site.)

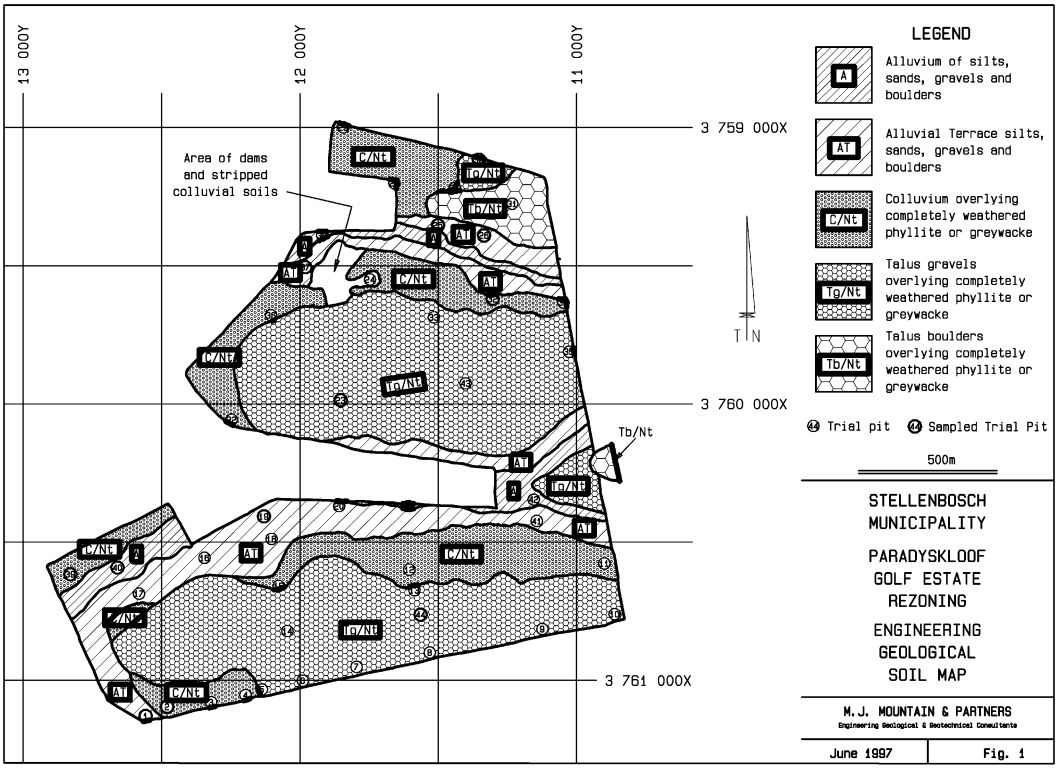

Figure 4. Substrate types recorded at the proposed Paradyskloof Golf Estate development (Mountain & Partners 1997).

1.2.3 Climate

The climate is typically Mediterranean with wet winters and dry summers (Figure 5). The annual rainfall is about 900 mm per year, with an average monthly precipitation of above 100 mm being recorded during winter between June and August. An arid period occurs from December to March. The mean annual temperature is approximately 17.5 °C. Mean daily minimum temperature of the coldest month is 5.9 °C, with subzero temperatures being recorded between June and August, reaching an absolute minimum of –0.2 °C. Winds during the winter months are characteristically northerly reaching gale force at times. Southerly winds are common during summer (Figure 6) (Boucher 1987).

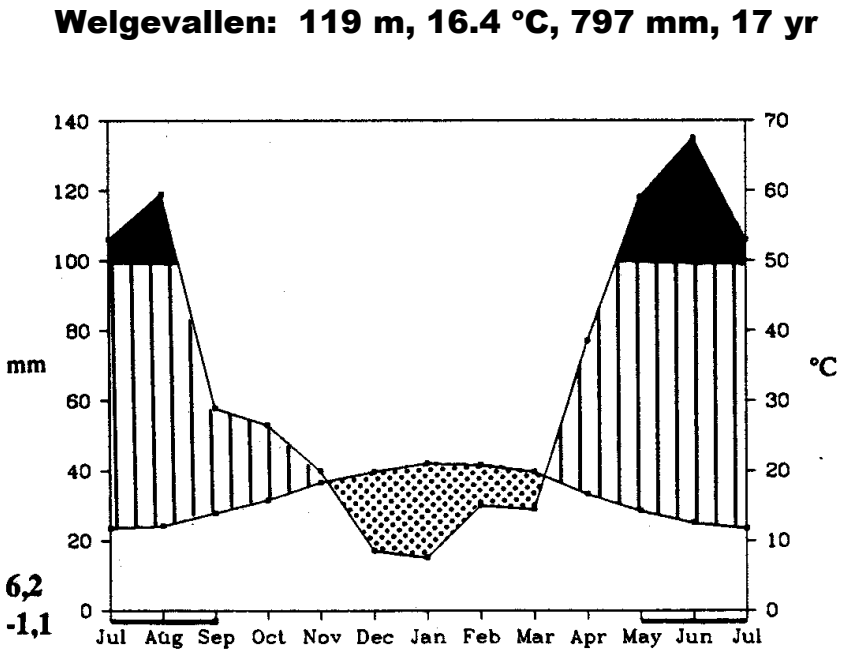

Figure 5. Klimadiagram for Welgevallen Experimental Farm (data from Weather Bureau 1988). Altitude 119 m; mean annual temperature is 16.4 ^{o}C; average annual precipitation is 797 mm; ; data for 17 years; mean daily minimum of coldest month is 6.2 ^{o}C; lowest absolute minimum is -1.1 ^{o}C; months with absolute minimum below 0 ^{o}C marked; humid period with vertical hatching; arid period with dotted hatching; period with precipitation above 100 mm black shading.

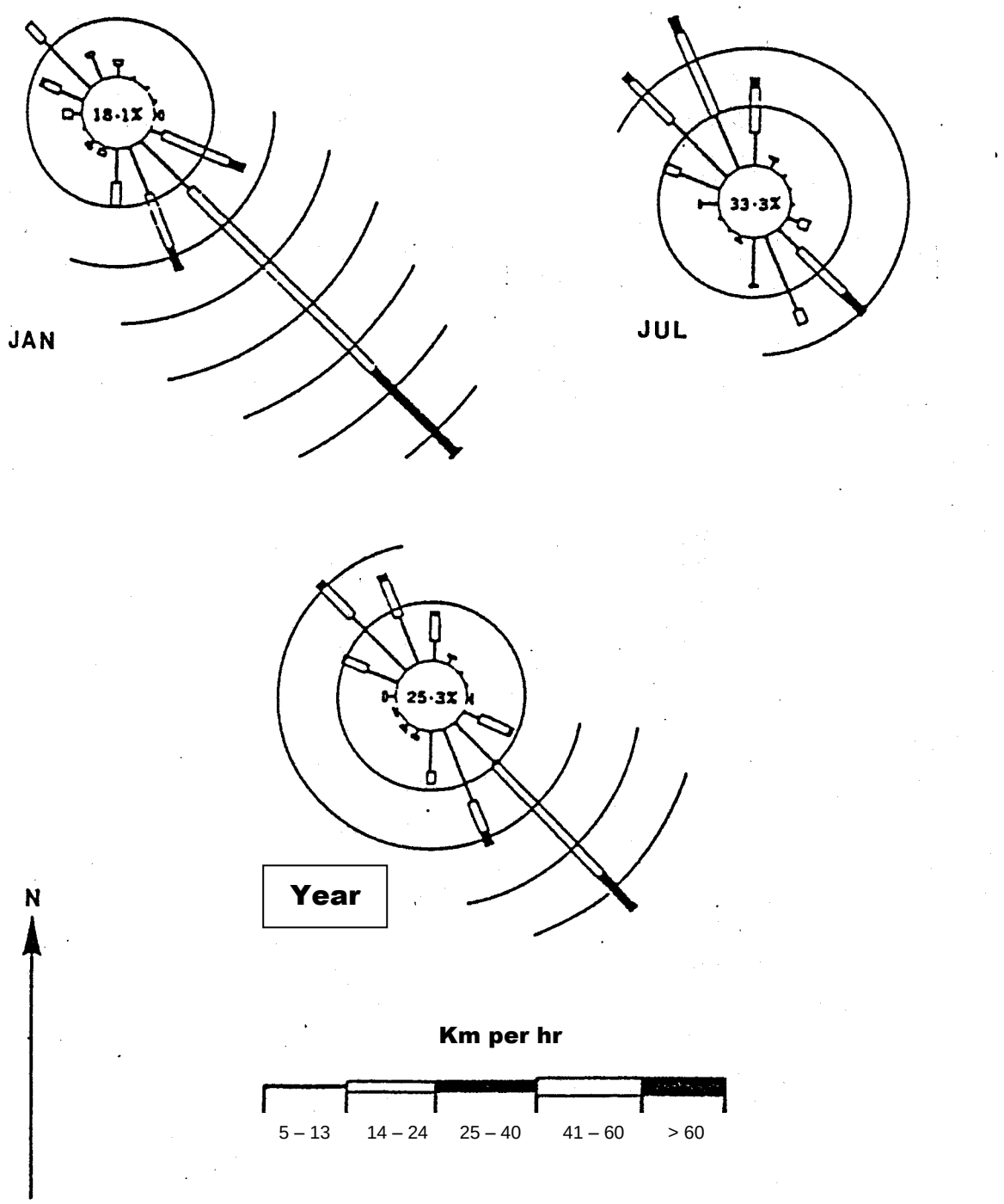

Figure 6. Wind roses for dry and wet months in Stellenbosch (Weather Bureau 1960). Percentages of calms within the circle.

Fire is an important cyclic climatic event rejuvenating and modifying the vegetation. Presently, it occurs in a 12-30 year natural cycle and is caused naturally by lightening strikes, rock falls and spontaneous ignition, while humans are a prime ignition source (Kruger 1979, Kruger & Bigalke 1984, Van Wilgen *et al*. 1992).

The results of a series of experiments at Swartboskloof, Jonkershoek allow for the evaluation of the resilience of the local fynbos ecosystem to fire. Ecosystem properties such as plant species richness, phytomass and streamflow appear to be resilient under a fire regime of intervals of 12-30 years, with increases in biomass and decreases in streamflow occurring with increasing post-fire age. Frequent fires (e.g. every 5 years) will reduce species richness slightly by eliminating seed-reproducing shrubs, and phytomass will also decrease. Fire exclusion will cause a net reduction in plant species richness as the vegetation becomes moribund. Management in fynbos is usually aimed at conserving species and representative ecosystems, reducing fire hazard, and ensuring that catchments deliver high quality water. Fire is the most important management practice to achieve these aims and is applied at intervals of about 12-15 years during late summer or autumn (Van Wilgen *et al*. 1992).

1.2.4 History: Archaeological to present

The Stellenbosch area has been occupied by humans for about 1.5 million years. The stone-aged Acheulian Culture was first identified in South Africa from materials found at Stellenbosch (Deacon 1983). In activities like honey-hunting, the improvement of pastures, game-driving and the "farming" of geophytes, fire may have been as important in the Middle Stone Age as it was during the Late Stone Age (Deacon 1976). Deacon is of the opinion that the vegetation in this area has probably been subjected to fire management for at least 100 000 years. Fields of clones of geophytes (e.g. *Watsonia borbonica*) as occurs in the present study area (Figure 7) were an important source of food. Contrived veld-burning would have maintained the productivity of geophytes for own gain.

Figure 7. *Watsonia borbonica* flowering after the December 2003 fire at Paradyskloof.

Observations by early Europeans show that large herds of cattle and sheep were maintained at the Cape, in this area, at the time of first contact. Archaeological evidence suggests that stock was kept for ca. 1000-2000 years prior to European contact. Van Riebeeck recorded the presence of more than 2 000 cattle and sheep near the Table Bay fort (Thom 1952). This stock-keeping, and associated burning practices to maintain natural pastures, would have had a marked impact on the ecology of the area (Deacon *et al.* 1983). Stock-farming continued into the 20th century on the Paradyskloof site (Mr J. (Boland) Coetzee pers. comm.) and grazing terracing is still visible to the present day (Figure 8).

Figure 8. Terracing through grazing by stock at the source of the Paradyskloof River.

Because the colonists were largely dependant on indigenous wood for firewood, the building of houses, wagons and the making of farm implements, it does not come as a surprise that the natural forests around Stellenbosch were heavily utilized. Proclamations by governors at the Cape attempted, unsuccessfully, to stem the destruction of the natural forests and their habitat has now widely been taken over by introduced plants. *Podocarpus elongatus* (yellowwood) was used for furniture, doors, floors and ceilings; wagon-making relied on local materials, for example, ironwood (*Curtisia dentata*) for spokes, red alder (*Cunonia capensis*) for rims and waboom (*Protea nitida*) for breakpads. *Olea europaea* subsp. *africana* was used for axe-handles and for harrow teeth. *Leucospermum conocarpodendron* (kreupelhout) (Figure 9, 10) and *Protea repens* (sugar bush) provided a sweet syrup. *Brabejum stellatifolium* (wilde amandel) fruits were edible after being soaked in water for a few days and were boiled and roasted for use as a substitute for coffee. *Oxalis pes-caprae* (suring) was cooked with vegetables. *Cyclopia genistiodes* gave honey tea. *Tulbaghia capensis* (wild garlic) and *Dodonaea viscosa* var *angustifolia* (ysterhout) (Figure 11) are still collected here for medicinal purposes by Rastafarians (pers. obs.). All the above species are or were present in Paradyskloof.

Figure 9. *Leucospermum conocarpodendron* provided a sweet syrup to the Khoi-Khoi and early colonists.

Figure 10. Moribund and etiolated *Leucospermum conocarpodendron* plants survive under the pine plantations.

Figure 11. *Dodonaea viscosa* var. *angustifolia* is distributed through the site. It is collected by Rastafarians for medicinal purposes.

1.2.5 General flora and vegetation

The Cape Floristic Kingdom, one of six world floral kingdoms, is internationally renowned for its special rich flora containing an estimated 9 000 species of vascular plants of which almost 69% are endemic (restricted to the region). This makes it one of the richest regions in the world in terms of botanical diversity. It is characterized by five endemic families and by the conspicuous presence of, amongst others, species belonging to the families Aizoaceae, Ericaceae, Fabaceae, Iridaceae, Orchidaceae, Proteaceae, Restionaceae, Rutaceae and Scrophulariaceae (Goldblatt & Manning, 2000). The flora and vegetation of the Stellenbosch Region was first described by Duthie (1929, 1930).

The vegetation in the study area is variously described and mapped in general terms under the names Western Coastal Renosterveld (Veld Type 46, Acocks 1988), West Coast Renosterveld (of which 97% is transformed; Low & Rebelo 1996); Swartland Shale Renosterveld and Cape Winelands Shale Fynbos (Mucina & Rutherford 2004). The last names being currently accepted.

The CAPE (Cape Action for People and the Environment) project mapped the area at too coarse a scale, but essentially indicates that this area supports Boland Coast Renosterveld (Cowling & Heijnis 2001) (Figure 12). This vegetation types is regarded as 100% irreplaceable in terms of the CAPE rankings (Cowling et al 1998), which means that all remaining examples of this vegetation type are needed in order to achieve regional conservation targets.

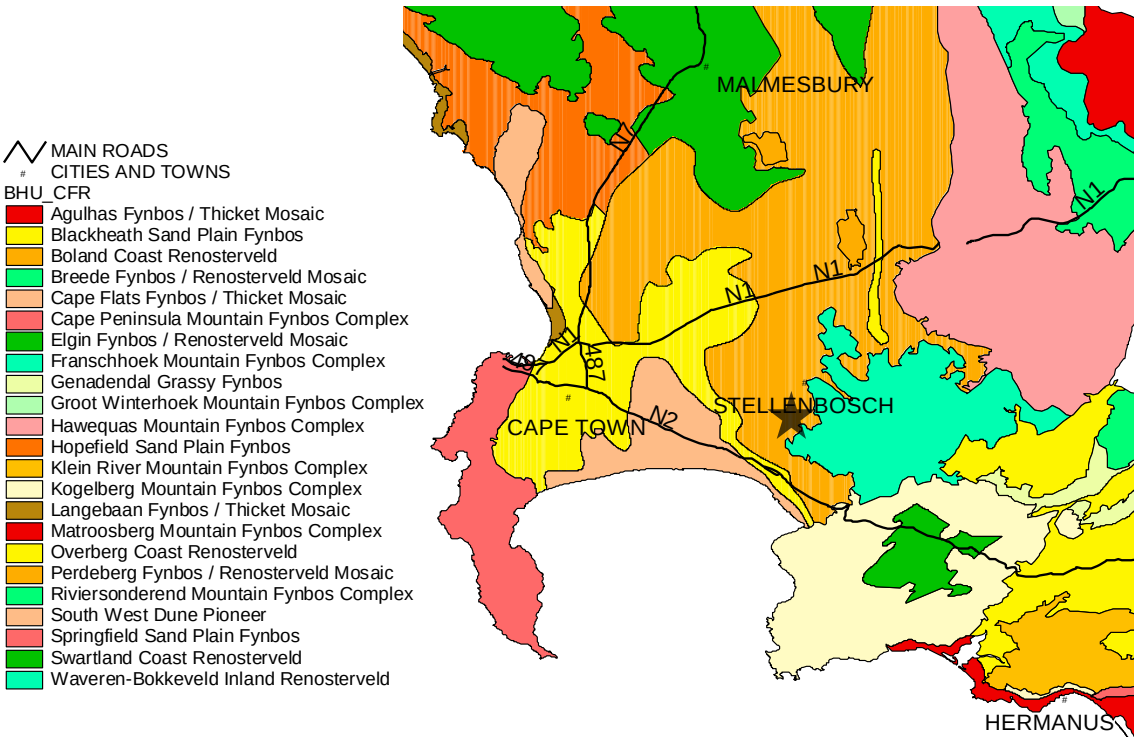

Figure 12. Broad habitat units of the Western Cape (Cowling & Heijnis 2001). (Star indicates the location of the Paradyskloof site.)

Mucina & Rutherford (2004) map the vegetation on and adjacent to the Paradyskloof Farms involved in this study as Swartland Shale Renosterveld in the lower footslope and Cape Winelands Shale Fynbos on the higher footslope of Stellenbosch Mountain with Kogelberg Sandstone Fynbos on Stellenbosch Mountain itself (Figure 13). Azonal Riparian woodland occurs along the streams. The first two types are both fynbos shrublands in which small-leaved shrubs are prominent. The fynbos types differ from the renosterveld in that Restionaceae, Ericaceae and Proteaceae, amongst others, are prominent in them with less Asteraceae being present, in contrast to the renosterveld where they are abundant to dominant.

The latest South African National Biodiversity Institute data (unpublished) indicate that only 2 out of 441 national vegetation types are reduced to less than 10% of their original extent. Swartland Shale Renosterveld has about 9% left untransformed and 0.5% is formally protected, it is thus classified as being Critically Endangered and a very high priority for conservation of all remaining patches. The Cape Winelands Shale Fynbos with 52% transformed and 12% formally protected, is listed as Endangered (this is because it also has a very limited distribution range of only 8 613 ha). This classification will carry certain implications in terms of the new Biodiversity Bill, such as that any development applications within such a system will require a full Environmental Impact Assessment process. **As an absolute minimum, all planners and decision makers should consider development applications that may impact on these vegetation types very carefully indeed, and the onus is on the developer to prove why such developments are necessary in this particular area even should the vegetation require restoration.**

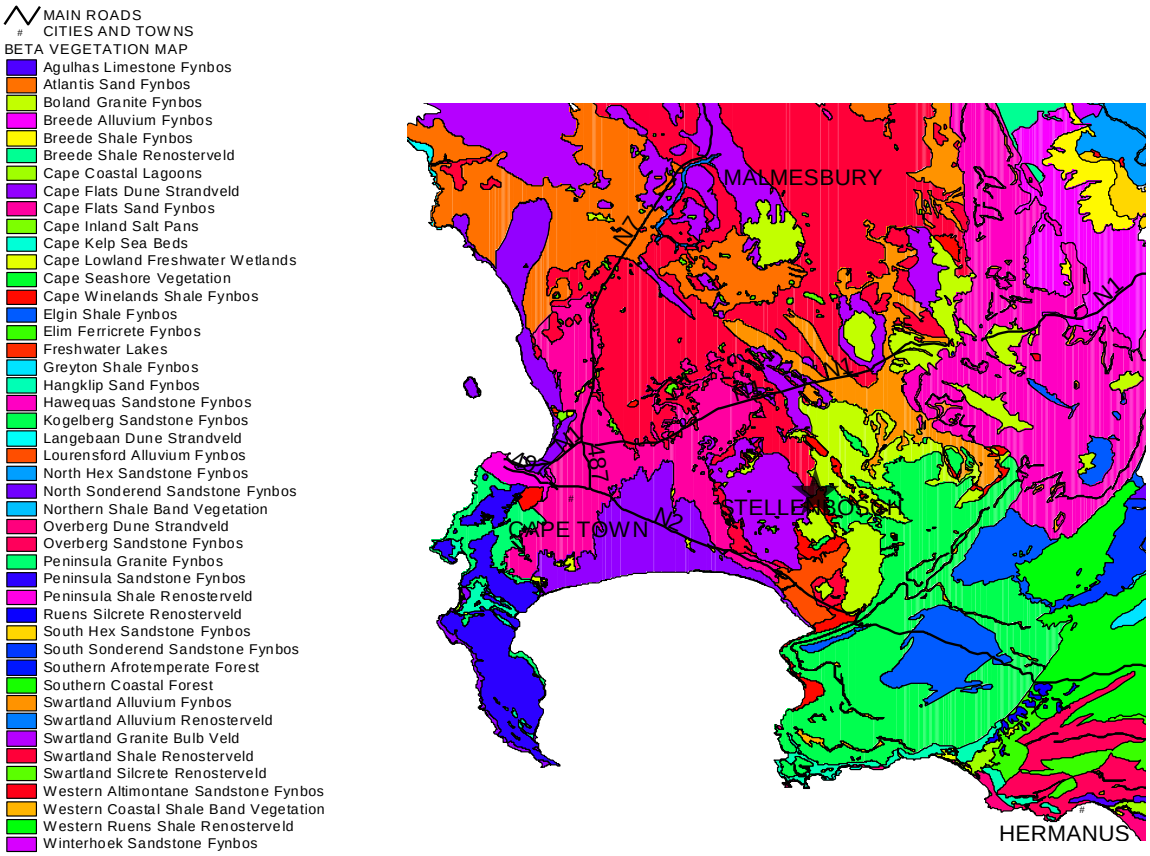

Figure 13. Vegetation map of the Western Cape (from Mucina & Rutherford, 2004). (Star indicates the location of the Paradyskloof site.)

1.2.6 Vegetation studies in Stellenbosch area

The data collected during the present study were assessed against that obtained for a wider detailed study and comprehensive literature review of the vegetation described in the Western Cape Coastal Foreland (Boucher 1987). Buys (1991) examined the species-area relationships of the flora in the Stellenbosch Region with two of his intensive study sites being immediately south of Paradyskloof on sandstone and granite-derived soil. He compiled a check-list of the flora of the region, which is useful for comparison to assess the richness of Paradyskloof.

The vegetation on site has been the subject of brief investigations by Helme (1997), with Jones (1997) supporting his evaluation of the site. Helme (1997) notes that none of the area he surveyed were “free from some sort of alien plant invasion, ..” and that “The extent of the alien plant problem on the site is one that will need much attention should the clients wish to develop the site and restore some of the natural vegetation.” His report describes what is left of the natural vegetation and does not concern itself with the original vegetation patterns in

the area, prior to the planting of pine. He identified five areas with significant different natural vegetation remaining on the site, namely:

- Area 1: Renosterveld-Fynbos community on upper slope colluvium with *Protea neriifolia* and *P. repens.*
- Area 2: Kloof wetland riparian forest with *Brabejum stellatifolium, Cunonia capensis* and *Pittosporum viridiflorum* trees and boulder bed community with *Elegia capensis, Psoralea aphylla* and *Aloe mitriformis.*
- Area 3: Renosterveld-Fynbos community on lower slopes clay alluvium.
- Area 4: Stream wetland with *Cliffortia odorata, Zantedeschia aethiopica, sedges* and grass invaded by *Acacia mearnsii, A. melanoxylon* and *Rubus* sp.
- Area 5: Foothill renosterveld with *Elytropappus rhinocerotis, Rhus angustifolia, Lichtensteinia lacera, Bobartia indica, Felicia filifolia, Erepsia ramosa Metalasia densa, Leucadendron salignum, Protea neriifolia* and *Protea repens.*

Areas 2 and 4 above were rated as being wetlands with very high and high sensitivity, respectively and their integrity should not be compromised. All Areas 1 – 5 listed above together represent 20% of the site and should be accorded a high conservation priority and sensitivity rating with development taking place outside these sites (Helme 1997).

Helme (1997) acknowledges that small populations of resilient indigenous species persist under the pine plantation canopy although he regarded none of these to be present in sufficient density to be able to call them “natural communities”. This implies that Helme did not consider areas with the potential to recover naturally should the pine plantations be removed. Milton (1977) supports his conclusion, based on a study at Jonkershoek, namely, that pine plantations have a “very severe” effect on fynbos because distinguishing elements “disappear” (only remaining as seed) leaving pioneers, such as *Xiphotheca lanceolata*, and weeds. This was confirmed by Landman & Nel, (1989) on the nearby Papegaaiberg. Reasons given for the absence of fynbos are:

- Low light intensities under a dense canopy.
- Mist condenses on the pine trees and is thus not directly available to the fynbos under them. Kerfoot (1968) notes that fynbos utilizes moisture directly from mist.
- The dense layer of pine needles covering the soil prevents the fynbos seed from germinating.
- Pine plantations reduce the strong winds required by fynbos.
- Chemical changes to the soil affect fynbos negatively.

Milton (1977) also comments that the fynbos vegetation in Jonkershoek has the potential to recover once the pines were removed as the pines do not alter the acid environment on which this fynbos occurs. This conclusion is clearly supported by the recent natural restoration of fynbos after removal of pines on the Papegaaiberg (C. Boucher pers. obs.).

Studies of terrestrial environments in the Stellenbosch Area that could include decriptions of plant communities at Paradyskloof are the following: Boucher (1987) - West Cape coast lowland transects; Buys (1991) – numerous study sites around Stellenbosch; Duthie (1929) - Stellenbosch Flats; Landman & Nel (1989) - Papegaaiberg; Lötter & Wageningen (1988) - Coetzenburg; Nel (1995) - Veldwachters River Catchment, Devon Valley; Van der Merwe (1966), McDonald (1985) and McDonald & Morley (1988) - All Swartboschkloof, Jonkershoek. Smit (1983) mapped the alien vegetation against the slopes of Stellenbosch Mountain.

Studies specifically of rivers around Stellenbosch were undertaken by : Brown & Dallas (1995) - Eerste River; Gale (1998) - Paradyskloof Rivers; Grindley (1982) Eerste Estuary; McDowell (1996) - Eerste River; Nel (1995) - Veldwachters River; Salie (1995) - Eerste River; Salie (2003) Jonkershoek River; Sieben (2003) Rivers in Hottentots Holland Mountains; Wahl (1986) - Eerste River; Werger *et al.* (1972) and McDonald (1985) - Swartboschkloof.

Detailed results of the Lötter & Van Wageningen (1988) study of the vegetation above Coetzenburg, on the lower slopes of Stellenbosch Mountain are presented here because this is the nearest detailed study to Paradyskloof, although it was for a generally drier more northerly aspect and principally on granites. (There are numerous similarities to the communities described from the Paradyskloof Site.) Their communities are compared to others that are relevant and are described from the Stellenbosch area.

Communities on Sandstone

- *Leucadendron salignum—Eremia totta* Community. This short closed shrubland occurs on sandstones. Dominant species included *Eremia totta, Thamnochortus punctatus, Tetraria ustulata, Restio filiformis, Erica imbricata, Cliffortia ruscifolia, Protea neriifolia, Metalasia muricata, Dodonaea viscosa* subsp. *angustifolia* and *Anthospermum aethiopicum.* The presence of *Eremia totta, Thamnochortus punctatus, Oxalis incarnata* and *Merxmuellera lupulina* are diagnostic (Lötter & Van Wageningen 1988).

Dryland communities on granites

- *Leucadendron salignum—Protea repens* Community. *Olea europaea* tree clumps are scattered through the community. This mixed fynbos and low closed shrubland and thicket mosaic is found on dry, north-facing, granite-derived soils, in areas left fallow for about 65 years. Dominant species included *Protea repens, Heteropogon contortus, Leucadendron salignum, Hermannia scabra, Erica imbricata, Cliffortia ruscifolia, Metalasia muricata, Elytropappus rhinocerotis, Dodonaea viscosa* subsp. *angustifolia, Ischyrolepis capensis, Aristea major* and *Eriocephalus africanus.* The presence of *Protea repens, Heteropogon contortus, Clutia polifolia, Hermannia flammea* and *Hibiscus aethiopicus* are diagnostic. Stock grazed in this community in the historic past. Invasive plants are common (Lötter & Van Wageningen 1988).
- *Elytropappus rhinocerotis—Crassula cymosa—Erica imbricata* Community. This low open shrubland occurs on dry, north-facing, intermediate depth, granite-derived soils. Dominant species include *Elytropappus rhinocerotis, Dodonaea viscosa* subsp. *angustifolia, Anthospermum aethiopicum, Eriocephalus africanus* and *Rhus angustifolia.* The presence of *Crassula cymosa, Erica paniculata* and *Erica imbricata* are diagnostic. Stock grazed in this community in the historic past. This community probably represents an undisturbed form of the *Leucadendron salignum—Protea repens* Community (Lötter & Van Wageningen 1988).
- *Elytropappus rhinocerotis—Crassula cymosa* Community. This low, open, shrubland occurs on a northerly aspect on very shallow clayey soils with granite sheet-rock exposed in places. Dominant species include *Erica paniculata, Spiloxene flaccida, Elytropappus rhinocerotis, Dodonaea viscosa* subsp. *angustifolia, Eragrostis curvula, Eriocephalus africana* and *Mohria caffrorum.* The presence of *Crassula cymosa* and *Erica paniculata* are diagnostic. Virtually no invasive species were recorded in this community suggesting a history without major substrate disturbances, probably because the shallow soils could not be tilled (Lötter & Van Wageningen 1988).
- *Elytropappus rhinocerotis—Athanasia trifurcata* Community. This short closed shrubland occurs on very deep granitic soil. Dominant species include *Athanasia trifurcate, Elytropappus rhinocerotis, Dodonaea viscosa* subsp. *angustifolia*, *Plagiochloa uniolae, Chrysanthemoides monilifera, Helichrysum crispum, Rhus angustifolium, Oxalis pes-caprae, Merxmuellera stricta, Stoebe plumose, Anthospermum aethiopicum* and *Eriocephalus africanus.* Two subcommunities based on the presence or absence of either *Pinus radiata* or alternatively, *Leysera gnaphalodes,* forming a mosaic, are distinguished. The presence of *Leysera gnaphalodes* is diagnostic of one subcommunity. There are no diagnostic species of

the community as a whole. The area was cultivated in the historic past (approximately 65 years ago) (Lötter & Van Wageningen 1988).

Wetland and Stream Communities

Five variations of Boucher's (1987) *Polygono—Cliffortietum odoratae* Wetland and Riparian community described in the area include:

- *Cliffortia odorata—Prionium serratum* Community (Lötter & Van Wageningen 1988).
- *Cliffortia odorata—Selago corymbosa* Community (Lötter & Van Wageningen 1988).
- *Cliffortia odorata—Kiggelaria africana* Community (Lötter & Van Wageningen 1988).
- *Polygonum salicifolium—Cliffortia odorata* Riverine Shrubland (Nel 1995).
- *Pteridium aquilinum—Cliffortia odorata* Closed Tall Shrubland (Sieben 2003).

Riparian Scrub Forests found in the area include:

- *Polygonum salicifolium—Kiggelaria africana* Riverine Thicket Community containing the *Kiggelaria africana—Populus canescens—Ehrharta erecta* Riverine Thicket Subcommunity (Nel 1995).
- *Brabejum stellatifolium* Riparian Scrub Forest. A number of variations of this riparian forest have been described along the Eerste River and its tributaries (McDonald 1985; Salie 1995; Salie 2003; Sieben 2003; Wahl 1986 and Werger *et al.* 1972).

2. Methods

2.1 Vegetation

This report is based on data assimilated during monthly collecting expeditions through the site over a period of a year. Sample sites were located subjectively to obtain a representative sample of the vegetation.

The Braun-Blanquet phytosociological method (Werger 1974) was used to sample and analyse data collected from the study area. This method uses subjectively chosen representative sites to sample the vegetation in an area.

The following Braun-Blanquet cover-abundance values (Boucher 1987) were attributed to species recorded in the remaining patches of vegetation, as follows:

R = Few individuals with a cover of less than 0.1% of the area.

\+ = Occasional plants but with a cover of less than 1% of the area.

1 = Many plants but with a cover of less than 1%, or a few plants but with a cover of 1-5% of the area.

2 = Many plants with a cover of 1-5% or any number of plants with a cover of 6-25%.

3 = Any number of plants with a cover of 26-50% of the area.

4 = Any number of plants with a cover of 51-75% of the area.

5 = Any number of plants with a cover of 76-100% of the area.

Data refinement was undertaken using manual tabulation procedures to identify communities. Photo-images were used to correlate members of phytosociological groups (communities) to each other and to deduct boundaries between the groups. Structural terminology used is based on that used in the wider context of the Fynbos Biome (Campbell *et al*., 1981).

The communities are recognised and described on the basis of the presence or absence of defining species determined following Braun-Blanquet phytosociological principles.

A vegetation map showing the distribution of plant communities is used to determine the area and percentage contribution of each plant community to the study area. Vegetation units identified are then compared to published and unpublished vegetation descriptions or other relevant information for the area and to existing databases to determine their wider distribution.

Exotic invasive plants have been recognized for some years as a major threat to the vegetation in the Cape (Stirton 1978) and the Paradyskloof area in the Western Cape is no exception.

The Vegmap database, together with unpublished local detailed studies by the author of this report and others (see Reference list), provide an adequate basis against which to measure the findings presented here.

2.2 Flora

Plants were collected through the area intermittently over two years, firstly by Pienaar (2005) and secondly by the author of this report. The author traversed through different habitats on a monthly basis collecting flowering material and dispatching pressed specimens to the South African National Biodiversity Institute (SANBI) at Kirstenbosch for identification. Names used in this report are based on those identifications received from SANBI. A complete checklist for the area would take a number of years to compile as species flower in

different post-fire cycles and this study has not covered a full cycle, yet it is reasonably complete for the area. The rarity status attributed to each rare and endangered species recorded from the area is taken from information published by Hilton-Taylor (1996), in the Red Data List for Southern African plants, namely:

Extinct = Taxon no longer known to exist in the wild.

Endangered = Taxon in danger of extinction and whose survival is unlikely if the causal factors continue operating.

Vulnerable = Taxon believed likely to move into the endangered category in the near future if the factors causing decline continue operating.

Rare = Taxon with small world populations that is not at present endangered or vulnerable, but is at risk as some unexpected threat could easily cause a critical decline. These taxa are usually localized within restricted geographical areas or habitats, or are thinly scattered over a more extensive range.

Indeterminate = Taxon known to be extinct, endangered, vulnerable or rare, but for which information is insufficient to decide which of the four categories is appropriate.

Insufficiently known = Taxon that is suspected but not definitely known to belong to any of the above categories, because of lack of information.

Not threatened = Taxon no longer in one of the above categories due to an increase in population sizes or to subsequent discovery of more individuals or populations. A change in numbers could result in them again being given one of the above rankings.

No information = Taxon for which there is no information available.

A further detailed assessment of identified endangered species found at the site entails traversing the area and recording the specific location of individuals or of populations of the species using a Global Positioning instrument. Generally plant communities can be rated in respect of their rarity status on the number of rare and endangered species located within them. The more rare species they contain, the more endangered the community is rated.

3. Results

3.1 Vegetation

Thirty three sample sites, approximately 50 m² in extent, were selectively distributed through the whole area using the Braun-Blanquet method (Figure 14). Data recorded in the sample plots are included in Table 1 (Appendix A).

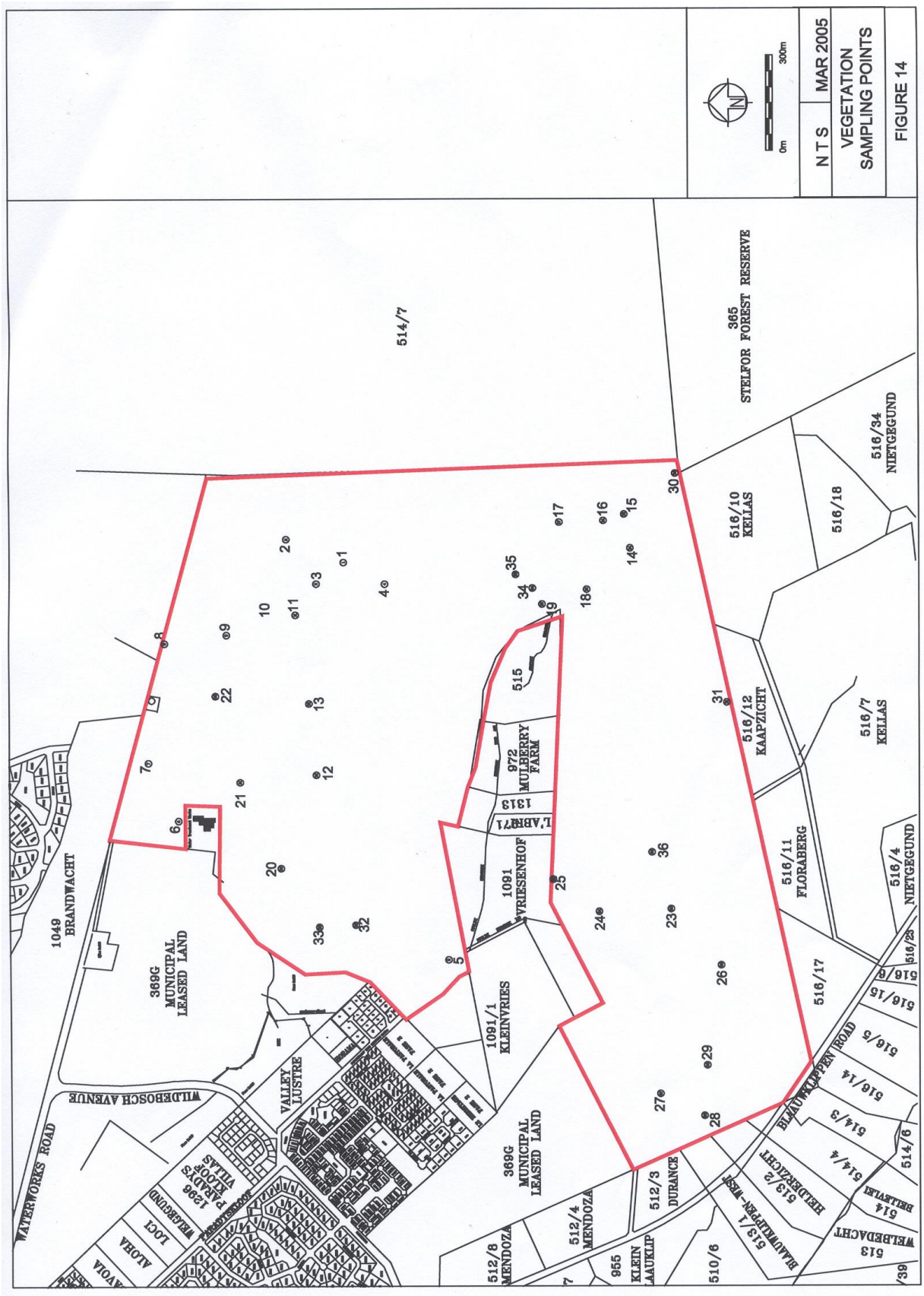

Figure 14: Map showing the distribution of vegetation sampling points.

Very little natural vegetation remains on the site as is indicated in the land use map (Figure 15). Pine plantations have been established over most of the area. Extensive parts of the plantations were burnt by a wild-fire in December 2003. Plantations damaged by the fire have been clear-felled during 2004-2005.

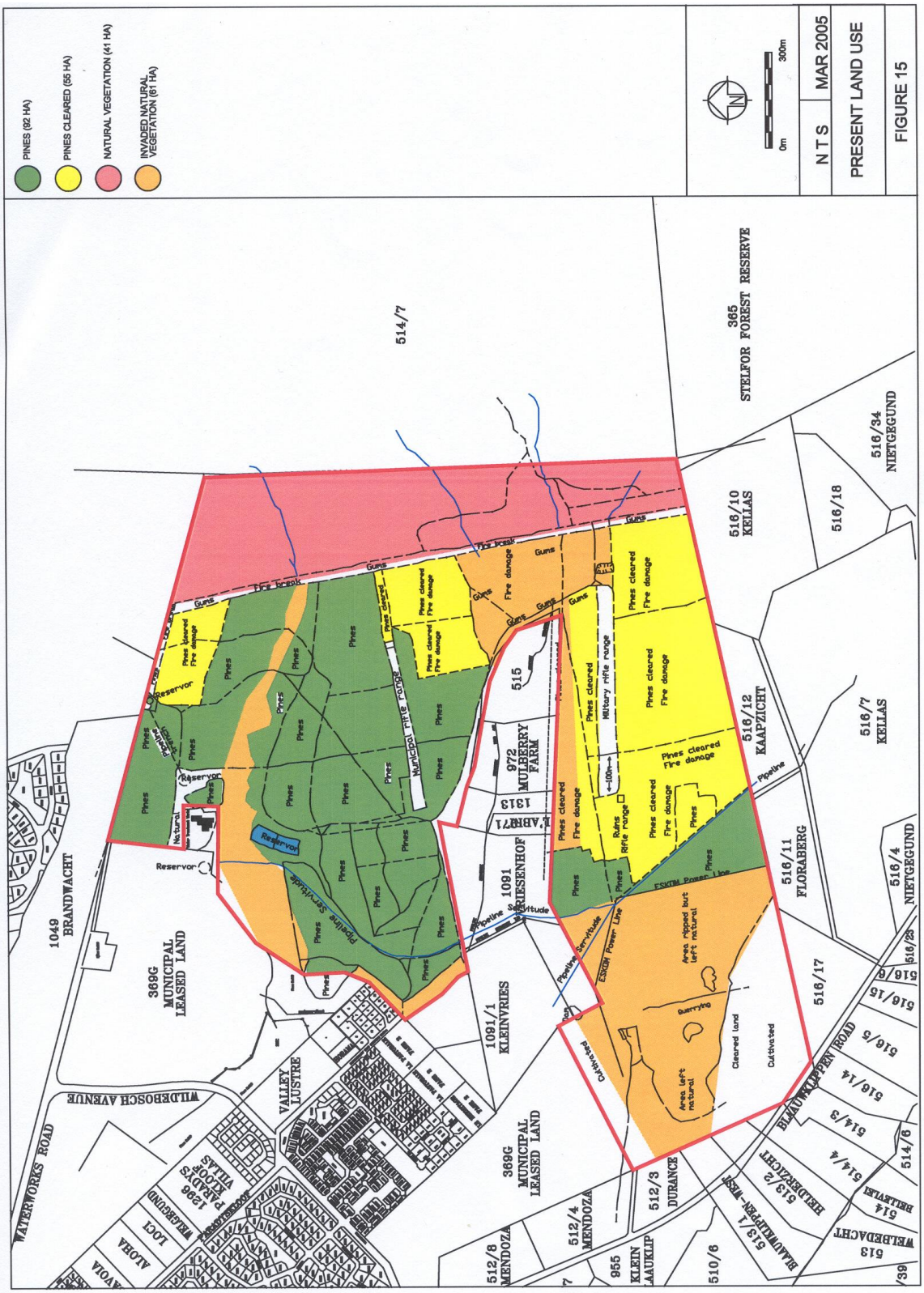

Figure 15: Land use map of Paradyskloof Golf Estate showing pine plantations and areas subsequently clear-felled.

The degree of disturbance and invasion makes it extremely difficult to determine or map the potential extent of different vegetation types. Five plant communities identified on site are described below. Their distribution is illustrated in Figure 16.

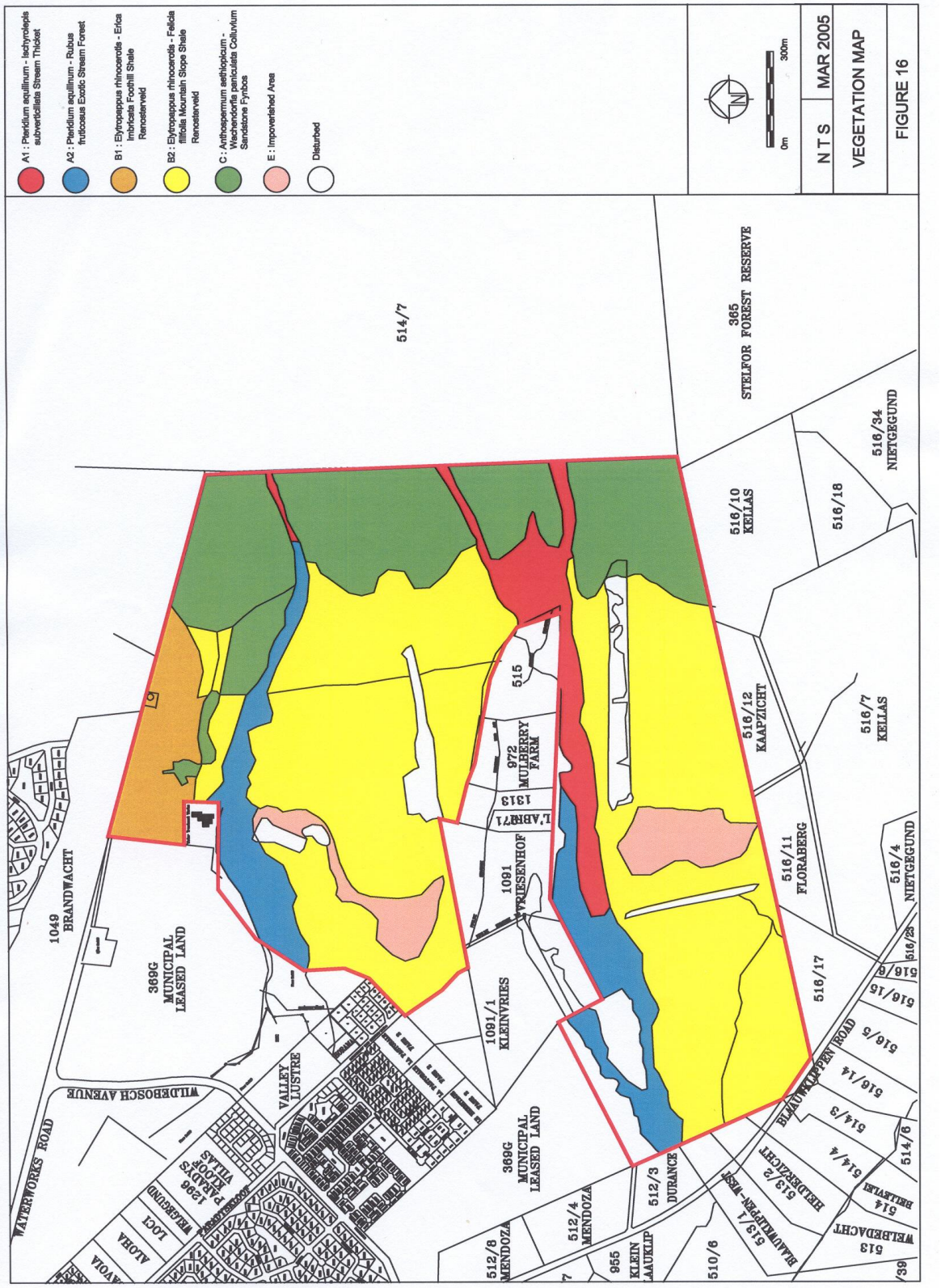

Figure 16: Vegetation map showing distribution of plant communities.

3.1.1 Description of plant communities

The following plant communities were identified on the site)

Classification

The following communities described from the site exclude anthropogenic communities such as occur on farm lands, quarries, other recently disturbed areas and dams. Vegetation under pine plantations were sampled, despite its impoverished nature through silvicultural activities:

A *Pteridium aquilinum–Cliffortia odorata* Stream Community

B *Typicum Elytropappus rhinocerotis* Shale Renosterveld Shrublands

C *Anthospermum aethiopicum–Wachendorfia paniculata* Colluvium Sandstone Fynbos

3.1.1.A *Pteridium aquilinum–Cliffortia odorata* Stream Community

Group A in Table 1 (Appendix A) with 12 samples was used to characterize this community which is mapped as Units A1 and A2 in Figure 16. Sample 6, a transitional sample, contains elements of this group together with those of community B1, the *Elytropappus rhinocerotis–Erica imbricata* Foothill Shale Renosterveld, and is considered to be transitional between Groups A and B.

Classification

A1 *Pteridium aquilinum–Ischyrolepis subverticillata* Stream Thicket

A2 *Pteridium aquilinum–Rubus fruticosus* Exotic Stream Forest

The two communities in this group are together characterized by the presence of the following species (Table 1): *Cliffortia odorata, Cortaderia seloana, Paraserianthes lophantha, Pennisetum macrourum, Pteridium aquilinum, Senecio pterophorus* and *Zantedeschia aethiopica*.

3.1.1.A1 *Pteridium aquilinum–Ischyrolepis subverticillata* Stream Thicket

The following five vegetation samples in Group A1 in Table 1 (Appendix A) were used to characterize this community: 17, 19, 24, 34 and 35. The distribution of the sample plots is shown in Figure 14 and that of the community in Figure 16.

This community occurs in the rivers and streams that are wet or have running water throughout the year. The alluvial substrate is composed of silts, sands, gravels and boulders (Figure 4) (Mountain & Partners 1997).

Up to four strata are found in this community. The emergent dense low, 3–5 m tall tree stratum is dominated by *Brabejum stellatifolium, Ilex mitis, Maytenus oleoides* and *Metrosideros angustifolius* in the natural state in the upper reaches and *Olea europaea* subsp. *africana* together with *Kiggelaria africana* in the lower reaches (Figure 17) with *Acacia longifolia, Acacia saligna* and *Eucalyptus saligna* being conspicuous where the natural vegetation is disturbed and invasion by exotic tall shrubs and trees has taken place (Figure 18). More common tall shrubs include *Freylinia lanceolata* and *Rhus angustifolia*. A scattered low shrub stratum is formed by *Halleria elliptica* where there is a dense canopy, while impenetrable large stands of *Cliffortia odorata* (Figure 19) occur in patches without trees and shrubs. *Othonna quinquedentata* is conspicuous here in the first two years after a fire before larger shrubs and trees close the canopy again. The open herbaceous stratum is formed by *Ischyrolepis subverticillatus* and *Mariscus thunbergii* nearer the stream, while dense stands of the fern, *Pteridium aquilinum* form along the outer margins of the water courses (Figure 20). The sedge, *Isolepis prolifer*, commonly occurs in the shallow running water and wet soils of the streams.

Characteristic species regularly recorded in this community in the study area are (Table 1): *Brabejum stellatifolium, Halleria elliptica, Ischyrolepis subverticillatus, Mariscus thunbergii, Othonna quinquedentata* and *Podalyria calyptrata.*

A number of variations of the *Cliffortia odorata* community occur in the Western Cape around Stellenbosch. These have been summarized in the introduction to the vegetation of the area. This vegetation plays an important role in protecting the soil against erosion as well as providing refuge to birds, such as the rare flufftail population at Grootte Zalze lower down the Paradyskloof River.

Extensive dense riparian stands of *Olea europaea* subsp. *africana* thicket are rarely found in the Western Cape. The example illustrated in Figure 17 represents a relict of this once common vegetation type and must be cleared of woody alien invasive species and be afforded very high conservation status.

Figure 17. *Olea europaea* subsp. *africana* forms a dense thicket along the lower reaches of the Blaauwklippen River.

Figure 18. *Eucalyptus saligna* is conspicuous where the natural vegetation is disturbed and invasion by exotic tall shrubs and trees has taken place

Figure 19. *Cliffortia odorata* forms dense tangled stands, particularly along the lower sections of the rivers on the property.

Figure 20. Dense stands of the ferm *Pteridium aquilinum* occur in wetlands along river banks.

3.1.1.A2 *Pteridium aquilinum–Rubus fruticosus* Exotic Stream Forest

The following six vegetation samples in Group A2 in Table 1 (Appendix A) were used to characterize this community: 2, 11, 20, 21, 25 and 27. The distribution of the sample plots is shown in Figure 14 and that of the community in Figure 16.

This community mainly occurs along the disturbed wetland streams on alluvial terrace silts, sands, gravels and boulders (Mountain & Partners 1997). It is best developed in openings between the plantations, such as along the roads and tracks. It has been disturbed during construction of the water filtration plant and remnant building material occurs in the community at this point.

This wetland community represents a highly invaded and disturbed form of the *Pteridium aquilinum–Ischyrolepis subverticillata* Stream Thicket. The dominant tree stratum is generally formed by *Pinus radiata* in plantations, with remnants of the natural community beneath (Figure 21, 22). Typical dominant shrubs still remaining in the streams in the plantations are: *Cliffortia odorata, Pittosporum undulatum, Senecio pterophorus, Rhus angustifolia* and *Pinus radiata* juveniles.

This disturbed community is characterised by the following species in Table 1:
Rubus fruticosus, Quercus robur, Verbena bonariensis and *Juncus acutus.*

Figure 21. The dominant tree stratum is generally formed by *Pinus radiata* in plantations, with remnants of the natural community beneath

Figure 22. *Pittosporum undulatum* amongst *Populus canescens* and an incised stream channel along the lower reaches of the Paradyskloof River.

The invaded nature of the streams on this property is unfortunate but is also typical for the lower foothill streams of the Western Cape. Controlling the exotic invasive species and removing plantations from the close proximity to the stream will result in increased summer flows as the exotic species are known to utilize far more water than the natural vegetation. Allowing the natural vegetation to return will also assist in the reduction of the incision by the river illustrated in Figure 22, which is the direct consequence of exotic vegetation.

3.1.1.B *Typicum Elytropappus rhinocerotis* Shale Renosterveld Shrublands

Vegetation Groups B1 and B2 in Table 1 (Appendix A) were used to characterize this community. Sample 36 is unassigned because it was burnt during December 2003 and was subjected to an additional heavy disturbance with the subsequent plantation clear-felling operation during February-March 2005.

Classification

B1 *Elytropappus rhinocerotis–Erica imbricata* Foothill Shale Renosterveld

B2 *Elytropappus rhinocerotis–Felicia filifolia* Mountain Slope Shale Renosterveld

Scattered to dense pines form an emergent tree stratum some 10-30 m tall. The naturally dominant 1.2 m tall shrub stratum is formed by *Anthospermum aethiopicum, Cliffortia ruscifolia, Elytropappus rhinocerotis* and *Rhus angustifolia*. Grasses conspicuous in the 0.3 m tall herb stratum include *Cymbopogon marginatus, Eragrostis curvula, Themeda triandra* and *Tribolium uniolae.* Annual exotic grasses, such as *Briza maxima* and *Bromus japonicus* are common in disturbed areas.

Characteristic species (Table 1) include *Cliffortia ruscifolia, Elytropappus rhinocerotis, Tetraria ustulata* (Boucher 7122) and *Helichrysum crispum*.

3.1.1.B1 *Elytropappus rhinocerotis–Erica imbricata* Foothill Shale Renosterveld

The following three vegetation samples in Group B1 in Table 1 (Appendix A) were used to characterize this community which is mainly under pine plantations: 7, 8 and 28. The distribution of the sample plots is shown in Figure 14 and that of the community in Figure 16.

This community mainly occurs along the lower ridge in the northern sector. It is best developed in openings between the plantations, such as along the roads and tracks. It has been disturbed during construction of the water filtration plant and remnant building material occurs in the community at this point.

The substrate supporting this community is described as colluvium overlying completely weathered phyllites and greywackes (Malmesbury Group shales) (Mountain & Partners 1997).

Species characteristic of this community are (Table 1): *Arctotis acaulis*, *Adenandra umbellata* (Boucher 7194), *Cotula turbinata* and *Erica imbricata*.

Four strata are regularly present in this community on site, namely, a scattered to mid-dense tree stratum formed by invasive exotic *Pinus pinaster* with different cohort sizes of trees and juveniles depending on fire frequencies. Common medium-tall small-leaved shrubs found here include *Anthospermum aethiopicum*, and *Passerina vulgaris*. *Erica imbricata* and *Eriocephalus africanus* form a low shrub stratum (Figure 23). The restio *Ischyrolepis capensis* and *Ischyrolepis sieberi* occur together with the indigenous grasses *Eragrostis curvula* and *Tribolium uniolae* in the herb layer. The exotic annual grass *Briza maxima* is common where the vegetation has been disturbed. Annuals, including *Ursinia anthemoides* and geophytes, such as *Micranthus tubulosus*, amongst others, are conspicuous in spring.

A closely related community has been described by Lötter and Van Wageningen from above Coetzenburg, except that that is on a different substrate, namely Cape Granites while the substrate at this site is Malmesbury Shale. The consequence is the presence of a different nutrient status and a different species assemblage at Paradyskloof. Elsewhere in the Western Cape this community has been destroyed through agriculture except for tiny threatened remnants, such as in the Onder Papegaaiberg suburb of Stellenbosch.

Figure 23. *Erica imbricata* and *Eriocephalus africanus* form a low shrub stratum in the *Elytropappus rhinocerotis–Erica imbricata* Foothill Shale Renosterveld

3.1.1.B2 *Elytropappus rhinocerotis–Felicia filifolia* Mountain Slope Shale Renosterveld

The following 13 vegetation samples in Group B2 in Table 1 (Appendix A) were used to characterize this community: 3, 4, 5, 9, 12, 13, 22, 23, 26, 29, 31, 32 and 33. The distribution of the sample plots is shown in Figure 14 and that of the community in Figure 16.

This community occurs in the lower foothills to rolling hills of the area on loamy sand with lateritic pebbles and washed talus gravels overlying completely weathered phyllites or greywackes (Malmesbury Group shales) (Mountain & Partners 1997).

Characteristic species to identify this community are (Table 1): *Athanasia trifurcata, Cliffortia cuneata, Felicia filifolia, Oxalis pes-caprae, Tetraria cuspidata* and *Xiphotheca lanceolata.*

Four to five strata are conspicuous with the following dominant and conspicuous species in each (Figure 24): A scattered to dense talll shrub and tree stratum formed by exotic *Acacia saligna* and *Pinus pinaster* trees and saplings with indigenous *Maytenus oleoides* and *Olea europaea* subsp. *africana* trees; a 2.5-3.5 tall open shrub stratum formed by *Dodonaea viscosa* subsp. *angustifolia*; a dense 1.0-1.3 m tall shrub stratum of *Anthospermum aethiopicum*, *Chrysanthemoides monilifera, Cliffortia ruscifolia, Elytropappus rhinocerotis, Eriocephalus africanus, Passerina vulgaris Rhus angustifolia, Rhus tomentosa* and *Salvia africana-caerulea*; a mid-dense 0.5 m tall shrub and herb stratum in which *Asparagus rubicundus, Briza maxima, Ehrharta calycina, Ischyrolepis capensis, Mohria caffrorum* and *Tribolium uniolae*.

Lower parts of the southern section have been cross ripped in preparation for cultivation. This disturbance has allowed invasive plants to intrude here, but only to a relatively minor and easily controllable extent (Figures 24 & 25).

A threatened Red Data Book species *Xiphotheca lanceolata*, with a rarity status of Indeterminate, was recorded throughout this community (see section 3.4.1).

This community is extremely rare in the undisturbed state anywhere over its distribution range because it has high agricultural potential and it has therefore been reduced to the extent that very little remains in the Western Cape. **This implies that this community must not be reduced any more and that the lightly disturbed areas on this property should be restored forthwith and added to the conservation area**.

Figure 24. *Elytropappus rhinocerotis–Felicia filifolia* Mountain Slope Shale Renosterveld

Figure 25. *Elytropappus rhinocerotis–Felicia filifolia* Mountain Slope Shale Renosterveld invasion by invasive plants such as, *inter alia, Pinus pinaster* is assisted by disturbance through local ripping of the soil.

3.1.1.C *Anthospermum aethiopicum–Wachendorfia paniculata* Colluvium Sandstone Fynbos

The following six samples form vegetation Group C in Table 1 (Appendix A) and were used to typify this community: 1, 14, 15, 16, 18 and 30. The distribution of the sample plots is shown in Figure 14 and that of the community in Figure 16. All sites had been burnt less than two years prior to sampling.

The substrate supporting this community is given as talus boulders overlying completely weathered phyllites and greywackes (Malmesbury Group shales) (Mountain & Partners 1997). The location of the community nearer Stellenbosch Mountain implies that it receives fractionally more rain than the lower parts and is currently more exposed to the weather as it is above the plantations.

All areas supporting this community were burnt less than two years before sampling and the mature vegetation is inferred here. The rejuvenating form of this community is characterized by the presence of the following species in Table 1: *Arctotis hirsuta, Ornithogalum sp. (Boucher 7264), Othonna quinquedentata, Scirpus lateralis, Pseudoselago subglabra, Tetraria compar* and *Wachendorfia paniculata*.

The mature uninvaded form of this community is illustrated in Figure 26 while young vegetation recovering after the December 2003 fire is illustrated in Figure 27. Disturbance from the clear-felling of the burnt pine plantation in this community results in a slow recovery rate (Figure 28).

Dominant and conspicuous species recorded in the burnt community include: *Berkheya herbacea, Bobartia indica* (Boucher *7244*), *Ehrharta calycina, Dodonaea viscosa subsp. angustifolia, Leucadendron salignum, Micranthus tubulosus, Pelargonium alchemilloides, Rhus rosmarinifolius* and *Salvia africana-caerulea.* The mature form of this community (Figure 26) would have at least two strata, with *Dodonaea viscosa* subsp. *africana* and *Protea repens* forming the conspicuous emergent tall shrub stratum. *Leucadendron salignum* would be an important conspicuous plant in the low shrub stratum. The geophyte, *Bobartia indica*, remains conspicuous even in the mature community. *Eucalyptus saligna* seedlings were abundant in the regenerating community and do not bode well for the future of this community if extensive alien regeneration control is not instigated soon and maintained in a management programme.

Theiranthus racemosus, a threatened Red Data Book species with a rarity status of “Rare”, was recorded at site 15 in this community.

The wider distribution of this community is not clear as it hasn’t been described as such, previously in the literature. A fynbos vegetation type associated with underlying shales, however, is an unusual remnant in the Western Cape as it is generally converted to agricultural lands. **This suggests that it is a rare plant community worthy of high conservation attention.**

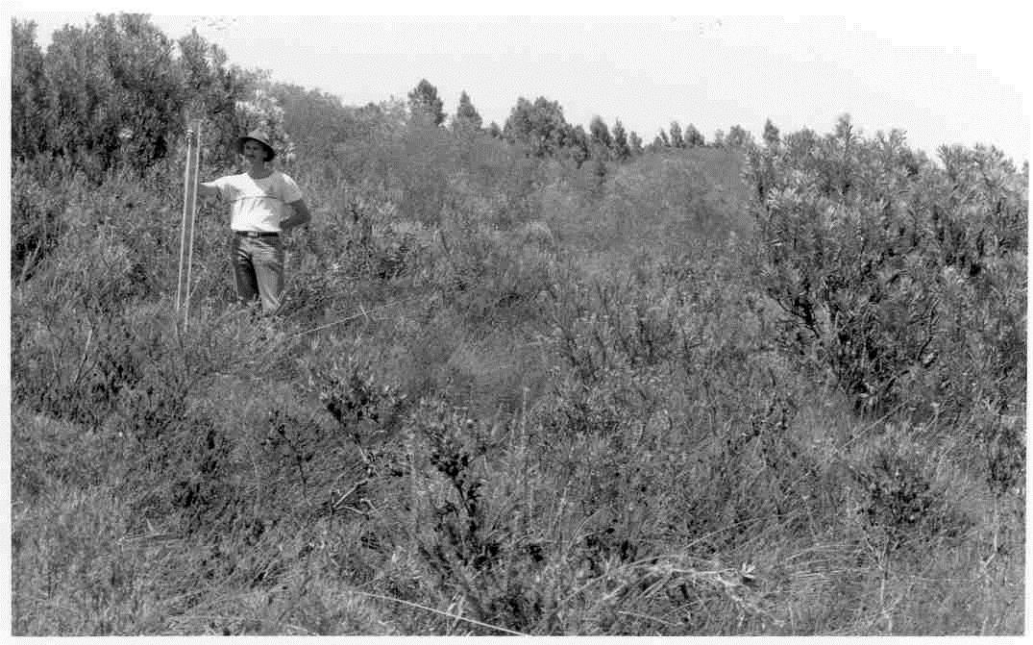

Figure 26. Mature vegetation in *Anthospermum aethiopicum–Wachendorfia paniculata* Colluvium Sandstone Fynbos immediately south of Paradyskloof photographed in 1991. *Protea repens* shrubs are conspicuous emergents in the foreground. Invading pines are visible in the centre distance.

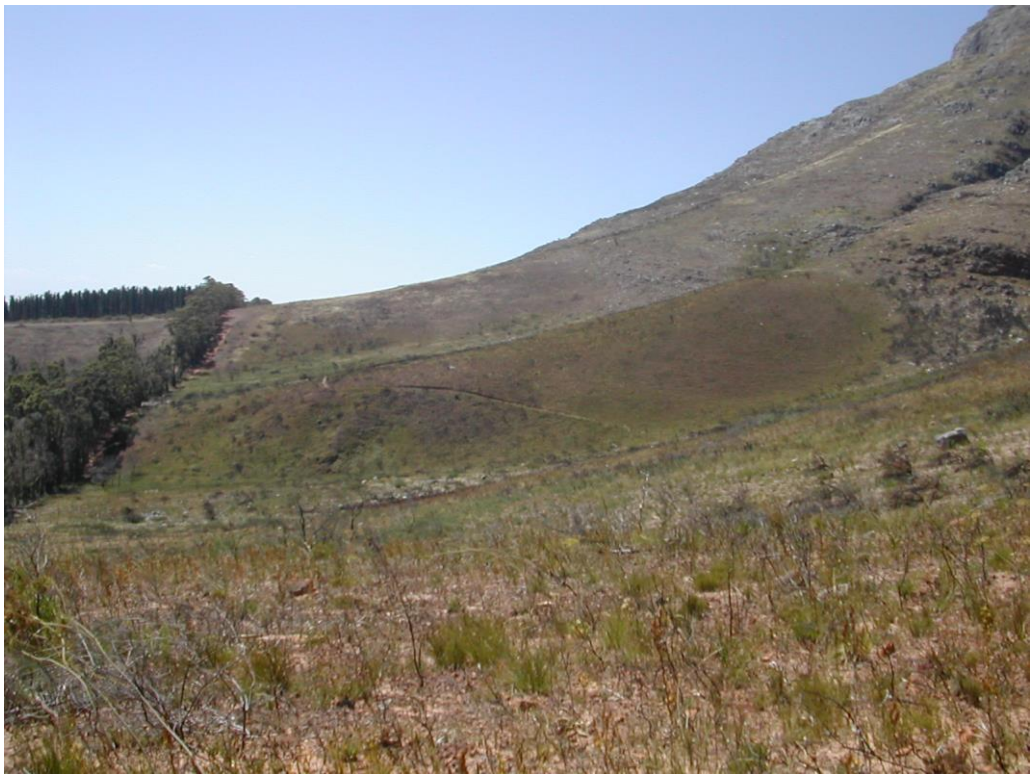

Figure 27. *Anthospermum aethiopicum–Wachendorfia paniculata* Colluvium Sandstone Fynbos along the upper footslope of Stellenbosch Mountain. The area above the *Eucalyptus* firebreak is to be kept in a natural state as a conservation area.

Figure 28. *Anthospermum aethiopicum–Wachendorfia paniculata* Colluvium Sandstone Fynbos recovering after fire and clear-felling of pines. Note the hollow created by ground-fire burning a pine stump in the centre right of the illustration.

3.2 Alien vegetation

Most of the riparian areas are invaded to differing degrees by alien invader plants. Their exact extent has not been quantified except in the case of pine plantations which originally covered ?? ha of the 277 ha of the site (Figure 15). Fortunately, fynbos restores itself well and relatively rapidly from seed banks in the soil, while remnant plants rejuvenate and seed again, once the alien plants are removed.

The wetland sponges at the source of the streams are badly invaded with juvenile invader alien plants particularly *Acacia longifolia, Acacia mearnsii, Acacia saligna* and *Paraserianthes lophantha* following the December 2003 wild fire. These will have to receive urgent attention to control them before they create dense thickets that shade out indigenous plants and lead to increased biomass and very hot environmentally damaging run-away fires. The areas that were bared for use as shooting ranges and roads through the plantations generally require considerably more effort and expense to return them to indigenous vegetation.

Low weirs in the streams are not particularly intrusive. The withdrawal of all the water from the streams during the height of the dry season is problematic and it is generally accepted that this results in the invasion of riparian areas by exotic invader species which start a generally negative spiral as they block streams during floods and cause erosion as well as using more water than indigenous plants.

3.3 Assessment of importance of vegetation

Riparian systems rate as the most threatened ecosystems in South Africa. They must be afforded highest protection status. The function of instream and bank riparian vegetation in maintaining stability in rivers, ameliorating flows and cleansing water, a scarce commodity in this drought-prone region, emphasises the importance of this ecosystem.

Two wetland stream communities are identified on the site within the *Pteridium aquilinum–Cliffortia odorata* Stream Community, namely the *Pteridium aquilinum–Ischyrolepis subverticillata* Stream Thicket and the *Pteridium aquilinum–Rubus fruticosus* Exotic Stream Forest. The first is particularly threatened throughout the biome with relatively few sites remaining where it is reasonably intact. (See summary of known localities in the vegetation introduction). Every effort must be made to ensure that this lowland stream community receives a high protection status. The *Pteridium aquilinum–Rubus fruticosus* Exotic Stream Forest is in a badly invaded and disturbed state but, nevertheless, has considerable potential

for restoration as most of the constituent species complements are still present. Recent restoration efforts by, *inter alia*, "Working for Water" in similar habitats has shown great success, particularly where the workers have been properly informed about species identities and management techniques, such as the removal of cut material from the riparian zone. **A minimum 30 m buffer zone must be maintained around all stream communities.**

The West Coast Renosterveld (Veld Type 46 of Acocks 1988; Low & Rebelo 1996), or Boland Coast Renosterveld (Cowling & Heijnis 2001), is reduced to less than 3% of its former extent. **This vegetation types is regarded as 100% irreplaceable in terms of the CAPE rankings** (Cowling *et al* 1998), which means that all remaining examples of this vegetation type are needed in order to achieve regional conservation targets. This vegetation has now been redefined and subdivided and, potentially, the Swartland Shale Renosterveld and Cape Winelands Shale Fynbos (Mucina & Rutherford 2004) occur on the site. Two Shale Renosterveld Shrubland communities were identified and described on the Paradyskloof site in the present study, namely, the *Elytropappus rhinocerotis–Erica imbricata* Foothill Shale Renosterveld and the *Elytropappus rhinocerotis–Felicia filifolia* Mountain Slope Shale Renosterveld. **Swartland Shale Renosterveld has about 9% left untransformed and 0.5% is formally protected, it is thus classified as being Critically Endangered and a very high priority for conservation of all remaining patches**. This classification will carry certain implications in terms of the new Biodiversity Bill, such as that any development applications within such a system will require the full Environmental Impact Assessment process. As an absolute minimum, all planners and decision makers should consider development applications that may impact on these vegetation types very carefully indeed, even if they require some rehabilitation, and the onus is on the developer to prove why such developments are necessary where these vegetation types occur.

No Cape Winelands Shale Fynbos was found on the site but an undescribed variation of Kogelberg Sandstone Fynbos, the *Anthospermum aethiopicum–Wachendorfia paniculata* Colluvium Sandstone Fynbos was found and described. This is closely related to the *Leucadendron salignum—Eremia totta* Community described by Lötter & Van Wageningen (1988) above Coetzenburg.

The Colluvium Fynbos on site is rich in species and the vegetation is generally in excellent condition. The most important features of this vegetation are that it is contiguous with the Hottentots Holland Nature Reserve and is a prime conservation candidate and secondly that three streams have their source here. The natural vegetation thus has a primary role to play in ensuring a stable water supply to the downstream communities.

3.4 Flora

The list of species (Appendix A, Table 2) contains all the species recorded from the area during this year-long study, namely 374 species to date from 277 ha, that is largely under pine plantation. This number of species is comparable in richness to the 651 vascular plants recorded from 373 ha of well studied, undisturbed natural vegetation in the nearby Swartboschkloof Nature Reserve, Jonkershoek (McDonald & Morley 1988) and the 1800 species listed by Buys *et al.* (1991) in the 240—250 km^2 Stellenbosch area.

Specimens that are still unnamed at the time of writing this report are identified by reference to the collection number given to each during the present survey (e.g. Boucher 6720). Unusual plants usually take longer to be identified as specialists have to be consulted individually and, in most instances, have to wait until the relevant taxa are studied again sometime in the future. The bulbous and annual floras appear to be particularly rich in rare or endemic species in this particular area.

3.4.1 Rare and endangered species

Two threatened Red Data Book species were recorded on site, namely *Theiranthus racemosus* (rarity category = Rare) and *Xiphotheca lanceolata* (rarity category = Indeterminate) (Figure 29).

Theiranthus racemosus

This dwarf bulbous plant (geophyte) is about 15—25 cm tall carrying attractive pale blue flowers with dark markings on the lower petals during October and December. On the Paradyskloof site it was recorded from the lower sandstone slopes where pines had been cleared following a fire during December 2003. Goldblatt & Manning (2000) give its distribution as Piquetberg and Porterville Mountains. This is a considerable extension to the distribution range of the species. (The specimen collected on site was identified by Dr J. Manning.)

Xiphotheca lanceolata

The wider known distribution of *Xiphotheca lanceolata* from the historic record are listed here from data extracted from the SANBI data base by Ms Domatilla Raimondo and information by courtesy of Ms AnneLise Vlok (the South African expert on this plant), as follows: Somerset West – Vergelegen; Faure; Stellenbosch – Onder Papegaaiberg, Coetzenburg; Kuilsrivier – Langverwacht; Durbanville – Hills, Race course, Altydgedacht, Kanonkop, Vissershok; Klipheuwel; Joostenburg; Paarl Mountain; Paardeberg – including Helderfontein

Farm; Malmesbury and Atlantis. These are general localities which suggest that granite and shale foothills stretching along a coastal axis from Sir Lowry's Pass to Darling and inland through Stellenbosch and Paarl to Malmesbury are prime localities for this species. Most of these areas have already been transformed for farming or housing, or are invaded by alien vegetation. The natural habitats where the plant can grow are very restricted now.

Figure 29. *Xiphotheca lanceolata* a threatened species (rarity category = Indeterminate) found on the Paradyskloof Golf Estate.

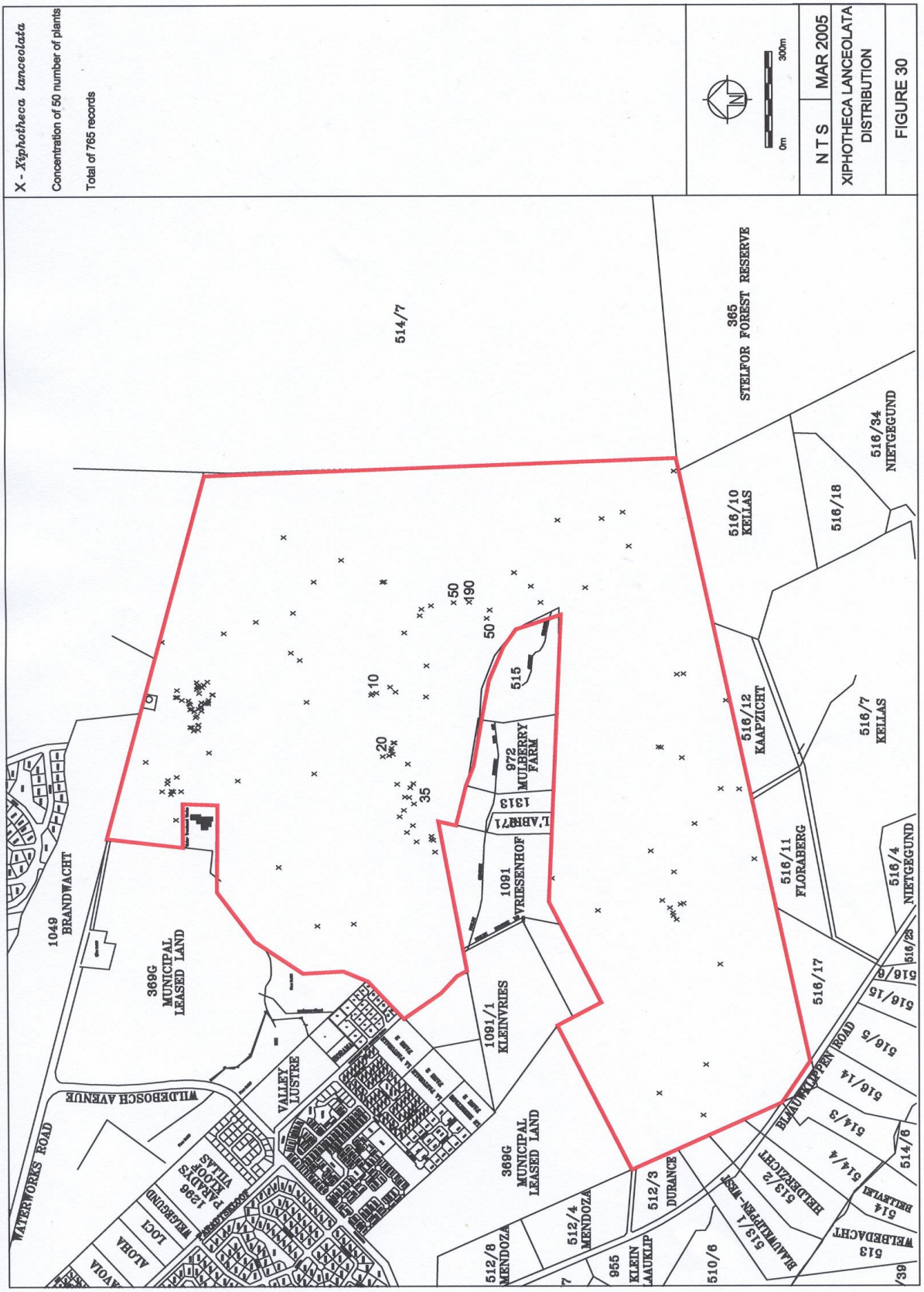

Figure 30. Map showing the location of populations of *Xiphotheca lanceolata*, a listed endangered red data book species (rarity category = Indeterminate).

The distribution of *Xiphotheca lanceolata* on the site is indicated in Figure 30 with precise details of records included in Table 3. These data are site records collected by Proff. Wynand Coetzer and Hans Eggers as well as by the author of this report. A study in progress to understand more about the ecology of this threatened plant suggests that it occurs on heavier granitic- or shale-derived soils usually where competition is reduced, such as along roadsides, in disturbed areas or under pine plantations where the vegetation undergrowth cover is sparse. It exhibits many characteristics of a pioneer species. A. Vlok (pers. comm.) suggests that late summer to autumn hot fires are required to stimulate the germination of this myrmecochorus species (seed dispersed by ants). It is quite feasible that the modern tendency to protect areas from the so-called devastations of fire is, in fact, a reason for the reduction in numbers of this species over its range. Removing plants from one site and transplanting them into another is not a generally recommended procedure for seed regenerating, myrmecochorus species, particularly when they are rare, as they usually have very specific habitat requirements. In this instance, propagation from seed is a recommended means of cultivation. Propagation from seed can be undertaken in a nursery followed by transplantation into very specific habitats in the wild.

3.4.2 Alien flora

Invasive species are widespread through the site and require urgent control measures to be initiated. Invasive and exotic species are marked with an asterisk in the list of species recorded from the area (Appendix A, Table 2). This list contains 19 woody invasive shrubs and trees, and 15 introduced herbaceous weeds. A number of less well-known invasives in the Western Cape are present. These include *Acacia baileyana, Acacia elata, Cortaderia selloana, Hakea saligna, Malus* hybrid and *Pittosporum viridiflorum.*

4. Discussion & Conclusions

4.1 Biodiversity process

Biodiversity maintenance on site requires that parts of all ecosystems present must be conserved. There are different elements involved in this process. Firstly, the two main streams draining and crossing the site in an east-west direction form logical foci for conservation corridors. The establishment of a 30—50 m wide buffer zone around the wetlands and streams would ensure that the functioning of the wetlands would remain intact and thereby that they can function properly to maintain the quality of the water in the streams. The establishment of the streams as conservation corridors implies that their main catchments and any point source origins also are maintained in a natural state. To do this it

is necessary for the total conservation of the Colluvium Sandstone Fynbos to the east of the *Eucalyptus* fire-break into the Hottentots Holland Nature Reserve. This conservation area would, for instance, include the fountain wetland at the source of the Paradyskloof River.

The Swartland Shale Renosterveld rates as one of the two most endangered vegetation types in South Africa. Conservation of all remaining parts of it is required. This is the motivation for the conservation of the two *Elytropappus rhinocerotis* Shale Renosterveld Shrubland communities identified in this study. Large parts of the areas occupied by these communities are presently or were in the recent past under pine plantations. It is essential that the remaining plantations are removed and that the vegetation in this ecosystem is allowed to recover. To this end, the area to the north of and adjacent to the Skuilplaats River, on the properties in question, is identified as a high priority conservation area.
Areas where the endangered plant, *Xiphotheca lanceolata*, occurs are identified in this report so that the plant can be protected. The management of populations of this plant on site requires careful evaluation as Paradyskloof supports the greatest known number of this threatened Red Data Book plant. *Xiphotheca lanceolata* appears to be reacting as a pioneer, avoiding competition and dense shrubby vegetation.

Removal of the pines from conservation areas must be undertaken in such a way that damage to the endangered plant, *Xiphotheca lanceolata*, growing in them, is minimal and that drag lines from the removal of the pines are parallel to the contours. Burning of brush removed off the felled trees must be co-ordinated so that the sterilization of the ground under the burning brush occurs in areas of low sensitivity.

4.1.1 Fire as a key ecological "driver"

The key ecological "driver" of ecosystems on the site and in the vicinity, is fire. All developments must take this into account. Present knowledge suggests that burning interval should be between 12—20 years depending on the characteristics of particular habitats. The actual timing of the use of fire to manage the vegetation is assessed by experienced fire managers and botanical experts using the reproductive state of the vegetation as a guideline. Some plants require short interval burns to increase their numbers, while others are eradicated if the fire interval is too short and they haven't reproduced, while damaging hot fires can occur from excessive biomass accumulation. Alien plants must be controlled according to a strict management plan to ensure that they do not result in a build-up of biomass and therefore in very hot fires occurring. This does not imply that management fires should always be cool. In fact, late summer to early autumn fires are preferred so that

"clean" burns result. The development of a long term fire management plan must take variability in interval and timing of control burns into account.

4.1.2 Environmental gradients

The Paradyskloof properties serve as a key link between upland and lowland areas along the environmental gradient. This area can provide very suitable migratory routes for fauna, such as, otter, antelope and birds, along the river corridors and the adjacent dryland conservation areas.

4.1.3 Changes in key processes

Should any development, such as a golf course, housing or agricultural development, take place in the area, then the development must allow for cleaning of run-off and drainage water of any enrichment and pollutants, such as fertilizers, herbicides and hormones, as these will have an adverse effect on the naturally acidic, nutrient poor water normally present in these systems. Flows released into the streams must also be controlled to ensure that natural flow patterns are maintained.

4.2 Limitations and assumptions

The results of the investigation on which this report is based are limited a) by the extensive mature pine plantations present that have already disrupted the natural vegetation and b) by the December 2003 wild-fire that burnt the higher plantations and natural vegetation. Subsequent removal of burnt pines has taken place. This process has caused considerable disturbance to the regenerating indigenous vegetation under the pines. No upland natural vegetation escaped the fire, hence this report is based on interpretation of remnants in conjunction with personal pre-fire knowledge of the general vegetation in the area.

4.3 Biodiversity linked to socio-economic aspects

Socio-economic aspects such as grazing or recreational potential of the area have not been assessed except to identify that the site has considerable potential to serve as an educational and recreational facility, irrespective of the land-use applied, if the areas identified as having conservation potential are not lost.

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Appendix A

Table 1. Paradyskloof Phytosociological Table.

Table 2. Systematic checklist of plants recorded on site.

Table 3. Precise localities for *Xiphotheca lanceolata* on the Paradyskloof site.