Challenges in resolving and protecting biodiversity in a developing city: the case of the Cato Ridge grasslands, Durban

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As the candidate's supervisor, I have approved this thesis for submission:

Signed: __________________ Name: ______________________ Date: _______________

PREFACE

The research contained in this dissertation was completed by the candidate while based in the Discipline of Environmental Science, School of Agricultural, Earth and Environmental Sciences of the College of Agriculture, Engineering and Science, University of KwaZulu-Natal, Westville Campus, from 2012 to 2017, under the supervision of Professor Serban Proches.

These studies represent original work by the author and have not been submitted in any other form for any degree or diploma to any tertiary institution. Where use has been made of the work of others, it is duly noted in the text.

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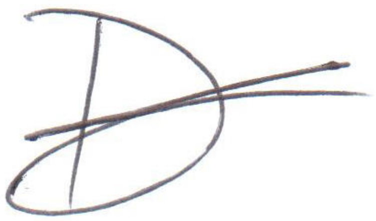

12 March 2017

David Styles **Date**

ABSTRACT

The area of Cato Ridge has been identified as a key node for future industrial and commercial development within the eThekwini Municipal Area, with a Local Area Plan approved to guide it. However, it also includes large areas of natural vegetation, including some of the best remaining instances of grassland in the city. These grasslands have been mapped as Ngongoni Veld but parts on Natal Group sandstone have contrarily been mapped as KwaZulu-Natal Sandstone Sourveld by the eThekwini Municipality's Environmental Planning and Climate Protection Department. KwaZulu-Natal Sandstone Sourveld is considered endangered and deserving of greater conservation attention. However, little information is available about either of these grassland types.

This thesis is based on surveying of 236 plots each of 100 m^2 situated in better quality grassland throughout Cato Ridge, focusing on the herbaceous component. Plots were surveyed widely in order to determine and compare species richness and composition on different geological substrates (mainly Dwyka Group tillite and Natal Group sandstone), and different aspects and slopes, including respective occurrence of endemic and biogeographically important species and Cape floristic elements.

Dwyka Group tillite plots were found to contain higher species richness. Both these plots and those on Natal Group sandstone were found to contain endemics, biogeographically important and Cape floristic element species. These results are used to interpret the question whether grassland on different geological substrates is to be referred to as Ngongoni Veld or KwaZulu-Natal Sandstone Sourveld. I conclude that, contrary to what has often been suggested in the past, under natural conditions Ngongoni Veld is neither a species-poor grassland type, nor does it lack distinctive species and deserves greater conservation attention.

All occurrences of all grassland in better condition are mapped and compared with the land uses set out in the Local Area Plan. From this it is apparent that the plan enables their significant reduction and degradation, and requires amendment if this is not to occur.

ACKNOWLEDGEMENTS

This research would not have been possible without assistance from a considerable number of people, as noted below:

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- Dr Yashica Singh, curator of the KwaZulu-Natal Herbarium, for use of this facility for lodging and processing of pressed plant specimens, permitting me to examine the herbarium collection and assistance provided by support staff at the herbarium particularly Mkhipheni Ngwenya.

- Dr Benny Bytebier, curator of the University of KwaZulu-Natal Herbarium (the Bews Herbarium) for enabling access to this collection.

- Many other individuals who provided miscellaneous advice in respect of the identity and ecology of plant species including: Prof. Kevin Balkwill (*Chaetacanthus*), Prof. Dirk Bellstedt (*Streptocarpus*), Prof. Neil Crouch (*Aloe* and the family Hyacinthaceae), Prof. Eric Knox (*Lobelia*), Dr David Gwynne-Evans (*Hermannia*), Gavin McDonald (Orchidaceae), Mkhipheni Ngwenya, Dr Ashley Nicholas (Asclepiadaceae), Dr Brian Schrire (*Indigofera*), Dr Yashica Singh (*Hypoxis*) and Prof. Charles Stirton (*Eriosema*).

- Landowners who provided access to their properties, particularly Gary and Sandi Edwards of Hill ‘n Dale Farm.

- Finally, and most of all to my family: my wife Philippa Styles and young son Alexander, for their patience and absence of time that would otherwise have been given to them.

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ACRONYMS AND ABBREVIATIONS

DGT	Dwyka Group tillite
EMA	eThekwini Municipal Area
KZNSS	KwaZulu-Natal Sandstone Sourveld
LAP	Local Area Plan
MBG	Megacrystic biotite granite
NGS	Natal Group sandstone
NV	Ngongoni Veld

UNITS OF MEASUREMENT

%	Percentage
km	Kilometres
m	Metres
mm	Millimetres

CHAPTER 1: INTRODUCTION

1.1. Background

Cato Ridge is a rapidly developing area situated on the western edge of the eThekwini or Durban municipal area, one of the fastest-growing conurbations in the world (Van Wyk 1994) (Figure 1.1). It is situated within the Maputaland-Pondoland-Albany Region, a region of exceptional plant diversity and endemism, within which other more distinct areas of plant endemism have been recognized, namely the Maputaland Centre, Albany Centre and Pondoland Centre (Steenkamp *et al.* 2004; Van Wyk & Smith 2001). The Pondoland Centre is founded on outcropping Msikaba Formation sandstone (Van Wyk 1990, 1994; Van Wyk & Smith 2001), which on the coastal escarpment north of Port Shepstone transitions to the unrelated, more complex and fragmented Natal Group sandstone (Marshall 1994, 2002) found at Cato Ridge.

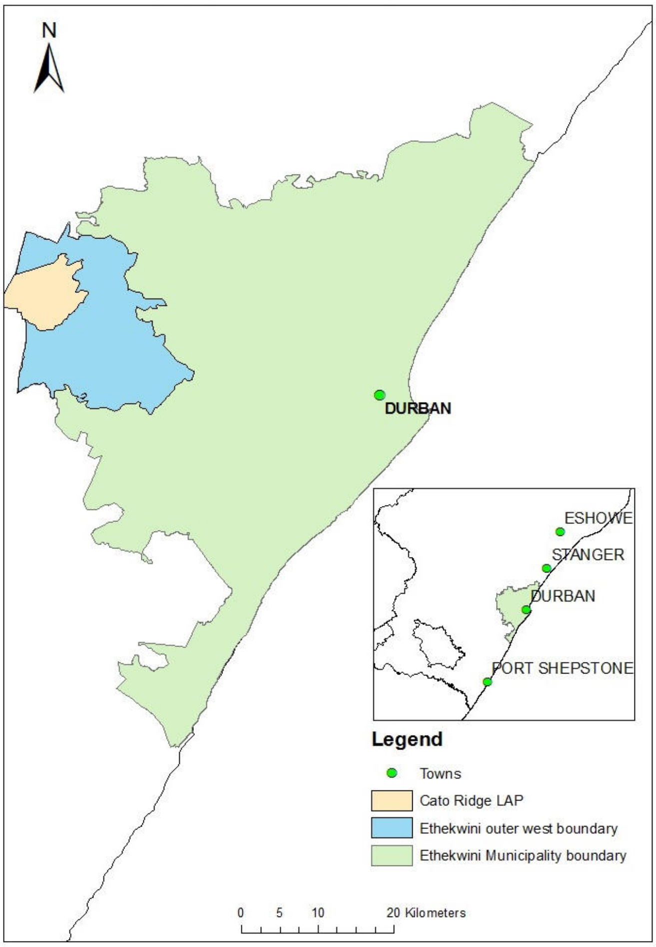

Figure 1.1. Cato Ridge within the eThekwini Municipal Area.

Cato Ridge is characterized by a range of land uses including a small-town area, a suburban residential area, informal settlement, industrial developments, small holdings and farms. Most recent development is commercial or industrial, involving the building of warehouses, factories or logistical facilities. The eThekwini Municipality has recently developed a Cato Ridge Local Area Plan (LAP) to designate and guide future land use (Graeme Muller Associates Consortium 2012).

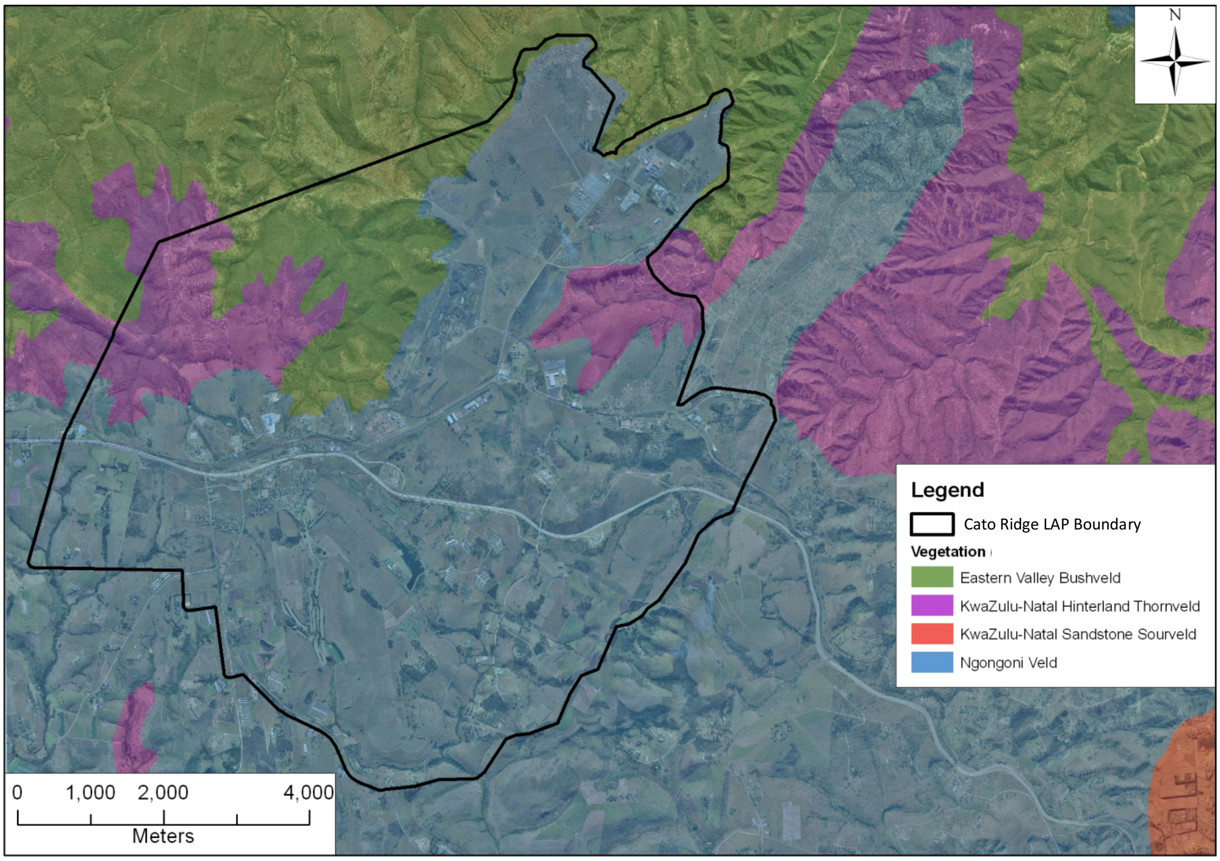

Figure 1.2. Mapping of Cato Ridge grassland types by Mucina & Rutherford (2006), showing the Local Area Plan boundary.

Most of Cato Ridge is still open space with its grassland including some of the largest remaining instances in good condition in the eThekwini Municipal Area (McLean *et al.* 2014). The grassland in this area has been classified in different ways. In Mucina & Rutherford (2006) it is described as Ngongoni Veld (Figure 1.2), as is the case in a report on Cato Ridge's biodiversity commissioned by the eThekwini Municipality (2006). By 2010, some of the grassland on Natal Group sandstone at Cato Ridge was reported as KwaZulu-Natal Sandstone Sourveld (GroundTruth 2010). Areas of mismatch between the map in Mucina & Rutherford (2006) and Natal Group sandstone at Cato Ridge are highlighted below (Figure 1.3).

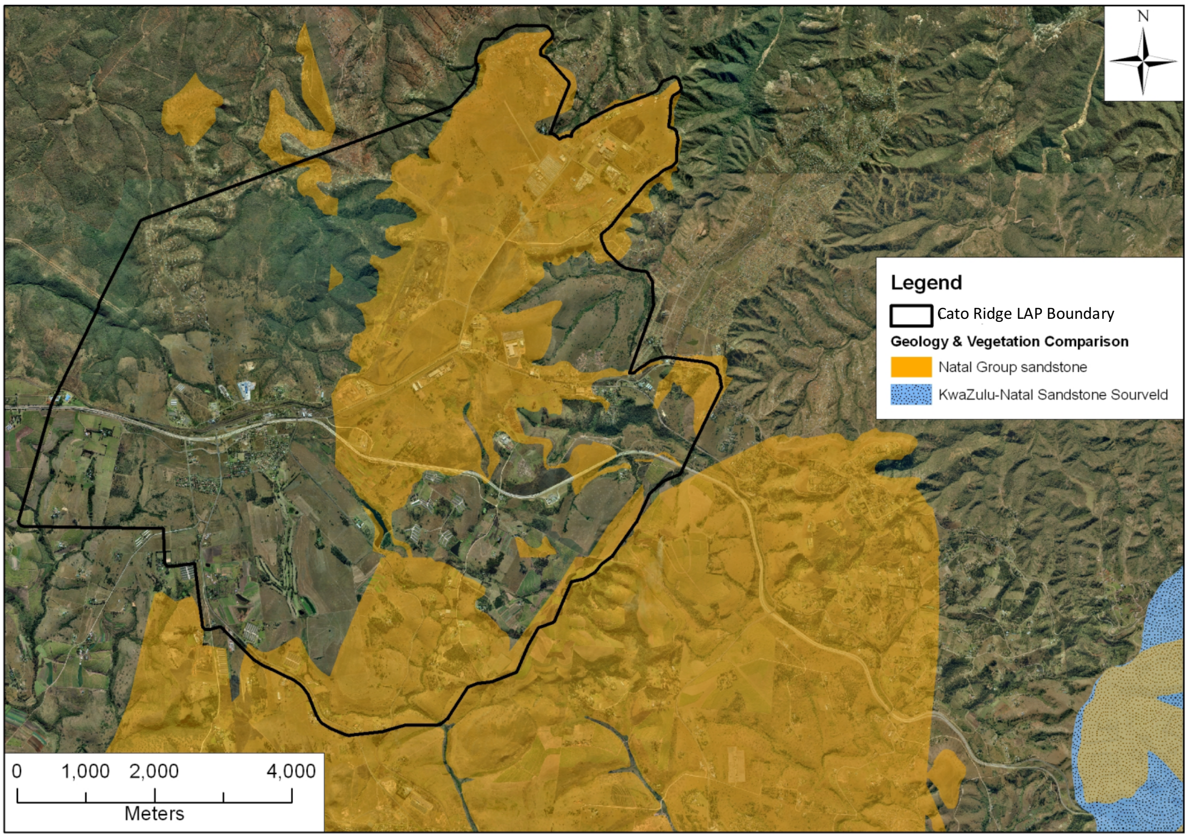

Figure 1.3. The mismatch between Natal Group sandstone and KwaZulu-Natal Sandstone Sourveld, with the latter only shown east of the Local Area Plan boundary by Mucina & Rutherford (2006).

All grassland on Natal Group sandstone has since been mapped as KwaZulu-Natal Sandstone Sourveld by the eThekwini Municipality's Environmental Planning and Climate Protection Department. Due to concerns about Ngongoni Veld, more specifically the unsatisfactory way this vegetation type is defined, other grassland in this area is simply mapped as "grassland – other geology" (McLean *et al.* 2014). KwaZulu-Natal Sandstone Sourveld is held to be an endangered vegetation type and Ngongoni Veld a vulnerable type (eThekwini Municipality 2011; Mucina & Rutherford 2006).

1.2 Aims of the research

Relatively little is known about the floristics of KwaZulu-Natal Sandstone Sourveld and Ngongoni Veld, including their endemics, biogeographically important and other important species. The grassland at Cato Ridge is amongst the most extensive that remains in the eThekwini Municipal Area, but also faces ongoing reduction and degradation that are set to greatly intensify in future. There are differences in interpretation of the type of grassland in this area. It occurs in a geologically diverse setting, with instances in good condition on the Natal Group sandstone cited as important for KwaZulu-Natal Sandstone Sourveld, together with Dwyka Group tillite cited as important for Ngongoni Veld (Mucina & Rutherford 2006), together with lesser instances on megacrystic biotite granite. This provides an ideal opportunity to establish whether geology and other factors such as aspect and slope result in important differences in species richness and abundance. It can then be assessed whether geology results in important differences in occurrence of endemic or biogeographically important species. Mapping of the better instances of this grassland also enables assessment of how these are affected by the Local Area Plan produced at the behest of the eThekwini Municipality.

1.3 Objectives

This study has the following objectives:

- Review of information on the distribution and floristics of KwaZulu-Natal Sandstone Sourveld, including the distribution of Natal Group sandstone.
- Review of other relevant botanical and taxonomic literature and herbarium collections to identify range restricted species that occur in grassland within the area of distribution

of KwaZulu-Natal Sandstone Sourveld, Natal Group sandstone and Ngongoni veld, and which consequently may be important in these grassland types.

- Carrying out a plot-based survey of grassland at Cato Ridge, to establish how this affects and results in differences in plant species richness, abundance, endemics and other important species.
- More particularly, whether Natal Group sandstone results in reported increased species richness, including in respect of endemic or biogeographically important species or not, compared to the reportedly more species-impoverished and endemic-poor Ngongoni Veld.
- Mapping the instances of grassland that are not degraded and comparing these with the land uses contained in the Cato Ridge Local Area Plan.

CHAPTER 2: LITERATURE REVIEW

2.1 Ngongoni Veld

Acocks (1953) was the first to define Ngongoni Veld, as one of 70 "veld" types he recognized in South Africa based on estimation of agricultural potential (Van Wyk & Smith 2001). Ngongoni Veld was stated to occur from the lowermost part of the coastal escarpment, at about 450 m a.s.l. and extending inland to about 900 m a.s.l., where it is cooler than the coastal belt and annual rainfall is 750 to 1300 mm. Although noting woody vegetation as also present, he recognized grassland dominated by *Aristida junciformis* Trin. & Rupr. (Ngongoni grass) as its main feature. Acocks (1953) says little else about its species composition and assumed that under former natural conditions the vegetation comprised forest and woody vegetation.

Tainton *et al.* (1976) divided KwaZulu-Natal into 11 "bioclimatic" groups in which mainly common and widespread grass species are stated to occur. Camp and others subsequently proposed the subdivision of the province into an even greater number of "bioresource" groups (Camp *et al.* 1995; Camp 1997). Relevant "bioresource" groups included Ngongoni Veld between 450 to 900 m a.s.l., but this was divided into two variants: Moist Coast Hinterland Ngongoni Veld where rainfall is between 800 to 1 160 mm per annum and Dry Coast Hinterland Ngongoni Veld, where rainfall is between 756 to 780 mm per annum. It is described as a secondary, *Aristida junciformis*-dominated grassland. Camp (1997) provides short lists of grasses he considers common in the moist variant, but says very little about the dry variant. The area mapped as Ngongoni Veld and low parts of the Midlands Mistbelt "bioresource groups" correlate with the area Mucina & Rutherford (2006) map to Ngongoni Veld and KwaZulu-Natal Sandstone Sourveld.

In White's (1983) seminal depiction of the phytochoria of Africa the grassland of the Tongaland-Pondoland Regional Mosaic (a precursor to recognition of a more expansive Maputaland-Pondoland-Albany region) is differentiated into two types. One of these is "Tongaland-Pondoland edaphic grassland". This corresponds with the current conception of Maputaland Wooded Grassland (Mucina & Rutherford 2006), a core vegetation type of the Maputaland Centre, which from field work was familiar to him (Pannell 1998; Friis 1998). Everything else is allocated to the category "Tongaland-Pondoland Secondary Grassland" which is an "*Acacia karroo* wooded grassland" where "coastal forest is destroyed" with a note that “[h]eavy grazing encourages *Aristida junciformis* … which is now dominant over large areas” (White 1983).

The work of Low and Rebelo (1996) was the first to reclassify the vegetation of South Africa since Acocks (1953). The authors discerned two vegetation types within the area now mapped to Ngongoni Veld and KwaZulu-Natal Sandstone Sourveld, including: Coast-Hinterland Bushveld between 450 to 900 m a.s.l. comprised of “*Acacia karroo* savanna or scrub, with Ngongoni Bristlegrass *Aristida junciformis* almost entirely dominant” and Moist Upland Grassland – sour grassland between the wide altitude range of 600 to 1 400 m a.s.l. “on Karoo sequence sediments and dolerite.” Few typical species were provided.

Mucina & Rutherford (2006) present Ngongoni Veld as occurring from Melmoth in northern KwaZulu-Natal KwaZulu-Natal to Libode in Transkei region of the Eastern Cape in the south. Soil is acid, leached and heavy, including Dwyka tillites and Karoo dolerites. Mean annual precipitation is 700-1 100 mm. It is a “dense, tall grassland overwhelmingly dominated by … *Aristida junciformis*, with this monodominance associated with low species diversity.” A small number of tree, shrub, grass and herbaceous species presented as important. The authors note that both Acocks (1953) and Camp (1999) consider Ngongoni Veld secondary.

2.2 KwaZulu-Natal Sandstone Sourveld

KwaZulu-Natal Sandstone Sourveld made its published debut in Mucina & Rutherford (2006). KwaZulu-Natal Sandstone Sourveld occurs on “elevated coastal inland [Natal Group] sandstone plateaux from Mapumulo near Kranskop to St. Faiths near Port Shepstone in the south”, between 500 and 1000 m a.s.l. Mean precipitation is given as between 700-1 200 mm. A feature of the landscape is the “flat (or rolling) plateau tops and steep slopes commonly forming table mountains.” The grassland is “short, species-rich” and with “scattered low shrubs and geoxylic suffrutices. Proteaceae trees and shrubs (*Protea*, *Leucospermum*, *Faurea*) can be locally common.” A more extensive range of important species is provided when compared to Ngongoni Veld. Unlike Ngongoni Veld, 20 biogeographically important species and 12 endemic species are listed as occurring in KwaZulu-Natal Sandstone Sourveld.

The Mucina & Rutherford (2006) account of KwaZulu-Natal Sandstone Sourveld contains some floristic problems. It is stated that species in the genera *Faurea*, *Leucospermum* and

Protea (Proteaceae) are locally common. However, *Faurea saligna* Harv. is a rather widespread if localized tree species, growing gregariously and forming woodlands (Boon 2010; pers. obs.). It is not an element or typical of grassland. *Leucospermum gerrardii*, the only member of the genus within the KwaZulu-Natal Sandstone Sourveld area, is very rare and known from only a few localities in KwaZulu-Natal (Boon 2010; Scott-Shaw 1999; Styles 2011), all north of Durban. *Protea* species (*P. caffra* Meisn. subsp. *caffra*, *P. roupelliae* Meisn. *roupelliae* and *P. simplex* E.Phillips) with the exception of *P. welwitschii* Engl. have a wide distribution in KwaZulu-Natal (Boon 2010; Rebello 1995), often on south-facing slopes, and were found to be locally common on Dwyka Group tillite at Cato Ridge. Of 31 important species listed a few do not occur in grassland: *Senecio medley-woodii* Hutch. occurs on rock faces (Hilliard 1977); *Brachystelma perditum* R.A.Dyer is a high-altitude Drakensberg endemic; *B. tenellum* R.A.Dyer is known only from the north of the Pondoland Centre (Dyer 1980, 1983). A few more are debatably typical of open grassland. *Bulbine inflata* Oberm. is not a biogeographically important species as it was described from collections from as disparate localities as Mpumalanga Province and Swaziland (Obermeyer 1967), with a superficially similar, more gracile species with smaller inflated fruits in the vicinity of Durban still awaiting description. *Crassula multicava* Lem. subsp. *floribunda* Friedrich ex Toelken occurs in forest and woodland (Toelken 1985). Of the 11 species listed as endemic, *Eriosema rossii* C.H.Stirt. is not so, although with a southern KwaZulu-Natal distribution (Stirton 1986). Another five do not occur in grassland: *Crassula inandensis* Schönland & Baker f. is not a climber, but a small herb entirely confined to the floor of damp forest (Toelken 1985; pers. obs.); *Helichrysum woodii* N.E.Br. is a species of sheer rock faces; it does not occur in grassland (Hilliard 1979, 1983; pers. obs.); *Cynorkis compacta* (Rchb.f.) Rolfe, *Gladiolus cruentus* T.Moore and *Hesperantha gracilis* Baker are endemic or nearly endemic to Natal Group sandstone but are species of wooded, usually sheer rock faces, and do not occur in grassland (Goldblatt 2003; Goldblatt & Manning 1998; Hilliard 1979, 1983, 1986; Linder & Kurzweil 1999; pers. obs.).

2.3 Distribution of Natal Group sandstone

The mapping of Natal Group sandstone in Marshall (1994) has been digitized and accurately overlaid on the occurrence of KwaZulu-Natal Sandstone Sourveld and Ngongoni Veld as presented in Mucina & Rutherford (2006) (Figure 2.1). The Pondoland Centre of Plant Endemism as mapped by Van Wyk and Smith (2001) just south of the Natal Group sandstones is also shown, founded on the different, younger and more homogenous Msikaba Formation sandstone (Marshall 1994).

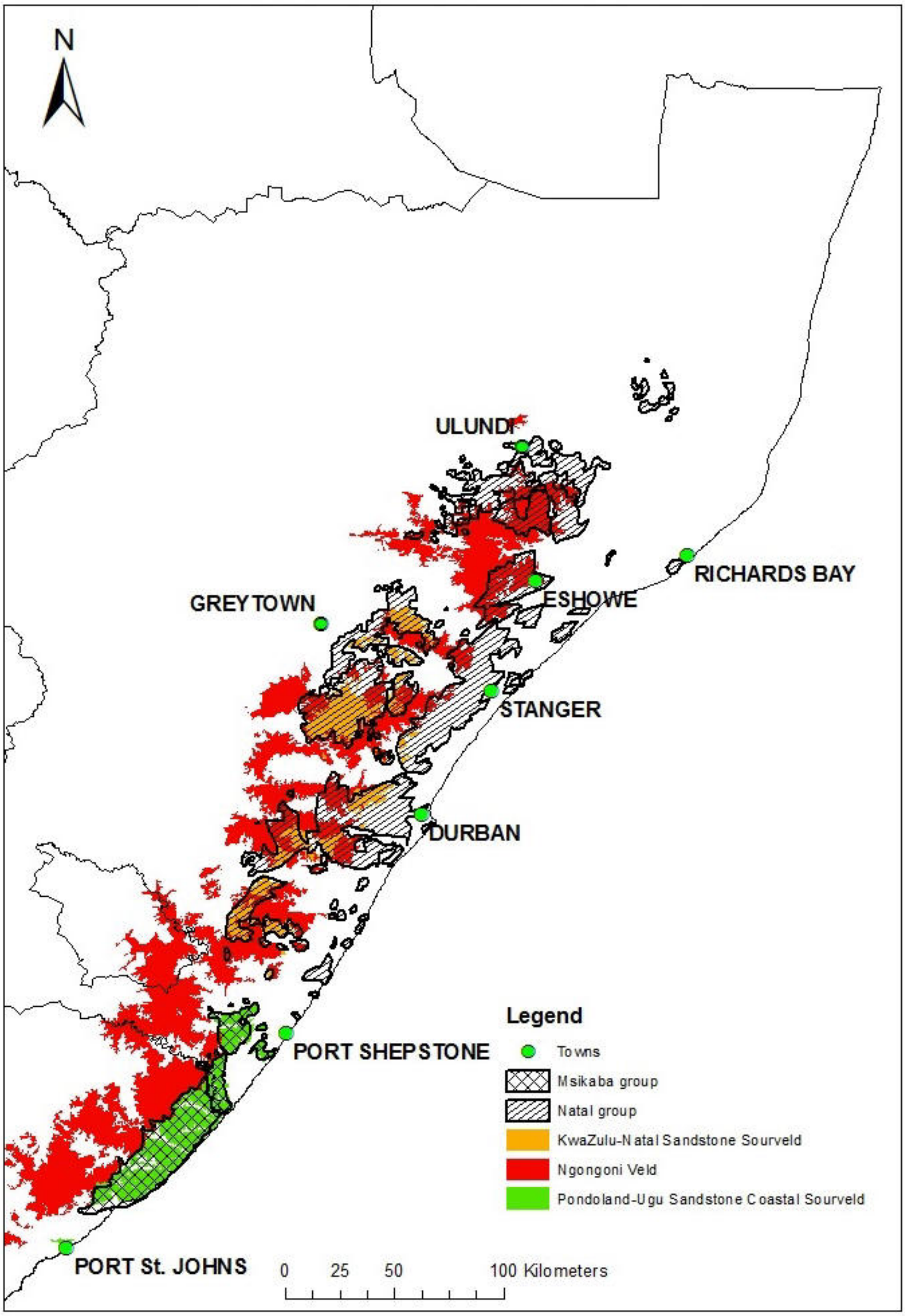

Figure 2.1. The mismatch between Natal Group sandstone and KwaZulu-Natal Sandstone Sourveld. The mapping of Natal Group sandstone is derived from Marshall (1994), KwaZulu-

Natal Sandstone Sourveld from Mucina & Rutherford (2006) and the Pondoland Centre of Plant Endemism from Van Wyk & Smith (2001).

Contrary to the good match between the Msikaba Formation sandstone of the Pondoland Centre and the presentation of Pondoland-Ugu Sandstone Coastal Sourveld in Mucina & Rutherford (2006), there appears to be a notable lack of correlation between Natal Group sandstone and KwaZulu-Natal Sandstone Sourveld, creating the perception that mapping of the latter is somewhat haphazard. It is, however, important to point out that not all occurrences have an important surface extent, particularly north of the Tugela River. The Natal Group sandstones comprise two formations and several members. The Kranskloof Member as the "most conspicuous unit of the Natal Group as, due to its resistant lithology, it almost invariably crops out as kranses, forming the scenery that typifies the Natal Group. "Care should be taken, however, not to necessarily equate krans with Kranskloof, as there are other units within the Natal Group which form kranses locally" (Marshall 1994). In particular, the Dassenoek Member, which is also quartz arenite, is erosion resistant, but not as much as the Kranskloof Member. It may be significant that the Kranskloof Member occurs only sporadically north of the Tugela River. The main Natal Group sandstone member north of Eshowe is the oldest, Ulundi Member. It is thin, coarse, very pebbly and immature sandstone, and except on a narrow-western part that extends through Nkandla to Hlabisa is not overlain by any other member (Marshall 1994).

2.4 Endemism within the KwaZulu-Natal Sandstone Sourveld, Natal Group sandstone and Ngongoni Veld areas

White's conception of the region of endemism he designated the Maputaland-Pondoland Regional Mosaic (1983) has been further refined to encompass a greater Maputaland-Pondoland-Albany Region (Steenkamp *et al.* 2004). This region includes more localized centres of endemism including the Maputaland Centre, a Pondoland Centre founded on extensive outcropping Msikaba Formation sandstone, and Albany Centre (Van Wyk & Smith 2001). Steenkamp *et al.* (2004) estimate there are 8100 plant taxa in this area of which 1900 are endemic. These are estimated at 7000 and 1800 respectively by Van Wyk & Smith (2001), with 230 endemics allocated to the Maputaland Centre, more than 120 to the Pondoland Centre and more than 600 to the Albany Centre. However, where then do the other endemics occur, and are there not other patterns of, or other minor centres of endemism within the Maputaland-Pondoland-Albany region? They do not resolve this further, citing insufficient information.

Pondoland Centre endemics make a distinctive contribution to Pondoland-Ugu Coastal Sourveld (Mucina & Rutherford 2006; Van Wyk & Smith 2001). The Msikaba Formation and Natal Group sandstones contribute to a common topography across their extent: "composed predominantly of resistant sandstone" the Msikaba Formation and Natal Group form "the kranses that provide "much of the rugged scenery along the eastern portion of KwaZulu-Natal and Pondoland, between Hlabisa in the North and Port St Johns in the south" (Marshall 1994). However, there has been no investigation of plant endemism on the coastal escarpment north of the Pondoland, nor of the broad area in which KwaZulu-Natal Sandstone Sourveld and Ngongoni Veld occur. If after such investigation, patterns of endemism appear, might these not also make similar contributions to these grasslands?

A comprehensive investigation has been made of botanical and plant taxonomic literature, together with review of collections held at the KwaZulu-Natal Herbarium (NH) and University of KwaZulu-Natal Herbarium (NU) to identify plant endemism on the coastal escarpment north of the Pondoland Centre. The following categories were investigated.

- Eastern coastal escarpment endemics (ECE-E): Species known from the coast and coastal escarpment of the Transkei region of the Eastern Cape (including the Pondoland Centre) extending northwards along the KwaZulu-Natal coastal escarpment at least as far as the Tugela River.
- Pondoland Centre floristic elements (PC-FE): Species with a distribution centred in the Pondoland Centre of Plant Endemism but which also occur northwards.
- Northern coastal escarpment endemics (NCE-E): Species confined to the broad Natal Group sandstone of the KwaZulu-Natal coastal escarpment north of the Pondoland Centre. Species that have a distribution centred on this area but extending a little beyond are referred to as northern coastal escarpment floristic elements (NCE-FE).
- Local endemics (LE): Species with a distribution confined to the eThekwini Municipal Area, including on a presumptive basis several species subsequently found and collected at Cato Ridge that were lodged at the KwaZulu-Natal Herbarium, but could

not be matched with any prior collections nor were any likely candidates found in literature.

All the species falling into the categories above, together with the smaller subset occurring in grassland are presented in Appendix 1, together with relevant citations. This review, as set out on a per species basis in Appendix 1, indicates that the broad coastal escarpment north of the Pondoland Centre is a minor centre of endemism, containing at least 57 endemics or near-endemics, compared to the > 120 estimated for the Pondoland Centre by Van Wyk & Smith (2001). Moreover, the Pondoland Centre and the coastal escarpment to the north are not entirely discrete in their endemism. Nineteen species cited as Pondoland endemics (Abbott 2006; Van Wyk & Smith 2001) extend north (and sometimes well north) of the Pondoland Centre, and there at least 31 species that are endemic or nearly endemic to both areas (i.e. they occur throughout, without obvious attribution to one or the other) (Table 2.1).

Table 2.1 Endemism on the northern coastal escarpment (coastal escarpment north of the Pondoland Centre).

Endemics and floristic elements	All species	Grassland species
Northern coastal escarpment	57	29
Pondoland Centre (extending onto the northern coastal escarpment)	19	7
Eastern coastal escarpment (Pondoland Centre and northern coastal escarpment)	31	14

The grassland species may be important in understanding the floristics of KwaZulu-Natal Sandstone Sourveld and possibly Ngongoni Veld. These patterns of endemism are corroborated by checking locality data for these species held in collections at the KwaZulu-Natal Herbarium (NH) and University of KwaZulu-Natal or Bews Herbarium (NU), presenting the data in maps and comparing them with the extent of KwaZulu-Natal Sandstone Sourveld and Ngongoni Veld as mapped by Mucina & Rutherford (2006).

2.5 Provincial conservation mapping

In an account of vegetation types of KwaZulu-Natal that has emerged from provincial conservation authority Ezemvelo KwaZulu-Natal Wildlife, Scott-Shaw & Escott (2011) retain KwaZulu-Natal Sandstone Sourveld as in Mucina & Rutherford (2006), although with briefer description. However, Camp's "bioresource" groups are resurrected, with Ngongoni Veld separated again into Moist and Dry Coast Hinterland Grassland, with differentiation according to whether above or below a mean annual precipitation of 800 mm. Except for the generalities that they are dominated by *Aristida junciformis*, or the grasses *Themeda triandra* Forssk. and *Tristachya leucothrix* Trin. ex Nees when in good condition, and that herbaceous richness in the dry variant is "much less," no information is provided on floristic composition. The moist variant is stated to occur in a "rolling and hilly" landscape" on "shallow sandy soils ... derived from Natal Group Sandstone" (Scott-Shaw & Escott 2011) even though this landform is not a particularly accurate or characteristic depiction of Natal Group sandstone geology (Marshall 1994, 2002). This brings considerable confusion to the separation of KwaZulu-Natal Sandstone Sourveld confined to Natal Group sandstone and Ngongoni Veld on other (mainly dolerite and tillite geological substrates) provided in Mucina & Rutherford (2006), who also note that floristic differences between Camp's moist and dry variants are unproven. The differentiation of Ngongoni Veld into these moist and dry forms by Scott-Shaw and Escott (2011) has nonetheless now been transposed into the National Vegetation Map, apparently also without any floristic foundation (South African National Biodiversity Institute 2012). Ngongoni Veld and all grassland at Cato Ridge is now mapped as Dry Coast Hinterland Grassland.

2.6 Local government perspectives

An important paper by Boon *et al.* (2016) deals with KwaZulu-Natal Sandstone Sourveld in the eThekwini Municipal area that includes Cato Ridge. It summarises the limited published information on this vegetation type. The degree of transformation is also reported, with the municipality's own mapping of the current and historical extent. Most importantly, details are provided on current threats, the work by the municipality and other agencies to secure better conservation of the remnant, and tools available to the latter endeavour. Although correspondence between KwaZulu-Natal Sandstone Sourveld with Natal Group sandstone is emphasized it is stated to occur "in contact zones between NGS [Natal Group sandstone] and granite and gneiss below sandstone scarps." It is also mapped as occurring at lower altitudes than provided by Mucina & Rutherford (2006).

2.7 Report on floristics of KwaZulu-Natal Sandstone Sourveld sites by Drury *et al.* (2016)

Drury *et al.* (2016) carried out a survey of three KwaZulu-Natal Sandstone Sourveld grasslands within the eThekwini municipal area. The sites were recorded as the Giba Gorge Environmental Precinct, Springside Nature Reserve and "Inanda Mountain". Significant floristic variability was found, with Giba Gorge having the highest cumulative number of species, followed by Springside Nature Reserve and "Inanda Mountain". The totals reported are 95 species (including 72 of non-graminoids) at "Inanda Mountain"; 121 (96 non-graminoids) at Springside Nature Reserve and 131 (108 non-graminoids) at the Giba Gorge Environmental Precinct. Results at "Inanda Mountain" are attributed to higher anthropogenic disturbance. A list of species is provided for each site without indication of their richness or abundance. Although it is recognized that of 12 species listed as endemic to KwaZulu-Natal Sandstone Sourveld in Mucina & Rutherford (2006), four do not occur in grassland, others are accepted as diagnostic. No attempt is made to determine whether any other species featured in their site lists may be endemic or biogeographically important and have diagnostic value.

There appears to be an issue with the name given by Drury *et al.* (2016) for one of the survey sites. The GPS position and altitudinal parameters provided for "Inanda Mountain" (S29 39 54.70 E30 56 22.02 and 428-476 m a.s.l. respectively) (Drury *et al*. 2016) are for the property Rem of Portion 13 (of 6) of the Farm Inanda No. 818. Contrary to the reporting this is not communal land. Inanda Mountain occurs 7 km to the west and at higher elevation (29°38'20.25"S 30°51'12.69"E and c. 590-710 m a.s.l. respectively).

In January 2008 I carried out a walk-through survey of vegetation on Rem of Portion 13 (of 6) of the Farm Inanda No. 818, including grassland, scrubby and woody vegetation along drainage lines, and Scarp Forest (Mucina & Rutherford 2006) on the edge of and below this Natal Group sandstone plateau. I then issued a report on this vegetation (Styles 2008a). This was commissioned for an environmental assessment process for a proposed affordable housing development that did not proceed. That this property is indeed the site incorrectly identified by Drury *et al.* (2016) as "Inanda Mountain" is also evident from the species list they provide –

for example *Protea welwitschii* Engl. is notable in part of Rem of Portion 13 (of 6) of the Farm Inanda No. 818 but is absent from Inanda Mountain.

Contrary to the depiction in Drury *et al.* (2016) of the property comprising degraded grassland, Styles (2008) provided maps showing it to be of differential quality. While somewhat more than half the grassland comprised: “KwaZulu-Natal Sandstone Sourveld which shows signs of some disturbance, with diminished presence diversity of forbs and geophytes” or which was even more transformed, the balance was: “Primary grassland … containing a rich diversity of forbs and geophytes” (Styles 2008a).

Styles (2008a) found 144 non-graminoids species in this grassland, exactly double the number reported by Drury *et al.* (2016) for this site and also exceeding the number reported at their richest site, the Giba Gorge Environmental Precinct. Furthermore Styles (2008a) indicated the 144 total was less than the number present: “The time allocated to this investigation, though sufficient to assess the quality of the vegetation in broad terms, was not sufficient to inventory it in detail. It is certain therefore, particularly since few plants were in flower, that a number of species were not detected, and that this very likely includes red listed and protected species.”

The discrepancy in non-graminoid species reported by Styles (2008a) compared to Drury (2016) suggests that plots in the latter study were not situated in better quality grassland on Rem of Portion 13 (of 6) of the Farm Inanda No. 818 or that problems were experienced in detecting species. An important limitation that may explain under-reporting by Drury *et al.* (2016) is the surveying of the majority of the quadrats (stated to have been c. 60%) during in the winter months (1 June–31 August), although combined with surveying of transects in every month to provide more compete species lists. In winter in South Africa’s summer-rainfall grasslands nearly all species cease flowering and fruiting, the majority of herbs senesce or die back and many have an underground presence only. This creates large problems for detection and identification as there is far less and poor material to consider. For this reason, biodiversity survey guidelines developed for environmental impact assessments by Ezemvelo KwaZulu-Natal Wildlife (2013) record that surveys of grasslands should only occur “during the summer season (beginning of November to the end of April). If the area has been burnt, the survey must be undertaken after vegetation has recovered.”

Misidentification appears to be a problem in the Drury *et al*. (2016) study, conspicuous in reporting of species occupying higher red list categories according to SANBI (2015) and endemics. *Alipedia amatymbica* Ecklon & Zeyher (vulnerable) does not occur at these sites and appears to have been confused with *Alipedea peduncularis* A.Rich. *Eriosema populifolium* Benth. ex Harv. subsp. *populifolium*, is endangered (Raimondo *et al.* 2009). It is the only endemic species reported and is described as common at two of the sites. This is certainly the result of misidentifying specimens of *E. cordatum* E.Mey. *Lotononis filiformis* B.-E.van Wyk, another endangered species reported by Drury *et al.* (2016) is a narrow Western Cape endemic that has never been known to occur in KwaZulu-Natal (Van Wyk 1990). A number of endemic or biogeographically important species that do occur at these sites are not reported. Had Inanda Mountain in fact been surveyed other endemic or biogeographically important species at this site (pers. obs.) may have been added, including *Gymnosporia woodii* Syzszyl. and *Phymaspermum pinnatifidum* (Oliv.) Kallersjo.

Site selection, with Springside Nature Reserve also comprising areas of degraded grassland (pers. obs.), surveying in an inappropriate season with consequent unknown but likely significant impact on the results, misidentifications and lack of reporting of species that are endemic, typical, endemic or biogeographically important beyond the advisory in Mucina & Rutherford (2006) affect the value of this paper in understanding the floristics of KwaZulu-Natal Sandstone Sourveld, particularly under natural conditions.

2.8 The Cato Ridge Local Area Plan

Although commissioned by the eThekwini Municipality, the Cato Ridge Local Area Plan was developed by an independent consortium that issued a final report in March 2012 (Graham Muller Associates Consortium 2012). This process was located within national and provincial strategies to:

- Identify priority development areas;
- Enable and promote industrial development;
- Improve major movement routes;
- Ensuring that municipal development plans align with provincial and national visions (Graham Muller Associates Consortium 2012).

The process included commissioning of a number of specialist reports, together with a public participation process during which the draft Local Area Plan was unveiled for comment.

The specialist biodiversity reporting was provided by GroundTruth (2010). The following Mucina & Rutherford (2006) vegetation types and proportions were identified:

- Grassland, either KwaZulu-Natal Sandstone Sourveld or Ngongoni Veld, comprising 78% of the vegetation;
- Eastern Valley Bushveld (11%); and
- KwaZulu-Natal Hinterland Thornveld (also 11%).

GroundTruth carried out several days of fieldwork in the winter, and utilized data from the eThekwini Municipality's land-class layer. A map was provided showing vegetation at Cato Ridge without differentiation to type, according to whether:

- "Good – natural habitats that contain valuable biodiversity features, including red listed species;
- Degraded – natural habitats that have been disturbed by various impacts, such as overgrazing, erosion, poor burning regimes, alien plant infestations, etc.; and
- Transformed – areas that are already developed" (GroundTruth 2010).

The final Local Area Plan report includes many of the GroundTruth findings (as it does the content other specialist reports). This includes the importance of conserving KwaZulu-Natal Sandstone Sourveld. However, after describing important environmental features and the need for their protection, a leap is made without explanatory nexus to its principal output, namely maps showing a range of determined land uses at Cato Ridge, including more detailed plans for a town centre (a Cato Ridge Village Land Use Management Plan) and industrial area (a Cato Ridge Industrial Precinct Land Use Management Plan). It is clear there are significant conflicts between environmentally sensitive features and the land uses. However, as no overlays are provided showing where environmentally sensitive features will be subjected to transforming or degrading land uses, nor summary statistics on how much vegetation or habitat will be affected as a result, these impacts are not made transparent.

CHAPTER 3. METHODS

3.1 Review of herbarium collections

In order to corroborate information obtained from botanical literature, patterns of endemism were checked against collections of species held at the KwaZulu-Natal Herbarium (NH) and University of KwaZulu-Natal Herbarium (Bews) Herbarium (NU). Species which were found to have been misidentified or for which proper locality data was not available were omitted. A total of 559 records were captured. In many cases the species were found to be poorly represented, and perhaps also due to rarity, a minority were not found. The locality data was captured and presented in maps to show any resulting patterns of endemism.

3.2 Site selection

Plots were only surveyed in grasslands that were assessed to be in fair to good condition, not so degraded that were floristically depleted or homogenized. While there are sizeable areas of grassland on Dwyka Group tillite in good condition, there is a smaller amount on Natal Group sandstone. However, there is a large area of grassland on Natal Group sandstone in good condition just beyond the Cato Ridge boundary. Surveying of plots was therefore extended up to 1.3 km beyond the south-east edge of the Cato Ridge LAP to incorporate this and allow more equivalent sampling and comparison.

Due to transformation and degradation, little grassland occurs on megacrystic biotite granite or gneiss in good to fair condition, and none on shale. Not all landowners were amenable to surveying on their properties, but this excluded only a minority of the grassland at Cato Ridge. To ensure that plot-related criteria (geology, aspect and slope) were accurately measured, the centre point of each plot was recorded with a handheld GPS device (a Garmin 76Csx) with a manufacturer-claimed resolution of 5 to 7 m when out in the open. A map showing the position of the plots in relation to geology is shown in Figure 3.1.

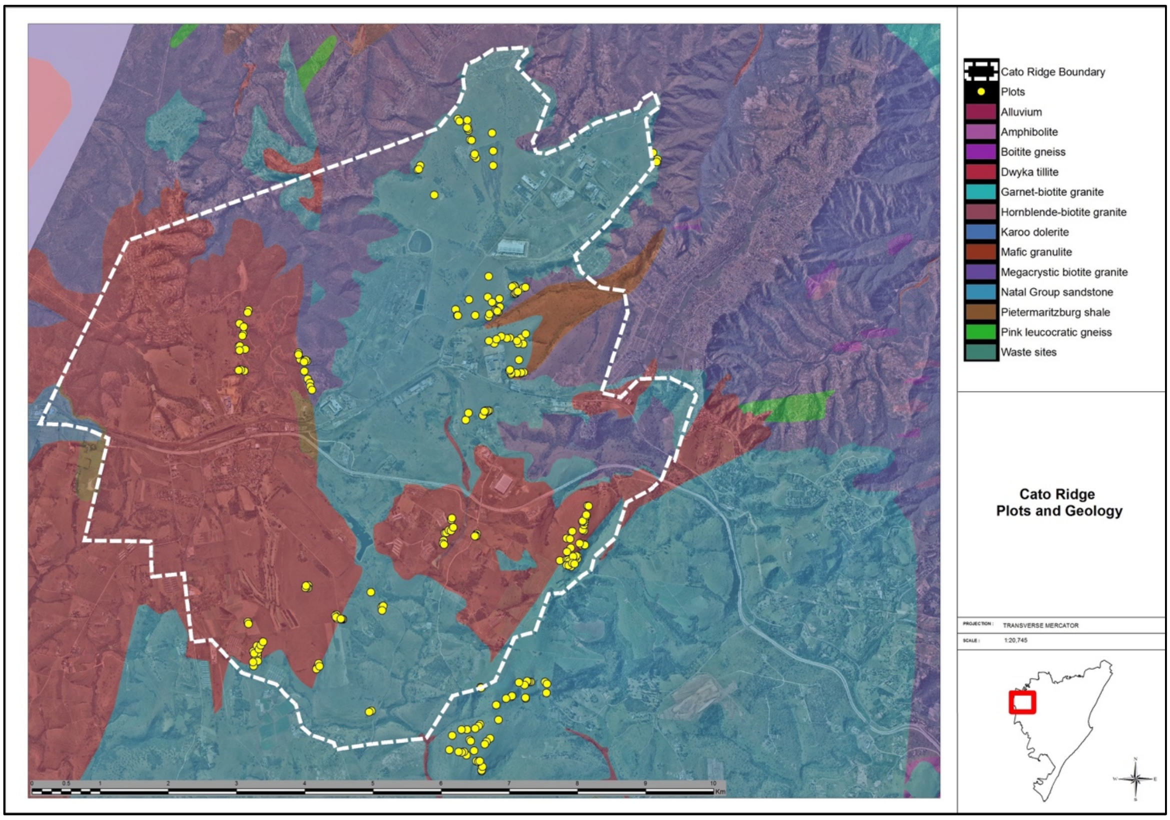

Figure 3.1. Plots surveyed at Cato Ridge against geology (Corporate GIS Department, eThekwini Municipality).

3.3 Survey methodology

The fieldwork during which data was gathered occurred between September 2012–March 2013 and September 2013–March 2014. The methodology used to survey and analyze grasslands at Cato Ridge is adapted from that utilized by Ezemvelo KwaZulu-Natal Wildlife to measure non-graminoid plant species richness and abundance in grassland (Scott Shaw & Morris 2014). A separate and different methodology is used by Ezemvelo KwaZulu-Natal Wildlife to measure graminoid richness. The question can be fairly asked why forb richness is recorded in this study and not graminoid richness? It is not gainsaid that recording both forb and graminoid richness provides more complete information. However, in good quality grassland in eastern South Africa, while comprising most biomass, grass species comprise a small minority of all species present (as little as 13.5%), with the great majority comprised of non-grass species" (Scott Shaw & Morris 2014). For most grass species, appearance of fertile characters important for accurate identification, occurs later than many forbs and geophytes, while including the graminoid survey methodology would have reduced the number of forb-surveyed plots.

The methodology used involves marking out of a 10 x 10 m^2 (100 m^2) plot and surveying between 10 x 1 m^2 subplots within it. The 1 m^2 subplots are circumscribed by throwing of a hoop within the 100 m^2 plot. All non-graminoid species within each subplot are recorded. Once 10 subplots were surveyed, the plot is investigated for species not in the subplots. Those seen outside the subplots were allocated to a virtual subplot, 11. This results in a measure of richness, namely a list and number of species occurring in the plot, where each species could be recorded only once. Illustrated by simple example, if Species 1 was recorded from 3 subplots and Species 2 from 5, they are still only recorded once for the plot, with a total of 2 species in the plot. However, data from each subplot can also be utilized to show relative abundance in the plot. Species 1 then has an abundance of 3 and Species 2 an abundance of 5, for a combined abundance total of 8 species records. These results can also be expressed as a percentage. For richness, the percentage is the number of plots in which a species is found divided by the total number of plots. For abundance, the percentage is the number of subplots in which a species is found divided by total number of subplots.

3.4 Identification of plant species

Where unfamiliar species were encountered, collections were made and identified at the KwaZulu-Natal Herbarium. The 543 different collections made and lodged at the KwaZulu-Natal Herbarium during this survey are listed in Appendix 2. Botanical names used during surveying are those in Germishuizen *et al.* (2006), with the following exceptions. Plants formerly known as *Scilla kraussii* Baker and *S. natalensis* Plach. were found easily discernable in the field and so are not combined in *Merwilla plumbea* (Lindl.) Speta. *Gerbera kraussii* Sch.Bip. is also a readily recognizable species (Hilliard 1997) and found to be so in the field, and so is not included in *G. ambigua* (Cass) Sch.Bip. On the advice of Dr Brian Schrire a legume systematist revising the genus *Indigofera* in southern Africa, the name *I. inandensis* Baker f. ex Schrire ined. (= DGA Styles 5122, 5237 NH) is applied to one species found in the plots. Following Van Wyk & Smith (2014) *Aloe parviflora* Baker is upheld.

A challenge was encountered with the genus *Indigofera*, some species of which are abundant in the Cato Ridge grasslands. The genus has not been revised in southern Africa since the Victorian era and a number of species are undescribed. However, the southern African *Indigofera* species are being revised by Dr Brian Schrire, a legume systematist formerly of the

Royal Botanic Gardens, Kew, who assisted with identification of *Indigofera* species at Cato Ridge, and provided descriptions and known distributions through comprehensive lists of herbarium collections.

3.5 Geology

Surveying was distributed in areas of different geology indicated by the eThekwini Municipality's 1:50 000 geological map. However, errors were sometimes observed near boundaries of transition. For plots in these areas, rock samples were provided to geologist Dr Ron Uken (formerly of the School of Geological Sciences at the University of KwaZulu-Natal) for analysis. As a result, a small number of plots in or near boundary areas were instead confirmed to be on Dwyka Group tillite rather than Natal Group sandstone or megacrystic biotite granite.

3.6 Aspect

When plots were marked out for surveying, a handheld compass was used to record aspect and notes were also taken for steepness. However, this was for comparison and confirmatory purposes only, and was not the primary method of aspect or slope determination. The primary method was use of existing GIS data for the area. The eThekwini Municipality has developed a digital elevation model for the city, which includes Cato Ridge, providing data for aspect and slope (in degrees) for any point to an accuracy of 2 m (Corporate GIS Department, eThekwini Municipality). The GIS centre point of each plot was placed exactly within the digital elevation model to obtain aspect and slope data. The aspect parameters recorded for plots are shown in Table 3.1 and an example of slope determination in Figure 3.2.

Table 3.1. Aspect parameters recorded for plots.

Flat – no value	No aspect values in the eThekwini Municipality's digital elevation model. No plots were found with this value.	North	0-22.5 °
North-east	22-5-67.5 °	East	67.5-112.5 °
South-east	112.5-157.5 °	South	157.5-202.5 °
South-west	202.5-247.5 °	West	247.5-292.5 °
North-west	292.5-337.5 °	North	337.5-360 °

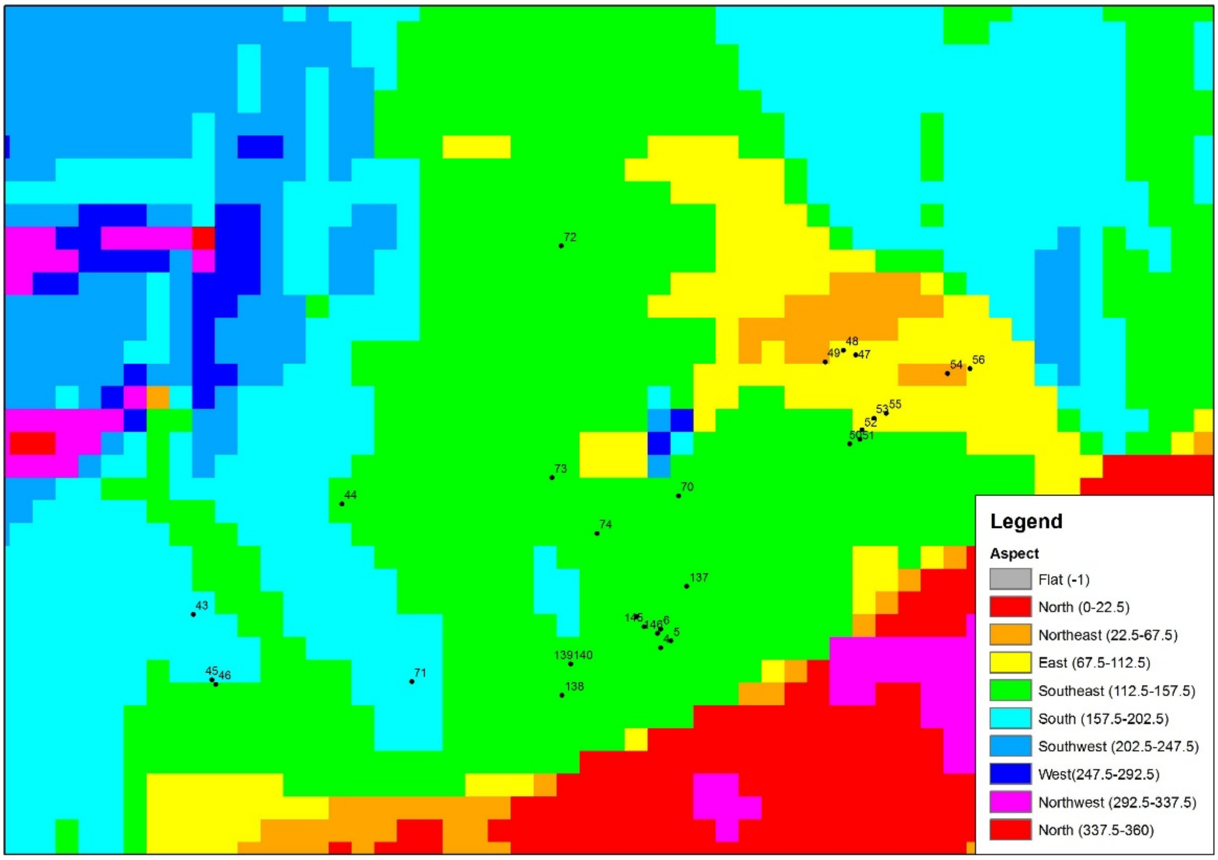

Figure 3.2. Example of aspect determination within the eThekwini Municipality's digital elevation model. Points and numbers are plots in this part of Cato Ridge.

3.7 Slope

Slope parameters are given below (Table 3.2), with an example of determination within the eThekwini Municipality's digital elevation model (Figure 3.3).

Table 3.2. Slope parameters recorded for plots.

Description	**Parameters**
Flat	0-2 °
Moderate	2 - 10 °
Steep	10 - 25 °
Very steep	> 25 °

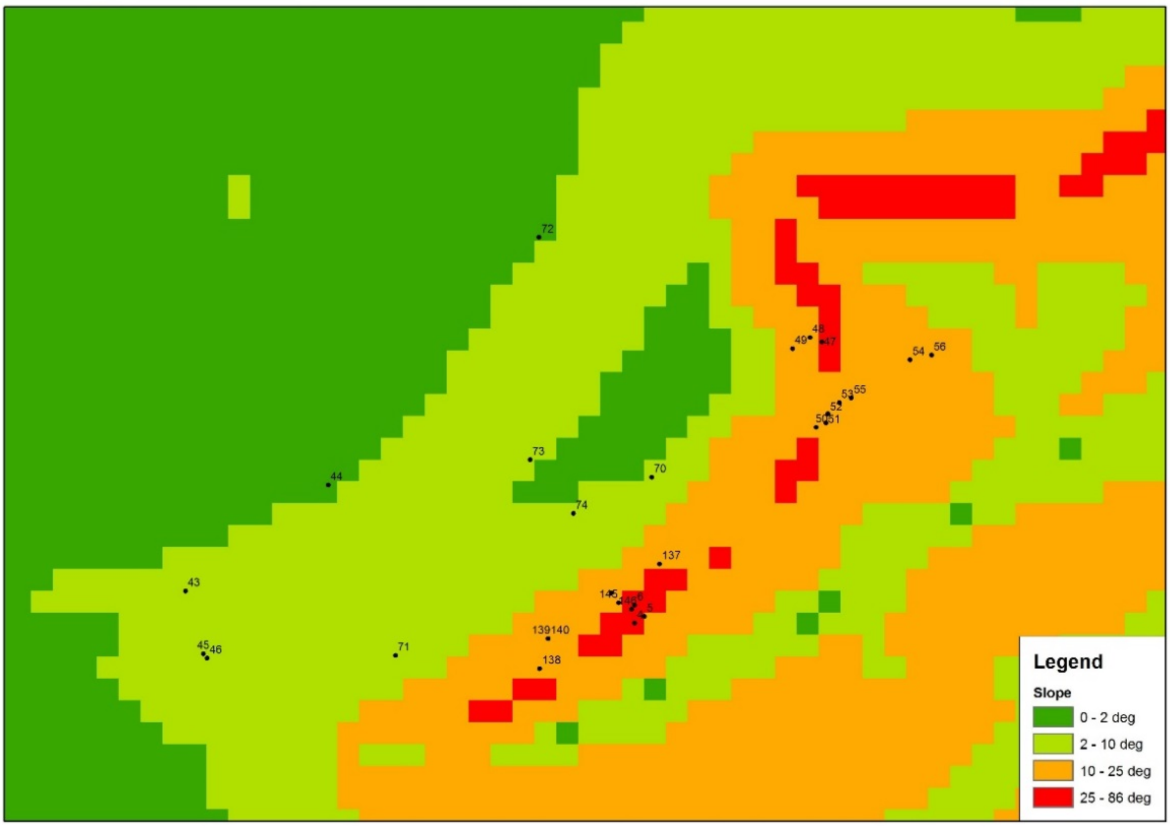

Figure 3.3. Example of slope determination within the eThekwini Municipality's digital elevation model. Points and numbers are plots in this part of Cato Ridge.

3.8 Rockiness

Very little grassland at Cato Ridge is not rocky, so only a small number of plots contain no rock exposure. The only data recorded was whether plots contained more or less than 25% rock exposure.

3.9 Data relating to plots

Geology, slope and aspect data is presented for plots below (Tables 3.3–3.4). At Cato Ridge, there is less grassland on Dwyka Group tillite that has a south-facing aspect than there is on a Natal Group sandstone. The different geologies also give rise to different landforms. Natal Group sandstone geology gives rise to flat-topped (table-top) plateaus that often have steep sides (Marshall 1994, 2002). The landform for Dwyka Group tillite areas at Cato Ridge is comprised of slopes that are mainly gentle to moderate and hills seldom have sides as steep as beneath Natal Group sandstone plateaus. Flat parts are rare. As a result, there are more plots on a Natal Group sandstone substrate that are either level or very steep compared to those on Dwyka Group tillite, and more plots on gentle to moderate slopes on Dwyka Group tillite compared to Natal Group sandstone. Megacrystic biotite granite and other granite areas of Cato Ridge also have a rolling landform without sharp gradations of Natal Group sandstone. Only one grassland area in fair to good condition was found on granite and so worth surveying. This grassland occurred where terrain was steep and south- or west-facing. While the large numbers of plots surveyed on Natal Group sandstone and Dwyka Group tillite substrates allow for more robust comparison, the limited surveying of grassland on granite means results should be treated more cautiously. Only one plot could not be certainly allocated to exclusively Natal Group sandstone, Dwyka Group tillite or megacrystic biotite granite geology.

Table 3.3. Plots by geology and aspect.

Geology	East (67.5-112.5 °)	North (292.5-67.5 °)	South (112.5-247.5 °)	West (247.5-292.5 °)	Totals
Natal Group sandstone	11	34	72	9	126
Dwyka Group tillite	11	42	39	8	100
Megacrystic biotite granite			5	4	9
Dwyka Group tillite-megacrystic biotite granite transitional			1		1

Table 3.4. Plots by geology, aspect and slope (aspect values as for Table 3.3).

Geology	Aspect summary	Flat	Moderate	Steep	Very Steep
Natal Group sandstone	East	1	3	7	
Natal Group sandstone	North	13	8	13	
Natal Group sandstone	South	8	11	45	8
Natal Group sandstone	West	1	5	3	
Dwyka Group tillite	East		4	7	
Dwyka Group tillite	North		30	12	
Dwyka Group tillite	South		16	22	1
Dwyka Group tillite	West	1	4	3	
Megacrystic biotite granite	South			5	
Megacrystic biotite granite	West			4	
Dwyka Group tillite-megacrystic biotite granite transitional	South		1		

3.10. Statistical analysis

In order to compare plant diversity across geologies, species richness values from plots on Dwyka Tillite and Natal Sandstone were compared using a t-test. To assess whether the representation of plants from different biogeographical categories (endemics, biogeographically important species, Cape floristic elements, and species identified as important in KwaZulu-Natal Sandstone Sourveld and Ngongoni Veld by Mucina & Rutherford (2006)) differed proportionally between geologies, chi-squared tests were performed for plants belonging and not belonging to each of these categories from the complete plant list for each of the two main geologies. These geologies analyzed are Natal Group sandstone and Dwyka Group tillite. An analysis of variance (ANOVA) test was performed to determine the effects of aspect on species richness at the plot level.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Basic plot data

In order to show the rate at which new species were recorded using the survey method used, the mean was calculated for each subplot (Figure 4.1). It is mentioned again that subplot 11 is not a real subplot, but a category to which species were added that were seen in the 100 m^2 plot, but outside the 1 m^2 subplots. Due to size, the 1 m^2 subplots could be searched more intensively than the entire 100 m^2 plot. As a result there is likely some under-reporting of species outside the subplots compared to those inside.

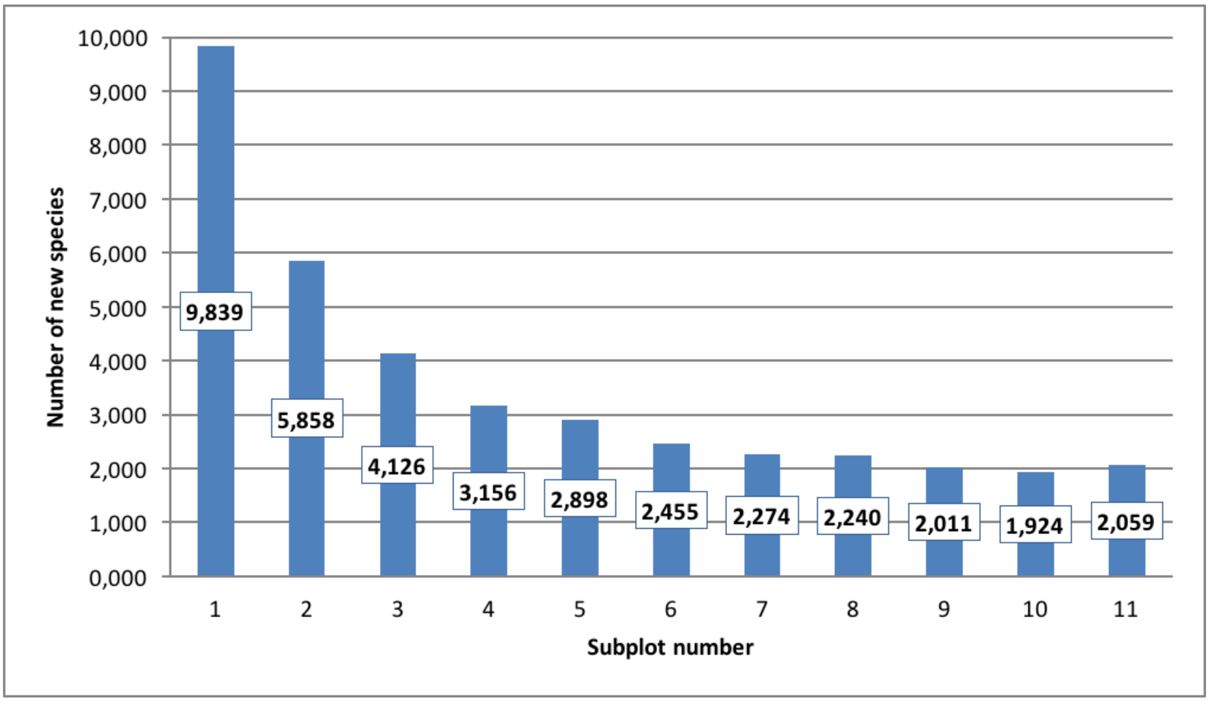

Figure 4.1. Mean number of species added per subplot (over 236 plots).

4.2 Number of species

A total of 23 502 records were gathered from the 236 plots, involving 484 non-graminoid taxon categories. A minority of the taxon categories reflect duplication. While the great majority of plants could be resolved to applicable species, subspecies or variety, some could not be (usually due to inadequacy or poor condition of material). These were then resolved only to genus or species. A good example of how this problem was accommodated is *Commelia africana* L.

Commelina africana L. var. *krebsiana* (Kunth) C.B.Clarke and *C. africana* L. var. *lancispatha* C.B.Clarke both occur in these grasslands but sterile material is difficult or impossible to determine to variety. As a result, material of *C. africana* L. was allocated to three taxon categories: *C. africana* L. only but also to the infraspecific taxa where this was possible.

Appendix 2 is a list of the non-graminoid taxa found in the Cato Ridge grasslands with these duplications removed. This shows 469 unique taxa recorded in plots together a further 153 outside of plots. Taxa found outside plots appear to have low abundance in the Cato Ridge grasslands. The stand-out families in terms of numbers of taxa are the Asteraceae (124 taxa including 29 *Helichrysum* and and 24 *Senecio* taxa) and Fabaceae (86 taxa). Other families that are well represented are the Apocynaceae (32), Rubiaceae (27), Orchidaceae (25), Hyacinthaceae (20), Lamiaceae 19, Iridaceae, Scrophulariaceae and Tiliaceae (all with 17), Acanthaceae (15) and Euphorbiaceae (14).

The grassland on Dwyka Group tillite on Thornridge Farm is different to that on a Dwyka Group tillite substrate elsewhere at Cato Ridge. Thornridge Farm is a well-known locality in the north-west of the Cato Ridge LAP area. The property is not a working farm and mainly comprises natural vegetation that is mapped as KwaZulu-Natal Hinterland Thornveld and Eastern Valley Bushveld in Mucina & Rutherford (2006). The grassland that occurs is drier and more fragmented and occurs in a mosaic with these other vegetation types. As a result, the species composition of this grassland is influenced by infiltration of herbaceous and geophytic KwaZulu-Natal Hinterland Thornveld and Eastern Valley Bushveld elements. For this reason, analyses below differentiate between plots surveyed in all Dwyka Group tillite grassland at Cato Ridge, that which occurs on Thornridge Farm, and that elsewhere in the area, in order to make more equivalent comparisons with grassland on a Natal Group sandstone substrate.

The number of species in plots according to geology is shown in Table 4.1.

Table 4.1. Number of species recorded in plots.

Geological substrate	Number of plots (out of 236 plots)	Species (out of 484 species)
Natal Group sandstone	126	385
Dwyka Group tillite	100	356
Dwyka Group tillite excluding Thornridge Farm	85	290
Dwyka Group tillite in the Thornridge Farm environs	15	147
Megacrystic biotite granite plots)	9	107

4.3 Geology

Species richness, comprising the minimum, maximum and mean number of species found in plots with Natal Group sandstone, Dwyka Group tillite or megacrystic biotite granite geology is presented below (Table 4.2).

Table 4.2. Species richness, comprising maximum, minimum and mean number of species in plots according to geology.

	Natal Group sandstone (126 plots)	Dwyka Group tillite (including Thornridge Farm, 100 plots)	Megacrystic biotite granite (9 plots)
Maximum	56	65	49
Minimum	10	18	28
Mean	32	39	37

Species abundance, comprising the minimum, maximum and mean number of records in plots (the sum of the subplots) is presented below. (Table 4.3).

Table 4.3. Species abundance, comprising minimum, maximum and mean number of records in plots.

	Natal Group sandstone (126 plots)	**All Dwyka Group tillite (including Thornridge Farm 100 plots)**	**Megacrystic biotite granite (9 plots)**
Maximum	185	250	149
Minimum	34	55	93
Mean	85	118	116

Dwyka Group tillite plots have significantly higher richness and abundance scores than those on a Natal Group sandstone or granite. However, the disturbance history of the grasslands may contribute to this outcome. Most of the Dwyka Group tillite grassland occurs on the south side of the N2 national road, where grazing pressure appears to be lower.

The grassland on Dwyka Group tillite in the vicinity of Thornridge Farm, situated on the western edge of Cato Ridge, is different to that on a Dwyka Group tillite substrate elsewhere at Cato Ridge. Of 101 plots surveyed on Dwyka Group tillite, 15 were surveyed on the farm. The farm and environs comprises vegetation that is mapped to KwaZulu-Natal Hinterland Thornveld and Eastern Valley Bushveld (Mucina & Rutherford 2006) which grade into one another in this area. The grassland is drier and more fragmented than elsewhere at Cato Ridge and occurs in a close mosaic with KwaZulu-Natal Hinterland Thornveld and Eastern Valley Bushveld (Mucina & Rutherford 2006). As a result, the species composition of this grassland appears to be influenced by infiltration of herbaceous elements from other vegetation types.

A t-test was conducted to compare the mean plant richness between plots on Natal Group sandstone and Dwyka Group tillite. Plots at Thornridge Farm were excluded. The analysis showed that on average plots in grassland on Dwyka Group tillite had greater species richness than on Natal Group sandstone (41 versus 32 species) (Table 4.4; Figure 4.2). The t-test results showed that the plant richness values were significantly different (p-value < 0.05) (Table 4.5). The Dwyka Group tillite grassland therefore had significantly more richness than the Natal Group sandstone grassland.

Table 4.4. Analysis of mean species richness in Natal Group sandstone and Dwyka Group tillite plots (excluding Thornridge Farm).

Geology	Number of plots	Mean	Std deviation	Std error mean
Natal Group sandstone	126	32.23	11.068	.986
Dwyka Group tillite	85	40.94	9.173	.995

Table 4.5. Independent samples test: species richness in Natal Group sandstone and Dwyka Group tillite plots (excluding Thornridge Farm).

	t	df	p-value	Mean difference	Std error Difference	95% Confidence interval of the difference	
						Lower	Upper
Total species richness	5.997	209	<0.01	8.711	1.452	5.848	11.574

Appendix 3 shows differences in the most abundant species on the respective geologies, ordered according to percentage. Despite mean richness in individual plots, a larger number of species were found in Natal Group sandstone plots but not Dwyka Group tillite plots, than vice versa (Appendix 4). If grassland on Dwyka Group tillite in the KwaZulu-Natal Hinterland Thornveld-Eastern Valley Bushveld mosaic is included the results are 46 versus 36, but falling to 46 versus 24 if excluded. In contrast, there are 23 species that occur only in Natal Group sandstone plots with an abundance of 0.1 % or more, only four such species are found on Dwyka Group tillite plots, excluding the environs of Thornridge Farm.

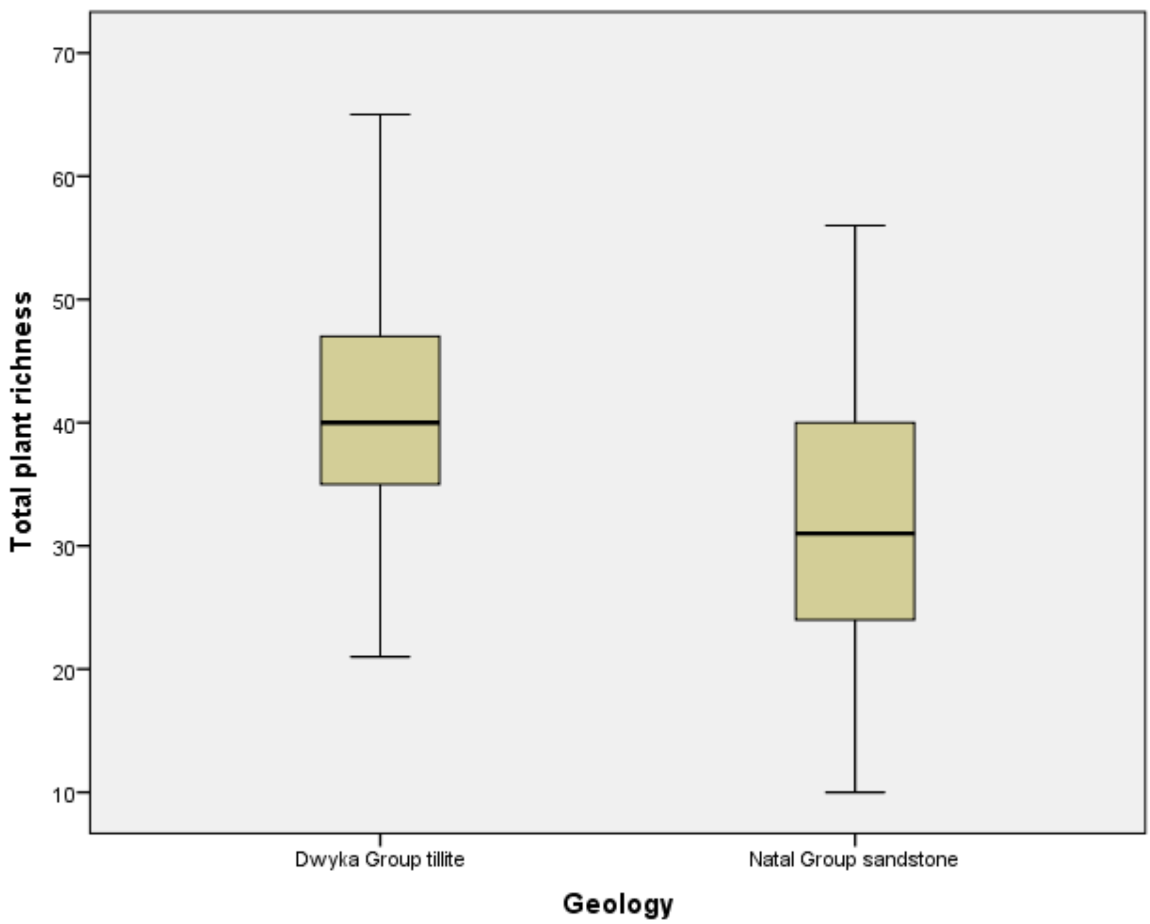

Figure 4.2. Mean plant species richness in Dwyka Group tillite and Natal Group sandstone plots.

4.4 Aspect

Topography, including aspect, has been reported as having important influence on vegetation structure, morphology and species composition (Ayyad & Dix 1964, Ackerly *et al.* 2002). At Cato Ridge, although grassland on south-facing versus north-facing slopes appears to gather biomass more rapidly, there are no ready visual differences.

An analysis of variance (ANOVA) test was carried out to compare the means of plant richness on south-facing, east-facing, west-facing and north-facing aspects, using plots on Natal Group sandstone and Dwyka Group tillite (excluding Thornridge Farm). The descriptive analysis also shows that south-facing plots had the highest mean plant richness followed by east-facing and west-facing respectively (Table 4.6). The ANOVA table (Table 4.7) showed that the means were significantly different from one another (p-value < 0.05).

Table 4.6. Descriptive analyis showing means of species richness on different aspects: Natal Group sandstone and Dwyka Group tillite plots (excluding Thornridge Farm).

	N	Mean	Std. Deviation	95% Confidence interval for mean		Min	Max
				Lower bound	Upper bound		
North-facing	70	31.33	11.139	28.67	33.98	14	59
East-facing	22	38.32	11.801	33.09	43.55	19	65
South-facing	102	38.73	9.895	36.78	40.67	16	60
West-facing	17	32.65	11.932	26.51	38.78	10	53
Total	211	35.74	11.177	34.22	37.26	10	65

Table 4.7. ANOVA comparison of mean species richness by aspect: Natal Group sandstone and Dwyka Group tillite plots (excluding Thornridge Farm).

	Sum of squares	df	Mean square	F	Sig.
Between groups	2580.252	3	860.084	7.527	<0.01
Within groups	23652.412	207	114.263		
Total	26232.664	210			

A Tukey HSD multiple comparisons test was conducted to find out which types of plots had significantly mean difference for plant richness. This shows that north-facing plots had significantly lower plant richness than east-facing ($F = 7.53$; p-value = 0 .040) and south-facing facing plots (p-value < 0.01) (Table 4.8 and Figure 4.3).

Table 4.8. *Post hoc* tests output for aspect: Natal Group sandstone and Dwyka Group tillite plots (excluding Thornridge Farm).

Multiple Comparisons						
Dependent Variable: Species Richness						
(I) Aspect	**(J) Aspect**	**Mean Difference (I-J)**	**Std. Error**	**p-value**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
North-facing	East-facing	-6.990*	2.613	.040	-13.76	-.22
	South-facing	-7.397*	1.659	< 0.01	-11.69	-3.10
	West-facing	-1.318	2.890	.968	-8.80	6.17
East-facing	North-facing	6.990*	2.613	.040	.22	13.76
	South-facing	-.407	2.513	.998	-6.92	6.10
	West-facing	5.671	3.452	.357	-3.27	14.61
South-facing	North-facing	7.397*	1.659	< 0.01	3.10	11.69
	East-facing	.407	2.513	.998	-6.10	6.92
	West-facing	6.078	2.800	.135	-1.17	13.33
West-facing	North-facing	1.318	2.890	.968	-6.17	8.80
	East-facing	-5.671	3.452	.357	-14.61	3.27
	South-facing	-6.078	2.800	.135	-13.33	1.17
* The mean difference is significant at the 0.05 level.						

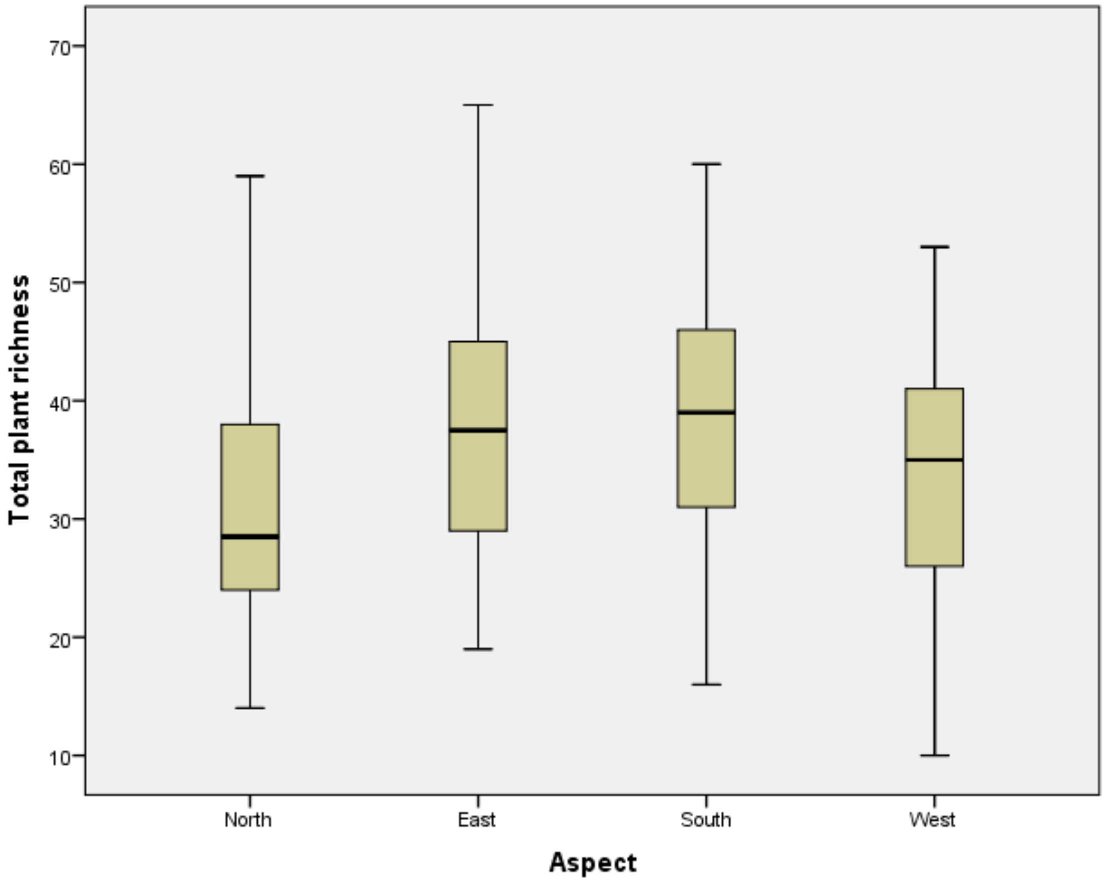

Figure 4.3. Mean species richness by aspect.

When results from Thornridge Farm are included, aspect continues to show significant changes in richness. Plots that are narrowly south-facing (157.5-202.5 °) were found to have highest mean richness scores, followed by more broadly south-facing (112.5-247.5 °), east-facing, west-facing, broadly north-facing (292.5-67.5 °) and narrowly north-facing (337.5-22.5 °).

The 30 most abundant species in plots with north-facing versus south-facing aspects are shown in Appendix 5. The most abundant species found on south-facing aspects but not north-facing aspects, and vice versa, are shown in Appendix 6. The most abundant species on steep and very steep north-facing plots and south-facing plots, according to whether on Natal Group sandstone or Dwyka Group tillite (excluding Thornridge Farm) are presented in Appendix 7. This is presented for plots with level and moderate slopes, according to the same criteria in Appendix 8.

When species found on south-facing slopes (112.5-247.5 °) but not north-facing plots (292.5-67.5 °) are analyzed and vice versa, there are 143 and 64 species respectively. These results indicate a preference by some species for more xeric versus mesic conditions and vice versa, but the reliability of prediction can be taken to decline as abundance decreases. These results should also not be taken to mean that species with indication of north- or a south-facing aspect preference will never be found on the other aspect. However, if found on the other aspects through further surveying of plots, this is likely to be at low abundance.

4.5 Rockiness

Detailed information on species richness is not presented for plots analyzed according to the rockiness criterion (that is plots that have more than, or less than 25 % rock exposure). However, it was found that species richness and abundance diminishes when the amount of rock exposure increases over 25 % (Table 4.9). It was also found that there is a larger decrease in abundance in Natal Group sandstone plots (Table 4.10) compared to Dwyka Group tillite plots (Table 4.11). Skeletal soils around Natal Group sandstone outcropping may explain this outcome.

Table 4.9. Rock exposure, richness and abundance on all geologies.

Mean richness where < 25 %	**Mean richness where > 25 %**	**Mean abundance where < 25 %**	**Mean abundance where > 25 %**
38	30	107	76

Table 4.10. Rock exposure, richness and abundance on Natal Group sandstone.

Mean richness where < 25 %	**Mean richness where > 25 %**	**Abundance where < 25 &**	**Abundance where > 25 %**
36	29	96	68

Table 4.11. Rock exposure, richness and abundance on Dwyka Group tillite.

Mean richness where < 25 %	**Mean richness where > 25 %**	**Mean abundance where < 25 %**	**Mean abundance > 25 %**
40	36	118	105

4.6 Endemism on the geologies

The majority of the species that occur on the different geologies have a wide distribution in South Africa and often beyond and except for their particular associations and their relative richness and abundance, are not on their own highly distinctive. However, a minority have narrow distributions that may be more significant and confer diagnostic value. Locality records for 559 collections of species in the different endemism categories described in Section 2.3 and Appendix 1, held in the main provincial herbaria, are presented in maps (Figures 4.4–4.6).

The patterns of endemism that emerge do not correspond well with the mapped extent of KwaZulu-Natal Sandstone Sourveld or Ngongoni Veld in Mucina & Rutherford (2006) or the South African National Biodiversity Institute (2012). However, there is a much better correlation when the distribution of Natal Group sandstone is brought into account, which extends very close to the coast (such as in the Durban area) (Figure 2.1). This supports the suggestion in Boon *et al.* (2016) that KwaZulu-Natal Sandstone Sourveld (or alternately floristically similar grassland) extends east of the coastal escarpment and to lower elevations than presented by Mucina & Rutherford (2006). As the Figure 2.1 shows, if occurrence of KwaZulu-Natal Sandstone Sourveld is indeed supported by Natal Group sandstone geology, it may have occurred close to the coast, perhaps even more so than indicated by Boon *et al.* (2016).

Unfortunately, there is little if any untransformed grassland left at lower elevations closer into the main eThekwini conurbation that can be investigated for corroboration. There mapping also indicates a migration corridor in the north-west including Nkandla and Ngome. A migration corridor exists between the Pondoland Centre and the Ingeli Mountain range considerably inland, although stated to link with the Drakensberg range (Van Wyk & Smith 2001).

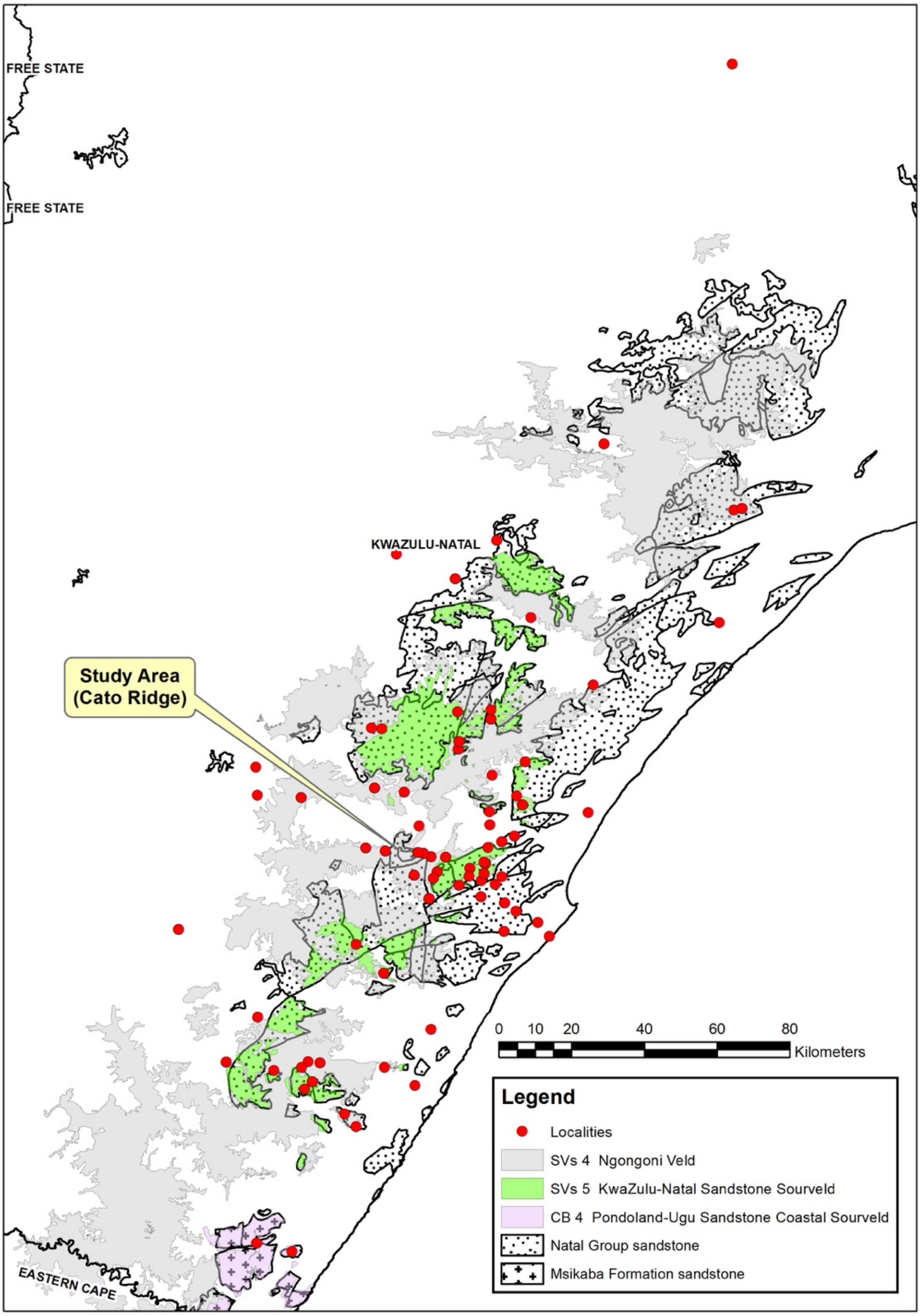

Figure 4.4. Map showing locality data for species endemic or nearly-endemic (to the coastal escarpment north of Pondoland). Points usually indicate localities at which more than one

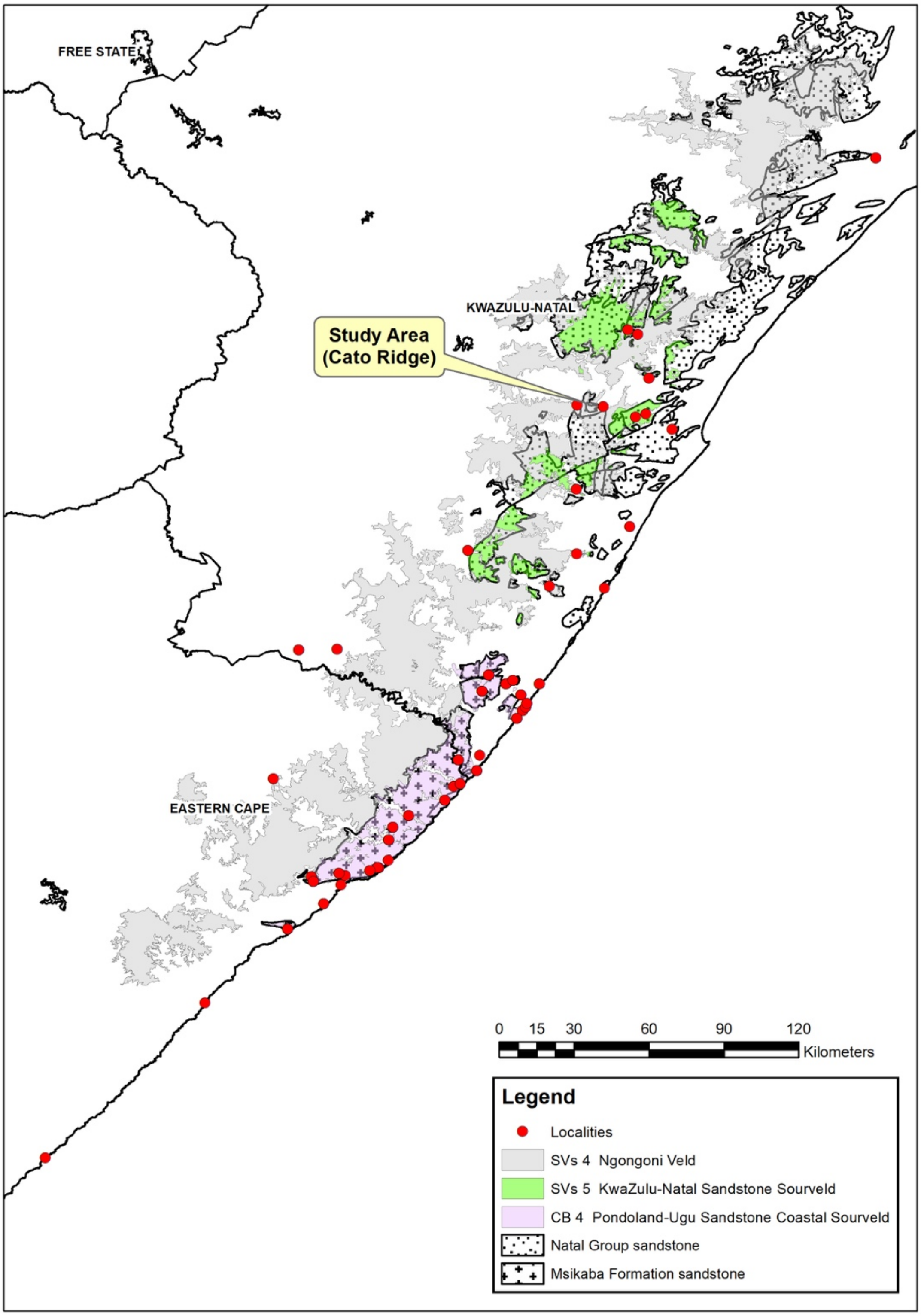

Figure 4.5. Map showing locality data for species cited as Pondoland Centre endemics by Van Wyk & Smith (2001) and Abbott (2006), which extend northwards. Points may indicate localities at which more than one species occurs (for example multiple species occur in the Ngoye Forest (the northernmost point shown).

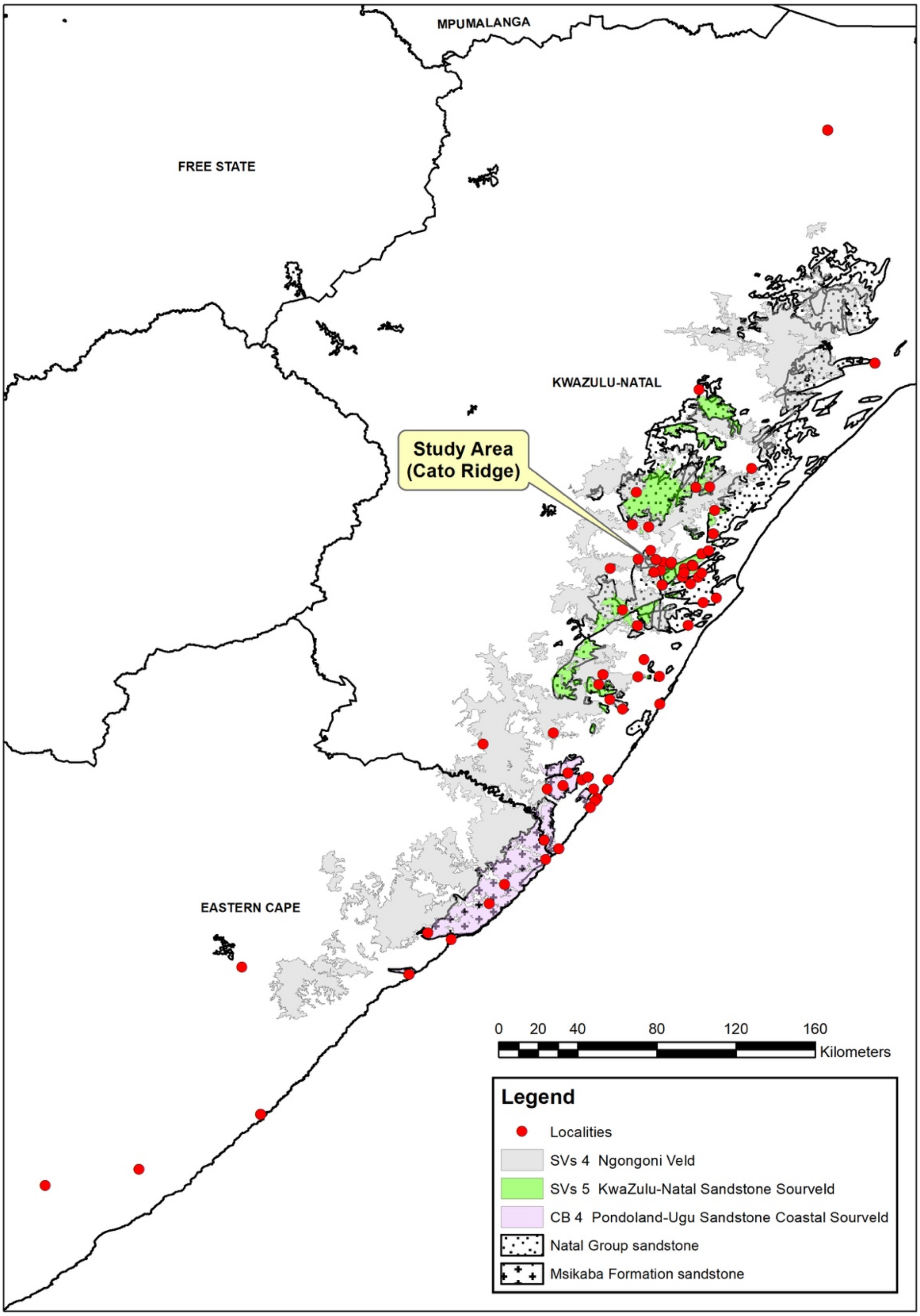

Figure 4.6. Map showing locality data for species that are distributed equally through the Pondoland Centre and across the northern coastal escarpment.

A number of the species identified in the various endemism categories set out in Section 2.3 and Appendix 1 were found in plots at Cato Ridge, nearly all of which are illustrated in photographs supplied in Appendix 11. Species that had no matches in the KwaZulu-Natal Herbarium (NH) or in literature are possibly undescribed and are considered possible local endemics. The species in these endemism categories found in the plots are set out with corresponding abundance results in Table 4.12.

Table 4.12. Endemic species found in plots according to abundance (* = number of records; END = endemism; NGS = Natal Group sandstone; DGT = Dwyka Group tillite; G = megacrystic biotite granite).

Species	**END**	**NGS ***	**NGS %**	**DGT ***	**DGT %**	**G ***	**G %**
Agathisanthemum chlorophyllum (Hochst.) Bremek. var. *chlorophyllum*	ECE-E	228	2.16	367	3.08	43	4.12
Aloe parviflora Baker	NCE-E	16	0.15	5	0.04		
Argyrolobium longifolium (Meisn.) Walp.	NCEF E	15	0.14	14	0.12		
Brachystelma pulchellum (Harv.) Schltr.	NCE-E	24	0.23				
Chaetacanthus sp. nov. = D.G.A. Styles 3822, 3919, 3950, 3972, 3973 (NH)	LE	68	0.64				
Cineraria atriplicifolia DC.	NCE-FE	39	0.37				

Crassula sp. nov. = D.G.A. Styles & M. Ngwenya 4082 (NH)	LE	1	0.01				
Crotalaria dura J.M.Wood & M.S.Evans subsp. *dura*	NCE-FE	22	0.21	34	0.29		
Dierama pallidum Hilliard	NCE-FE	10	0.10	15	0.13	6	0.58
Eriosema populifolium Benth. ex Harv. subsp. *populifolium*	NCE-E			11	0.09		
Eriosema superpositum C.H.Stirt. ined.	NCE-E			1	0.01		
Eriosemopsis subanisophylla Robyns	ECE-E / PC-FE	27	0.26	4	0.03	4	0.38
Helichrysum griseum Sond.	ECE-E	90	0.85	24	0.20		
Helichrysum pannosum DC.	ECE-E	29	0.27	33	0.28	1	0.10
Hermannia sandersonii Harv.	NCE-E/NCE-FE	6	0.06				
Indigofera inandensis Baker f. ex Schrire ined. (= DGA Styles 5122, 5237 NH)	NCE-E	5	0.05	2	0.02		
Indigofera sp. nov. B (= DGA Styles 5091 NH)	ECE-E	10	0.01	204	1.46	18	1.72
Indigofera rubroglandulosa	ECE-E	189	1.79	174	1.724		

Germishuizen sensu lato							
Pachycarpus coronarius E.Mey	ECE-E	2	0.02				
Phymaspermum pinnatifidum (Oliv.) Kallersjo	NCE-E	40	0.38				
Plectranthus hadiensis (Forssk.) Schweinf. ex. Spreng. *var. nov.*	LE	21	0.20				
Schizoglossum peglerae N.E.Br.	ECE-E	1	0.01				
Senecio albanopsis Hilliard	ECE-E	116	1.10	3	0.03		
Senecio exuberans R.A.Dyer	NCE-FE	24	0.23	9	0.08		
Streptocarpus polyanthus Hook. subsp. *polyanthus*	NCE-FE	9	0.09				
Totals		**803**	**7.60**	**726**	**6.10**	**54**	**5.20**
Totals for all species by geology		**10568**		**11925**		**1044**	

Indigofera sp. nov. A (DGA Styles 3457, 3477 NH), is an eastern coastal escarpment endemic, but often difficult to distinguish from the closely related *I. rubroglandulosa* Germishuizen. *Indigofera. sp. nov.* A appears to be less common and more clearly confined to confined to sandstone. Due to the problems in making rapid reliable distinction, when plots were surveyed it was recorded as *I. rubroglandulosa* sensu lato. *Indigofera sp. nov.* A is therefore also omitted from the tables showing endemism abundance results. However, *I. sp. nov.* B (= DGA Styles 5091 NH) is an easily identifiable species even when partial material is available, and is for this reason included.

Eighty-four % of Natal Group sandstone plots contain endemics, 91.09 % on Dwyka Group tillite and 88.9 percent on megacrystic biotite granite. However, these overall figures are somewhat misleading as the result is influenced by one more common species, *Agathisanthemum chlorophyllum* (Hochst.) Bremek. var. *chlorophyllum* occurring in 79.2 % of the Dwyka Group tillite plots, versus 52.8 % of the Natal Group sandstone plots and 77.8 % of the granite plots. While locally common at Cato Ridge, this is a poorly known species and more collecting may show it is only biogeographically important.

Twenty-six endemic species occur in Natal Group sandstone and Dwyka Group tillite plots. Twenty-three of the 26 occur in Natal Group sandstone plots compared to 14 in Dwyka Group tillite plots. Nine of the endemic species were found only on a Natal Group sandstone substrate and 3 are mainly present in Natal Group sandstone plots and occur in only one or a few Dwyka Group tillite plots. These include *Eriosemopsis subanisophylla* Robyns. Although cited as a Pondoland Centre endemic (Van Wyk & Smith 2001), it is here treated as a Pondoland Centre floristic element as it is found at many sites north of Pondoland where it may be locally common in small remaining instances of primary grassland as far north as Durban. This species is nearly absent from Dwyka Group tillite plots and was only found in Dwyka Group tillite plots close to occurrences of Natal Group sandstone. *Helichrysum griseum* Sond. occurs in more plots and with a higher abundance where there is a Natal Group sandstone substrate.

Only two endemic species are found on a Dwyka Group tillite substrate but not on a Natal Group sandstone substrate, namely *Eriosema populifolium* Benth. ex Harv. subsp. *populifolium* and *E. superpositum* (Stirton ined.) and are notably more common in Dwyka Group tillite plots than Natal Group sandstone plots. Some further comment is made about the *Eriosema* species. In email communication, Prof. Charles Stirton who has published extensively on *Eriosema* and confirmed Cato Ridge plants as *E. populifolium* Benth. ex Harv. based on photographs supplied, advises it has a preference for deeper soils in valley bottoms (pers. com.). This habitat is mainly absent from areas of Natal Group sandstone geology at Cato Ridge. Although *Eriosema populifolium* Benth. ex Harv. subsp. *populifolium* was separated from subsp. *capensis* (Stirton & Gordon-Gray) on the basis of unifoliate versus trifoliate leaves (C.H. Stirt. & Gordon-Gray 1978), plants at Cato Ridge may be unifoliate or trifoliate. As some plants are unifoliate and *E. populifolium* Benth. ex Harv. subsp. *capensis* (Stirton & Gordon-Gray) is considered to occur in the Eastern Cape, the Cato

Ridge plants are referred to *E. populifolium* Benth. ex Harv.subsp. *populifolium*. This raises the question of whether these infraspecific ranks should be upheld. The occurrence of *Eriosema populifolium* Benth. ex Harv. at Cato Ridge is also unusual in that it has not previously been recorded so far north (Stirton 1978). *Eriosema superpositum* C.H.Stirt. ined. was seen in only one place but has been reported from other parts of the eThekwini Municipal Area where there is a Natal Group sandstone substrate (Stirton 1986).

For the most part, endemics which occur in a roughly similar proportion of Natal Group sandstone and Dwyka Group tillite plots are also those that, while mainly occurring on the coastal escarpment, have been recorded somewhat further afield with outlier populations occurring historically at least as far inland as Pietermaritzburg, such as *Crotalaria dura* J.M.Wood & M.S.Evans subsp. *dura*, *Dierama pallidum* (Hilliard 1991) and *Senecio exuberans* (Hilliard 1977). Although Edwards (1994) reports a collection of *Argyrolobium longifolium* (Meisn.) Walp. from Dargle this record is questionable and may originate from a labelling error.

Some of the endemics confined to Natal Group sandstone plots were mainly or only recorded where there is extensive outcropping or pavements. In this category are *Brachystelma pulchellum* (Harv.) Schltr. (although also present in very sandy soil amongst outcrops in the vicinity of the old Cato Ridge airfield), *Chaetacanthus sp. nov.*, *Crassula sp. nov*., *Cineraria atriplicifolia* DC., *Plectranthus hadiensis var. nov.* and *Streptocarpus polyanthus* Hook. subsp. *polyanthus* (the latter also found on scrub forest-grassland ecotones). Excluding members of the family Fabaceae, all species that are undescribed (on a presumptive basis as found not to be previously collected at the KwaZulu-Natal Herbarium) occur where there is extensive sandstone outcropping or sheeting, including *Chaetacanthus sp. nov*., *Crassula sp. nov*. and *Plectranthus hadiensis* (Forssk.) Scweinf. ex. Spreng. *var. nov.*

A chi-squared test was conducted to establish whether richness of endemics is affected by geology (Table 4.13). It was found that marginally more endemic plants were found in Natal Group sandstone plots (6%), compared to those on Dwyka Group tillite excluding Thornridge Farm (5%), but the difference was not statistically significant (p=0.52). This means that at Cato Ridge there is no clear association between geology and endemism.

Table 4.13. Richness of endemic species by geology.

		Natal Group sandstone (species / %)	Dwyka Group tillite (species / %)	Chi-squared value	df	p-value
Endemic	Yes	23 (5.97)	14 (4.83)	0.419607	1	0.517133
	No	362 (94.03)	276 (95.17)			

4.7 Biogeographically important or interesting species

Species at Cato Ridge that are considered biogeographically important do not have a distribution in the above categories, but have other, limited distributions that are noteworthy (the species together with explanations provided in Appendix 9). The species with abundance results are set out below (Table 4.14).

Table 4.14. Abundance results for biogeographically important species according to geology (* = number of subplot records; G = megacrystic biotite granite).

Species	Natal Group sandstone *	Natal Group sandstone %	Dwyka Group tillite *	Dwyka Group tillite %	G *	G %
Acalypha glandulifolia Buchinger ex. Meisn.	126	1.192	162	1.358		
Adhatoda densiflora (Hochst) J.C.Manning			105	0.881		
Afrosciadium natalense (Sond.) P.J.D.Winter			1	0.008		

Argyrolobium baptisioides Walp.	1	0.009	61	0.512		
Brachystelma sandersonii (Oliv.) N.E.Br.	4	0.038				
Crassula capitella Thunb. subsp. *meyeri* (Harv.) Toelken	21	0.199	1	0.008		
Cyrtanthus obliquus (L.f.) Aiton	9	0.085				
Delosperma suttoniae Lavis	8	0.067				
Dierama argyreum L.Bolus	1	0.009	25	0.210		
Helichrysum asperum (Thunb.) Hilliard & Burtt var. *comosum* (Sch.Bip.) Hilliard	30	0.284				
Helichrysum auriceps Hilliard	73	0.691%	40	0.335	7	0.670
Kniphofia buchananii Baker			10	0.084		
Lobelia cochlearifolia Diels	5	0.047				
Ruellia baurii C.B.Clarke			26	0.218		
Senecio dregeanus DC.						
Senecio umgeniensis Thell.	42	0.397	157	1.317	17	1.628
Thunbergia venosa C.B.Clarke	3	0.028				

Some of these biogeographically important species occur at much higher abundance than others, including *Acalypha glandulifolia* Buchinger ex. Meisn., *Adhatoda densiflora* (Hochst) J.C.Manning, *Argyrolobium baptisioides* Walp., *Helichrysum auriceps* Hilliard, *Indigofera rubroglandulosa* Germishuizen sensu lato and *Senecio umgeniensis* Thell. Five species were found only Dwyka Group tillite plots (with this almost so for *A. baptisioides*) and six only in Natal Group sandstone plots.

A chi-squared test was conducted with richness results showing similar proportions of biogeographically important plants in Natal Group sandstone plots (2.86%) and Dwyka Group tillite plots (excluding Thornridge Farm) (2.76%) (p = 0.94) (Table 4.15).

Table 4.15. Richness of biogeographically important species by geology.

		Natal Group sandstone (species / %)	**Dwyka Group tillite (species / %)**	**Chi-squared value**	**df**	**p-value**
Biogeographically important	**Yes**	11 (2.86)	8 (2.76)	0.005869	1	0.938934
	No	374 (97.14)	282 (97.24)			

4.8 Cape floristic elements

Carbutt (2012) defines Cape floristic elements as follows: "[A] suite of genera whose species are most heavily concentrated in the [Cape Floristic Region] but which are also represented by other species in other floras … resulting in vestiges of the Cape flora as extra limital 'stations' or 'outposts'. The Cape element "extends north-eastwards and north-westwards, in diminishing fashion, along the highlands of sub-Saharan Africa." However, members of some families and genera extend as far north as Europe, for example *Erica*. In South Africa, the main occurrence of these elements is identified as occurring in dry regions "immediately north of the CFR, high mountains of the eastern Cape, Free State and the Drakensberg range in KwaZulu-Natal and Mpumalanga." However, he also notes a "rare association of the Cape element and a low-altitude subtropical environment" in the Pondoland Centre (Carbutt 2102).

A comprehensive list of the genera involved is presented by Carbutt (2004). A list of the species in these genera found in plots at Cato Ridge is provided in Appendix 10. A chi-squared test was carried out on the data from plots on Natal Group sandstone and Dwyka Group tillite (excluding Thornridge Farm) (Table 4.16). From this table, it can be concluded that there is more CFE richness in Natal Group sandstone plots (16% versus 15%) but they were not significantly different (p=0.81). This means that there was no association between geology and CFE richness.

Table 4.16. Cape floristic element richness by geology.

		Natal Group sandstone (species / %)	**Dwyka Group tillite (species / %)**	**Chi-squared value**	**df**	**p-value**
CFE species	**Yes**	61 (15.84)	44 (15.17)	0.05682	1	0.811594
	No	324 (84.16)	246 (84.83)			

Abundance data for all plots (including Thornridge Farm) show more CFE records on a Natal Group sandstone substrate. Abundance data shows these species comprise 10.1 % of all records on Natal Group sandstone, 7.1 % on Dwyka Group tillite and 14 % on megacrystic biotite granite. There are six genera that occur in Natal Group sandstone plots but not those on Dwyka Group tillite, nor seen elsewhere in grassland at Cato Ridge on the latter substrate. These genera are *Agathosma, Corycium, Erica, Osteospermum, Phymaspermum* and *Relhania*, with Cato Ridge at or near the northernmost limit from which the latter genus is known (Hilliard 1977). This may indicate a strong preference by some genera either for sandy soils or the steeper, cooler, south- and east-facing slopes that occur beneath Natal Group sandstone plateaus. It is perhaps no coincidence that *Erica cerinthoides* var. *cerinthoides* and *Relhania pungens* subsp. *angustifolia* were both found in the same plot on a precipitously steep slope.

On the other hand, differences indicated by the occurrence of some CFE genera in plots on Dwyka Group tillite but not Natal Group sandstone are possibly just a sampling artifact. Genera in this category are *Disa, Othonna* and *Tritonia*, together with *Gladiolus inandensis* Baker, *Moraea natalensis* Baker*, Protea caffra* Meisn. subsp. *caffra, P. simplex* E.Phillips and *Trachyandra gerrardii* (Baker) Oberm. They were found mostly at low abundance in Dwyka Group tillite plots, but were also seen outside plots in Natal Group sandstone grassland. *Hebenstretia comosa* Hochst., *Pelargonium alchemilloides* L. and *Zaluzianskya natalensis* Bernh. are the only CFE species not found in Dwyka Group tillite plots, nonetheless seen outside plots.

Carbutt (2012) following Van Wyk (2001) suggests that the reason for the large number of CFE species in the Pondoland Centre relates to "edaphically similar nutrient-poor substrates" – with the Cape Floristic Region and the Pondoland Centre extensively comprised of sandstone, and climate. This may also explain greater abundance of CFE species on a Natal Group sandstone substrate. Carbutt (2004) does not draw on plot-based data, but distributions of genera and species as recorded in literature and herbaria. In terms of genera, there are fewer at Cato Ridge than the Pondoland Centre (40 versus 77 genera). However, comparisons cannot be directly or fairly made because the 77 Pondoland Centre genera listed are not confined only to grassland and the figure is reached by including records from the entire Pondoland Centre, not an area of smaller size such as Cato Ridge. This being said, some CFE genera (such as *Leucodendron*) do not extend north of the Pondoland Centre. Abundance results for CFE species are also interesting when geology and slope are taken into account.

Abundance is highest on a south-facing aspect on a megacrystic biotite granite substrate, lower on a Natal Group sandstone substrate and lowest on Dwyka Group tillite (Table 4.17). However, the small number of plots on biotite gneiss may make these results an unreliable indicator of CFE abundance on this substrate.

Table 4.17. Abundance data for Cape floristic elements in all north-facing and south-facing plots.

	Natal Group sandstone (species / %)	**Dwyka Group tillite (species / %)**	**Megacrystic biotite granite (species / %)**
North-facing plots	170 (9.%1)	260 (5.5%)	-
South-facing plots	775 (10.7 %)	371 (8 %)	87 (13.3 %)

The analysis shows that while abundance of CFE species for plots with a south-facing aspect is slightly higher in Natal Group sandstone plots compared to Dwyka Group tillite, it is much higher where there is a north-facing aspect (Table 4.17). Conversely, on Dwyka Group tillite the abundance of CFE species falls much more sharply on north-facing aspects.

4.9 Mucina & Rutherford's (2006) presentation of KwaZulu-Natal Sandstone Sourveld and Ngongoni Veld

Mucina and Rutherford's (2006) statement that KwaZulu-Natal Sandstone Sourveld occurs on Natal Group sandstone and Ngongoni Veld on heavy soils "including significant Dwyka tillites" suggests a basis for separation of grassland at Cato Ridge. However, it is also possible to make correlations based on the occurrence of species they cite as important, biogeographically important or endemic in KwaZulu-Natal Sandstone Sourveld and important in Ngongoni Veld. This does not address whether the species listed as endemic, biogeographically important or important by these authors deserve an entirely meritorious place in these categories.

For the purposes of analysis, species cited as important, biogeographically important and endemic in KwaZulu-Natal Sandstone Sourveld by Mucina and Rutherford (2006) were reduced to a single category: important. A chi-square test was performed on the data from plots on Natal Group sandstone and those on Dwyka Group tillite, excluding Thornridge Farm. Results showed that more "important" KwaZulu-Natal Sandstone Sourveld species were found in these Dwyka Group tillite plots (8%) compared to Natal Group sandstone plots (6%) but the difference was not statistically significant (p=0.38) (Table 4.18). This means that there was no association between geology and the species that are cited as "important" for KwaZulu-Natal Sandstone Sourveld by Mucina & Rutherford (2006).

Table 4.18. Richness of "important" KwaZulu-Natal Sandstone Sourveld species by geology.

		Dwyka Group tillite	**Natal Group sandstone**	**Chi-squared value**	**df**	**p-value**
Important – KwaZulu-Natal Sandstone Sourveld	Yes	24 (8.28)	25 (6.49)	0.780514	1	0.376984
	No	266 (91.72)	360 (93.51)			

Comparisons are also made with relatively small number of species cited as "important" in Ngongoni Veld by Mucina & Rutherford (2006), who also report none that are endemic or biogeographically important. There are 18 species but three are trees that are hardly typical of open grassland, one is a widespread weed and one an herb not typical of open grassland (pers. obs.). As most are species common and widespread in many grassland types in KwaZulu-Natal (pers. obs.) they appear to be of limited diagnostic use, particularly when no other species are cited as being biogeographically important or endemic. Nonetheless, this is all that is available for comparison. *Gerbera ambigua* (Cass.) Sch.Bip. is held to be one of the important species in Ngongoni Veld, but it is a dumping ground in which *G. kraussii* Sch.Bip. is often included, as it is in Germishuizen *et al.* 2006). As *G. kraussii* is an easily recognizable species (Hilliard 1977) it was upheld in this survey, but it is included in *G. ambigua* in correlating with the Mucina & Rutherford (2006) important species, as it is not held as distinct by these authors.

Results showed more "important" species in Dwyka Group tillite plots (4%) compared to Natal Group sandstone plots (3%) but the difference was not statistically significant (p=0.38). This means that there was no association between richness of important Ngongoni Veld species and geology (Table 4.19).

Table 4.19. Richness of "important" Ngongoni Veld species by geology

		Dwyka Group tillite	**Natal Group sandstone**	**Chi-squared value**	**df**	**p-value**
Important – Ngongoni Veld	Yes	12 (4.14)	13 (3.38)	0.2688	1	0.604138
	No	278 (95.86)	372 (96.62)			

4.10 Mapping of grassland at Cato Ridge according to quality and comparison with land uses designated by Local Area Plan

The grasslands at Cato Ridge are mapped according to quality. Good quality grassland is considered to have richness of > 25 herbaceous species/100 m^2 but reducing to >20 on north-facing aspects where north-facing aspect alone accounts for both diminution and altered composition. Intermediate grassland is considered to have richness of 10–25 herbaceous species/100 m^2 or 10-20 herbaceous species/100 m^2 on north facing aspects. Degraded grassland, estimated as containing less than 10 herbaceous species/100 m^2 (these then mainly common species, ruderals or weeds of disturbance), is not mapped. As plots occupy only a small part of grasslands that have suffered differential disturbance, the plot data were combined with less precise estimations made on a reconnaissance or walk-through basis. The categories included in Figures 4.7–4.8 are as follows.

- Good;
- Good-Intermediate (containing interdigitated and often graduating good and intermediate quality grassland that cannot be differentially mapped except at fine scale);
- Intermediate;
- Intermediate-Degraded (containing patches of interdigitated and often graduating intermediate quality and degraded grassland that cannot be differentially mapped except at fine scale. Due to interdigitation, the degraded grassland cannot easily be developed without also destroying or degrading the intermediate quality grassland);
- Hygrophytic Intermediate (grassland in at least seasonally damp to wet areas, including short sedges);
- Hygrophytic Intermediate-Degraded (grassland in at least seasonally damp to wet areas, including short sedges, but including interdigitated degraded parts).

The results of this mapping are compared to the land uses designated in the Cato Ridge Local Area Plan according to whether the uses are transforming, potentially transforming or non-transforming. The following land uses in the Cato Ridge LAP are considered transforming, in that they entail high impacts that destroy grassland:

- Industry;
- Commercial/business;
- Residential – mixed use;
- Residential – rural;
- Facility;
- Garage;
- Truck stop;
- Utility/substation/reservoir/railway reserve;
- Sewage works;
- Future inter-modal hub;
- Future land fill;
- Future road.

The following land uses in the Cato Ridge LAP are considered potentially transforming:

- Agriculture 1. While ploughing of grassland is highly destructive, the Agriculture 1 use designation is considered lower risk as it consistent with status quo ante land use and owners are either not serious farmers or if so do not intend to place further land under cultivation at least for the foreseeable future, although baling and grazing occurs (with most of the latter on an unauthorized basis). Consequently, an Agriculture 1 land use will probably not result in significant reduction of the amount better quality grassland, at least for some time.
- Power line servitudes (as most of the vegetation under power lines will remain, although altered management may negatively affect species richness and abundance);
- Recreation (depending on the recreational development proposed).

The following land uses in the Cato Ridge LAP are considered to support low transformation, or to be non-transforming:

- Open space/conservation;
- Over-steep (too steep to develop);
- Valleys (considered less suitable for development).

Two maps are provided in Figures 4.7–4.8, showing the occurrences of grassland in the categories described, north and south of the N2 national road respectively. This mapping shows large significant conflicts, particularly north of the N2 national road, where most of this grassland is on a Natal Group sandstone substrate. When the results of the mapping exercise are shown in tabular form (Table 4.20), this permits the more exact estimate of the impacts of the Cato Ridge LAP land use designations.

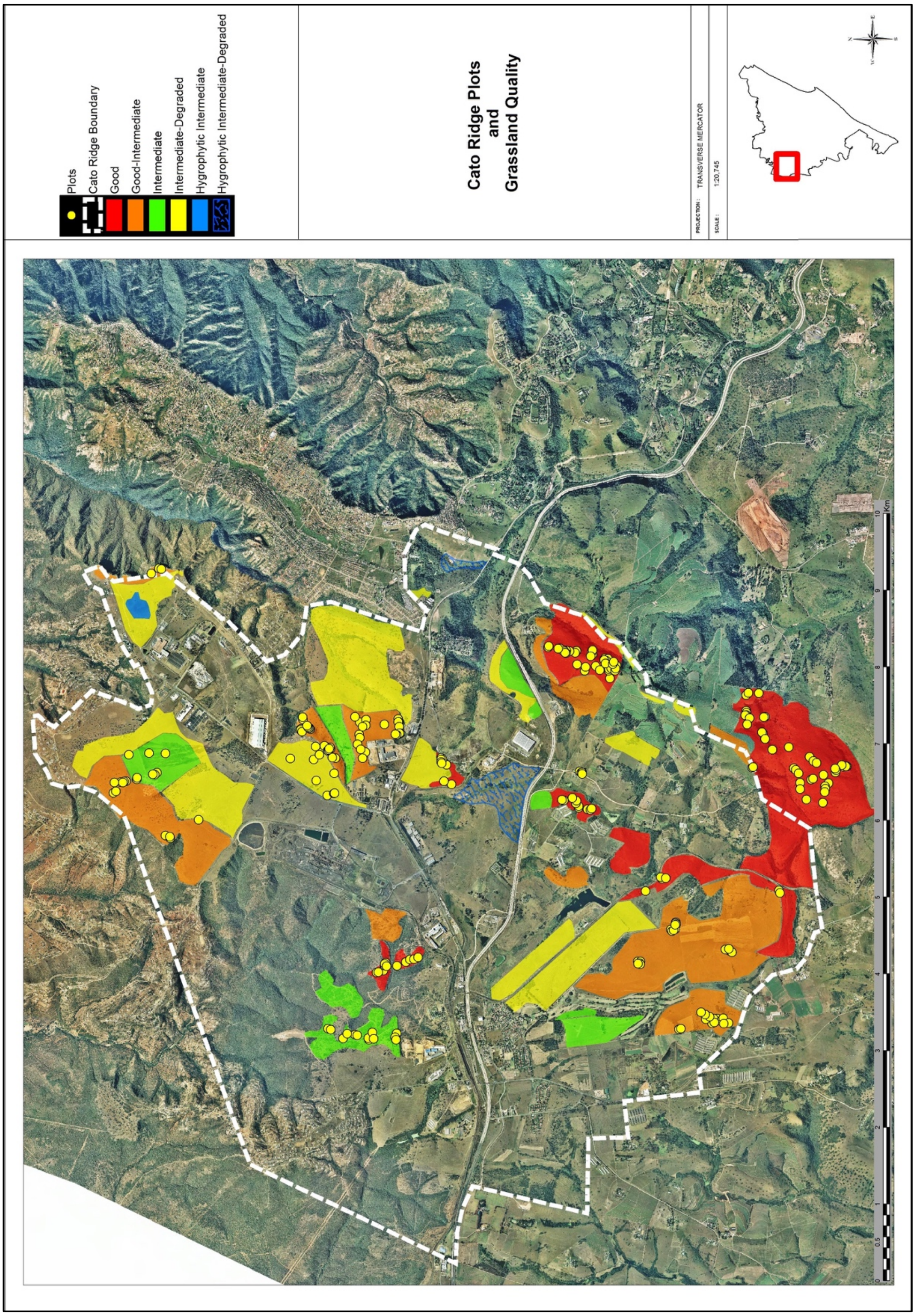

Figure 4.7. Plots surveyed at Cato Ridge showing occurrences of better quality grassland. Good grassland shown in red in which plots were surveyed outside the LAP boundary are for this reason not taken into account in Table 4.20.

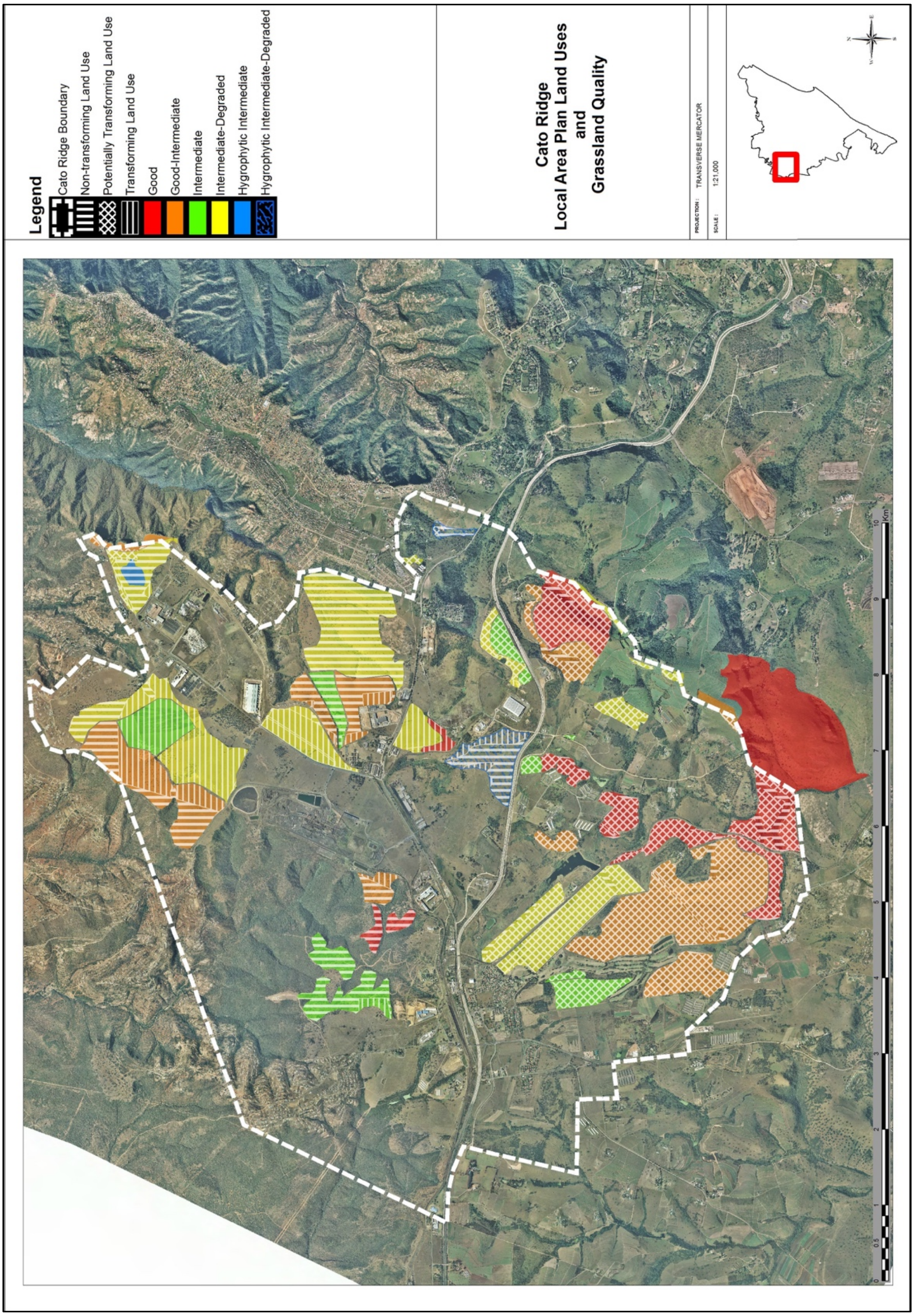

Figure 4.8. Better quality grassland showing the impact of land use designations in the Cato Ridge Local Area Plan. The N2 national road is shown bisecting the LAP area.

Table 4.20. Estimate of hectarage of better quality grassland affected by transforming and potentially transforming land uses in the Cato Ridge Local Area Plan.

	Transforming (ha)	Potentially Transforming (ha)	Non-transforming (ha)
Total LAP area	1956.62 (34,05%)	1782.93 (31,03%)	2006.8 (34,92%)
North of the N2	1723.35 (47,37%)	254.43 (6,99%)	1660.10 (45,63%)
South of the N2	233.25 (11,06%)	1528.50 (72,49%)	346.69 (16,44%)

The results show that throughout the Cato Ridge LAP area, approximately one-third of this grassland is affected by transforming land uses, and approximately the same proportions by potentially transforming and non-transforming land uses respectively. North of the N2 national road the impacts of the Local Area Plan are particularly severe. Almost half of this grassland (47,37%) occurs on land designated for transforming land uses. Moreover, the land uses encompass high impact activities that have edge, indirect and cumulative impacts beyond the footprints of developments so enabled, which will extend into the grassland on land designated for non-transforming land uses.

Most of this grassland is mapped by the eThekwini Municipality's Environmental Planning and Climate Protection Department as KwaZulu-Natal Sandstone Sourveld (McLean *et al.* 2014). During the plot-based survey, this grassland was found to contain large numbers of the following endemic species, particularly concentrated within transforming land use area, with corresponding red list status following Raimondo *et al.* (2009).

- *Agathisanthemum chlorophyllum* (Hochst.) Bremek. var. *chlorophyllum* (DDT);
- *Aloe parviflora* Baker;
- *Argyrolobium longifolium* (Meisn.) Walp. (vulnerable);
- *Brachystelma pulchellum* (Harv.) Schltr. (near threatened);
- *Chaetacanthus sp. nov*. = D.G.A. Styles 3822, 3919, 3950, 3972, 3973 (NH);
- *Crotalaria dura* J.M.Wood & M.S.Evans subsp. dura (near threatened);
- *Dierama pallidum* Hilliard (vulnerable);
- *Eriosemopsis subanisophylla* Robyns (vulnerable);
- *Helichrysum griseum* Sond.;

- *Helichrysum pannosum* DC. (endangered);
- *Hermannia sandersonii* Harv. (vulnerable);
- *Indigofera rubroglandulosa* Germishuizen;
- *Indigofera sp. nov.* A (= DGA Styles 3457, 3477 NH);
- *Indigofera sp. nov.* A (= DGA Styles 3457, 3477 NH);
- *Pachycarpus coronarius* E.Mey;
- *Phymaspermum pinnatifidum* (Oliv.) Kallersjo;
- *Senecio albanopsis* Hilliard;
- *Senecio exuberans* R.A.Dyer (endangered).

In addition, many other species occur in these grasslands that are otherwise rare, or which are unusual in the context of the eThekwini municipal area. In conclusion, the Cato Ridge LAP does not well serve the conservation of grassland at Cato Ridge. The ethos of the plan appears to be intensification of industrial and transforming land use north of the N2, with loss of approximately half of this grassland through direct impacts and loss or degradation (and at least some of the balance through consequent indirect and cumulative impacts). The amount of land designated for open space/conservation in the Local Area Plan is small and includes only wetland features that cannot sensibly be developed.

It is concerning that there are no calculations of the amount of grassland that will be lost under the Local Area Plan's designations, which creates the perception that this impact was either not properly assessed (which then seems to be a major omission), or they were assessed but omitted in the final report. Due diligence seems lacking in either scenario.

It is also unfortunate that the biodiversity reporting carried out by GroundTruth did not involve more detailed surveying aimed at mapping occurrences of rare, red listed or endemic plants. The few days allowed for the GroundTruth survey were also in the winter months when there was little to see. While more fine-scale information could have resulted in a plan less harmful to these grasslands, the eThekwini Municipality's mapping, refined by this short survey, was available and reflects occurrences of better quality grassland with accuracy. The losses now enabled by the Cato Ridge Local Area Plan can only be avoided if non-transforming land uses are designated for these grasslands instead. Observations made during plot-based work demonstrate this grassland is also threatened by a range of informal development and activities, including home-building (some after unlawful occupation of land), sand-mining (also unauthorized and illegal) and unauthorized grazing. Protection of these grasslands cannot be protected by only one mechanism, but requires a range of complementary interventions.

CHAPTER 5. CONCLUSION

The KwaZulu-Natal coastal escarpment north of the Pondoland Centre contains a number of range-restricted species, including Pondoland Centre floristic elements that percolate as far north as Durban, species that are mainly known from the Pondoland Centre but extend to the coastal escarpment to the north, and species that are confined only to the latter area. This suggests that the broad KwaZulu-Natal coastal escarpment north of the Pondoland Centre may itself be a minor centre of endemism. Unlike the Pondoland Centre, endemics that occur within broad coastal escarpment to the north are overwhelmingly herbaceous. Many of these are species of grassland and a number were found in plots at Cato Ridge.

The results of surveying at Cato Ridge show that grassland on Natal Group sandstone, Dwyka Group tillite and megacrystic biotite granite at Cato Ridge all contain high species richness and abundance. However, highest species richness was found in plots on Dwyka Group tillite, which have been mapped as Ngongoni Veld or its dry variant (Mucina & Rutherford 2006; South African National Biodiversity Institute 2012) or as grassland that is not KwaZulu-Natal Sandstone Sourveld (McLean *et al.* 2014). Although there is slightly higher richness of endemic and biogeographically important species and Cape floristic elements in plots on Natal Group sandstone, this is not statistically significant. Mucina & Rutherford (2006) report species that are important, biogeographically important and endemic in KwaZulu-Natal Sandstone Sourveld. While plots on Dwyka Group tillite are richer these in species than those on Natal Group sandstone, this is not statistically significant. Insofar as “important” Ngongoni Veld species are concerned, there are slightly more in Dwyka Group tillite plots, but this is again not statistically significant. However, aspect had an important and statistically significant effect on plot species richness. This was highest in south-facing plots, followed by east-facing, west-facing to north-facing plots.

Mucina & Rutherford (2006) introduced a grassland type not previously recognized, namely KwaZulu-Natal Sandstone Sourveld, which is held to occur on a Natal Group sandstone substrate. However, current mapping does not align well with the occurrence of Natal Group sandstone in KwaZulu-Natal nor is it anywhere explained why grassland on Natal Group sandstone north of the Tugela River, within a similar altitudinal range, may not also be of this type. It also does not align very well with the area of endemism that has been identified on the broad coastal escarpment north of the Pondoland Centre. The misalignment between Natal

Group sandstone and KwaZulu-Natal Sandstone Sourveld has been remedied in mapping undertaken by the eThekwini Municipality's Environmental Planning and Climate Protection Department within its own municipal bounds, where it is also reported as occurring beneath the coastal escarpment (McLean *et al.* 2014; Boon *et al.* 2016).

KwaZulu-Natal Sandstone Sourveld is assessed as endangered and has attracted considerable conservation attention (Boon *et al.* 2016). This occurs in proximity of, and interdigitating with, another type, namely Ngongoni Veld, for which few distinctive species are provided and none that are biogeographically important or endemic. It is not properly differentiated from KwaZulu-Natal Sandstone Sourveld, except insofar as reportedly occurring on dolerite and Dwyka Group tillite, being dominated by *Aristida junciformis*, or containing a limited range of other plant species.

With KwaZulu-Natal Sandstone Sourveld's impoverishment held to exceed any depletion of plant species richness in rangelands elsewhere in the world" (Scott-Shaw & Morris 2014), resolving the floristics of this type or "Ngongoni Veld" should not rely on surveying depauperate examples. The increase in *Aristida junciformis*, loss of most non-graminoid richness, persistence of mainly common and widespread generalists, and increase in ruderals and weeds will then support a more homogenous interpretation tilted towards the current unsatisfactory depiction of Ngongoni Veld (at least when the latter is also not in natural condition).

As a result, surveying of KwaZulu-Natal Sandstone Sourveld and Ngongoni Veld (including purported moist and dry variants) should focus on instances in fair to good condition. The floristics of each, including the validity of their separation (and indeed any other types present) and more exact provenance also needs to be properly investigated through competent, well-resolved surveying that includes the non-graminoid component, which appears to have been lacking to date.

The results of surveying at Cato Ridge are particularly revealing for Ngongoni Veld. There is a wide consensus that *Aristida junciformis*, after which this vegetation type takes its name, becomes dominant in grassland that has suffered anthropogenic misuse (Gibbs Russell *et al.* 1990; Tainton *et al.* 1976; Scott Shaw & Morris 2014; Van Wyk & Van Oudtshoorn 2004). Except for one species, other grass species listed as being typical in this type by Mucina &

Rutherford (2006) are common and very widespread species that have weedy properties or are associated with disturbed sites (Fish *et al.* 2015; Gibbs Russell *et al.* 1990). The non-graminoid species listed as important in Ngongoni Veld are relatively few and include mostly common and widespread species (Pooley 1998). However, it appears unlikely that "Ngongoni Veld" ever comprised or even now only comprises a depauperate, species-poor type. This erroneous idea appears to have originated with Acocks (1953), possibly from investigating only degraded instances, and has continued to travel without much critical trammeling through the work of a number of others who have treated vegetation in the area of its occurrence, including White (1983); Low & Rebelo (1996); Camp (1997); Mucina & Rutherford (2006) and Scott-Shaw & Escott (2011). Instead, there is reason to believe that grassland in the Ngongoni Veld area, prior to anthropogenic disturbance, contained species richness and abundance comparable to other grassland types in eastern South Africa and still does where relatively undisturbed instances remain. This is consistent with the general description of grassland within the Maputaland-Pondoland Region (and elsewhere in South Africa) as floristically rich (Steenkamp *et al.* 2004; Van Wyk & Smith 2001). That 'Ngongoni Veld' has been built partly on a foundation of floristic sand is also shown by the richness and abundance of plant species on Dwyka Group tillite at Cato Ridge, where purportedly a 'dry' variant occurs in which "herbaceous species richness is much less" (Scott-Shaw & Escott 2011).

It is possible that 'Ngongoni Veld', even if KwaZulu-Natal Sandstone Sourveld can be better separated out of it, comprises more than one grassland type, and these may not correspond with reported 'dry' and 'moist' forms. It is also possible that where there is close interdigitating of Natal Group sandstone and Dwyka Group tillite substrates, Natal Group sandstone and granite and gneiss, there is some percolation of species between them that attenuates over distance. This can only be investigated through wider plot-based surveying in the reported Ngongoni Veld and KwaZulu-Natal Sandstone Sourveld distributional areas. Although Ngongoni Veld is provided with the conservation status of vulnerable (Mucina & Rutherford 2006), instances of grassland on Dwyka Group tillite in good condition such as at Cato Ridge may also be rare, contain species richness and abundance that exceeds that on Natal Group sandstone, and contain a significant number of endemic and biogeographically important species. This suggests that the conservation importance of grasslands on Dwyka Group tillite, either mapped as Ngongoni Veld or its 'dry' or 'moist' variants, is underrated and deserves more attention.

Finally, the results of mapping the grassland combined with an overlay of land uses designated in the Cato Ridge Local Area Plan, show that these enable significant losses of grassland, particularly north of the N2 national road. These impacts are most severe for grassland on a Natal Group sandstone substrate, most of which is mapped as KwaZulu-Natal Sandstone Sourveld by the eThekwini Municipality's Environmental Planning and Climate Protection Department (McLean et al. 2014) and found to contain large numbers of red listed species. These losses can only be reduced or avoided if land uses designated for these occurrences of grassland are altered, although they are also threatened by a range of more informal activities.

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Appendix 1. Endemism on the KwaZulu-Natal coastal escarpment north of the Pondoland Centre

Acronyms

ECE-E = Plant species endemic or nearly endemic to the Pondoland Centre and the coastal escarpment to the north;
LE = Local endemics, species collected from Cato Ridge without apparent matches in provincial herbaria or candidates in botanical literature
NCE-E = Northern coastal escarpment endemics, entirely confined to this area;
NCE-FE = Northern coastal escarpment floristic elements (nearly confined to this area);
PC-FE = Pondoland Centre Floristic Elements (mainly distributed in the Pondoland Centre but extending as far north as the Ngoye Forest).

HC = Herbarium collections

* Collections in the KwaZulu-Natal Herbarium (NH) or University of KwaZulu-Natal (Bews) Herbarium (NU)

** Collections lodged at the NH, collected from Cato Ridge grasslands during this study

1.1 Grassland

Northern coastal escarpment endemics and floristic elements

Aloe parviflora Baker *	NCE-E	Van Wyk & Smith (2014)
Argyrolobium longifolium Walp. *	NCE-FE	Edwards (1994)
Barleria natalensis Lindau	NCE-E	Scott-Shaw (1999)
Brachystelma modestum R.A.Dyer *	NCE-E	Styles (2008b)
Brachystelma natalense N.E.Br. *	NCE-E	Scott-Shaw (1999)
Brachystelma pulchellum Schltr. *	NCE-E	Dyer (1978, 1980, 1983), Styles (2008b)
Ceropegia rudatisii Schltr.	NCE-E	Dyer (1980, 1983)
Chaetacanthus sp. nov. = D.G.A. Styles 3822, 3919, 3950, 3972, 3973 (NH) **	LE	HC
Cineraria atriplicifolia DC. *	NCE-FE	Cron *et al.* (2006), Hilliard (1977)
Crassula smithii Van Jaarsveld, D.Styles & G.McDonald	NCE-E	Van Jaarsveld *et al.* (2008)
Crotalaria dura subsp. dura J.M.Wood & M.S.Evans *	NCE-E	Styles & Le Roux (2012)
Dierama pallidum Hilliard *	NCE-E	Hilliard &Burtt (1991)
Dierama pumilum N.E.Br. *	NCE-FE	Hilliard &Burtt (1991)
Eriosema populifolium Benth. ex Harv. subsp. *populifolium* *	NCE-E	Stirton (1978)
Eriosema superpositum sp. nov. C.H.Stirton, ined.	NCE-E	Stirton (1986)
Gymnosporia woodii Szyszyl.	NCE-E	Jordaan (2004)
Hermannia sandersonii Harv. *	NCE-E	Gwynne-Evans (2015)
Indigofera inandensis Baker f. ex Schrire ined. (= DGA Styles 5122, 5237 NH) *	NCE-E	Dr Brian Schrire, pers. comm.
Indigofera setosa N.E.Br. *	NCE-E	Brown (1912); Dr Brian Schrire, pers. comm.
Kniphofia pauciflora Baker *	NCE-E	Codd (1968)
Lotononis dichiloides Sond. *	NCE-E	Van Wyk (1991)
Macrotyloma coddii Verdc. *	NCE-E	Verdcourt (1982)
Pachycarpus acidostelma M.Glen &	NCE-E	Glen *et al.* (2011)

Nicholas		
*Phymaspermum pinnatifidum (*Oliv.) Källersjö *	NCE-E	Hilliard (1977)
Rhus rudatisii Engl. *	NCE-FE	Moffet (1993)
Satyrium rhodanthum Schltr. *	NCE-FE	McDonald & Styles (2012)
Sisyranthus anceps Schltr. *	NCE-E	Raimondo (2009)
Syncolostemon latidens (N.E.Br) Codd *	NCE-FE	Codd (1985); Scott-Shaw (1999)
Tephrosia inandensis H.M.L.Forbes *	NCE-E	Scott-Shaw (1999)
Zaluzianskya pilosa Hilliard & B.L.Burtt	NCE-FE	Hilliard (1994); Scott-Shaw (1999)

The KwaZulu-Natal form of *Leucospermum gerrardii* appears to be endemic to grassland on Natal Group sandstone, where known from a few localities on the high coastal escarpment between the Umvoti and Tugela Rivers (Scott-Shaw 1999, pers. obs.). Due to the form's uncertain taxonomic status, it is not included in the list above.

Pondoland centre endemics and floristic elements

Asclepias praemorsa Schltr. *	PC-FE	Nicholas (1982, 1999)
Eriosemopsis subanisophylla Robyns *	PC-FE	Scott-Shaw (1999); Van Wyk & Smith (2001)
Indigofera pondoensis Schrire sp. nov. ined. *	PC-FE	Dr Brian Schrire, pers. comm.
Kniphofia coddiana Cufod. *	PC-FE	Codd (1968); occurrence north of the Pondoland Centre based on personal observation
Lopholaena dregeana DC. *	PC-FE	Hilliard (1977); Scott-Shaw (1999)
Schizoglossum atropurpureum E.Mey. subsp. *virens* (E.Mey) Kupicha *	PC-FE	Kupicha (1984); occurrence north of the Pondoland Centre based on personal observation
Senecio glanduloso-lanosus Thell. *	PC-FE	Hilliard (1977); Scott-Shaw (1999)

Eastern escarpment endemics

Afrosciadium natalense (Sond.) P.J.D.Winter *	ECE-E	HC
Erica aspalathifolia Bolus var. *aspalathifolia*	ECE-E	Scott-Shaw (1999)
Helichrysum pannosum DC. *	ECE-E	Hilliard (1977, 1983)
Helichrysum populifolium DC. *	ECE-E	Hilliard (1977, 1983)
Indigofera sp. nov. A (= DGA Styles 3457, 3477 NH *	ECE-E	Dr Brian Schrire, pers. comm.
Indigofera sp. nov. B (= DGA Styles 5091 NH) *	ECE-E	Dr Brian Schrire, pers. comm.
Indigofera rubroglandulosa Germishuizen *	ECE-E	
Pachycarpus coronarius E.Mey *	ECE-E	Smith (1980, 1988)
Schizoglossum peglerae N.E.Br.	ECE-E	Kupicha (1984)
Selago elongata Hilliard *	ECE-E	Hilliard (1999
Selago hyssopifolia subsp. *hyssopifolia* E.Mey. *	ECE-E	Hilliard (1999)
Senecio albanopsis Hilliard *	ECE-E	Hilliard 1977
Senecio exuberans R.A.Dyer *	ECE-E	Dyer (1943); Hilliard (1977)
Turraea pulchella (Harms) T.D.Penn. *	ECE-E	White & Styles (1986)

1.2 Forest

Northern coastal escarpment endemics and floristic elements

Clivia gardenii Hook. *	NCE-FE	HC
Crassula multicava subsp. *floribunda* Lem. Friedrich ex Toelken *	NCE-E	Toelken (1985)
Emplectanthus cordatus N.E.Br. *	NCE-E	Styles (2010)
Eugenia sp. nov. A *	NCE-FE	Boon (2010)
Eugenia sp. nov. B *	NCE-FE	Boon (2010)
Geranium ornithopodioides Hilliard & B.L.Burtt *	NCE-E	Hilliard & Burtt (1985)
Gerbera sylvicola Johnson, N.R.Crouch & T.J.Edwards	NCE-E	Johnson *et al.* 2014

Gerrardanthus tomentosus Syzsyzl. *	NCE-E	Baxter & Crouch (1996)
Plectranthus purpuratus Harv. subsp. *purpuratus*	NCE-E	Codd (1985)
Riocreuxia woodii N.E.Br. *	NCE-E	Dyer (1980, 1983)
Streptocarpus floribundus Weigend & T.J.Edwards *	NCE-E	Weigend & Edwards (1994)
Streptocarpus molweniensis Hilliard subsp. *molweniensis* *	NCE-E	Hilliard (1966); Hilliard & Burtt (1971)
Streptocarpus molweniensis subsp. *eshowicus* Hilliard & B.L.Burtt *	NCE-E	Hilliard & Burtt (1971)
Streptocarpus polyanthus Hook. *subsp. polyanthus* *	NCE-FE	Hilliard & Burtt (1971)
Streptocarpus prolixus C.B.Clarke *	NCE-E	Hilliard & Burtt (1971)
Streptocarpus saundersii Hook. *	NCE-E	Hilliard & Burtt (1971)
Streptocarpus sp. nov. = Hilliard 832 (NU), Hilliard & Burtt 3440 (NU) *	NCE-E	Hilliard & Burtt (1971), pers. obs.

Pondoland Centre endemics and floristic elements

Impatiens flanaganiae Hemsl. *	PC-FE	Crouch & Styles (2002)
Maytenus abbottii A.E.Van Wyk *	PC-FE	Boon (2010, 2012); Scott-Shaw (1999); Van Wyk (1984)
Philenoptera sutherlandii (Harv.) Schrire *	PC-FE	Boon (2010); Scott-Shaw (1999)
Pseudoscolopia polyantha Gilg *	PC-FE	Boon (2010); Scott-Shaw (1999)
Streptocarpus formosus (Hilliard & B.L.Burtt) T.J.Edwards	PC-FE	Hilliard & Burtt (1971)
Streptocarpus trabeculatus Hilliard *	PC-FE	Hilliard & Burtt (1971)
Cryptocarya wyliei Stapf	PC-FE	Boon (2010); Scott-Shaw (1999)
Dahlgrenodendron natalense J.J.M. van der Merwe & A.E.van Wyk *	PC-FE	Boon (2010); Van der Merwe *et al.* (1998)
Memecylon bachmannii Engl. *	PC-FE	Boon (2010); Scott-Shaw (1999)
Ficus bizanae Hutch. & Burtt Davy *	PC-FE	Boon (2010); Burrows & Burrows (2003)
Colubrina nicholsonii A.E.van Wyk & Schrire *	PC-FE	Boon (2010), Van Wyk & Schrire (1986)

Cyphostemma rubroglandulosum Retief & A.E.van Wyk *	PC-FE	Retief (1996), pers. obs.

Eastern escarpment endemics and floristic elements

Bulbine sp. nov. A cf. *asphodeloides* (= DGA Styles 3623 NH) *	ECE-E	HC
Anisochaeta mikanioides DC. *	ECE-E	Hilliard (1977)
Atalaya natalensis R.A.Dyer *	ECE-E	Boon (2010); Scott-Shaw (1999)
Crassula sarmentosa var. *integrifolia*	ECE-E	Toelken (1985); pers. obs.
Eugenia simii Dümmer *	ECE-E	Boon (2010)
Hypoxis nivea Y.Singh *	ECE-E	Singh *et al.* (2007)
Indigofera braamtonyi Schrire *sp. nov*., ined.	ECE-E	Boon (2010)
Indigofera rubroglandulosa Germishuizen *	ECE-E	Germishuizen (1987)
Maytenus cordata (E.Mey. ex Sond.) Loes. *	ECE-E	Boon (2010); Scott-Shaw (1999)
Maytenus sp. (= *Gymnosporia filiformis* Davison) *	ECE-E	Boon (2010); Scott-Shaw (1999)
Pavetta bowkeri Harv. *	ECE-E	Boon (2010); Scott-Shaw (1999)
Riocrexia alexandrina (Huber) R.A. Dyer	ECE-E	Dyer (1980, 1983)
Tarchonanthus trilobus DC. subsp. *trilobus* *	ECE-E	Beentje (1999), Hilliard (1977)

1.3 Rock faces and outcrops

Northern coastal escarpment endemics and floristic elements

Crassula sp. nov. D.G.A. Styles & M. Ngwenya 4082 (NH) *	LE	HC
Cynorkis compacta Rchb.f. *	NCE-FE	HC
Drimia flagellaris T.J.Edwards, D.Styles & N.R.Crouch *	NCE-E	Edwards *et al.* 2005.
Gasteria croucheri (Hook f.) Baker subsp. *pendulifolia* (Van Jaarsv.) Zonn	NCE-E	Van Jaarsveld & Van Wyk (2001)
Gladiolus cruentus T.Moore *	NCE-E	Goldblatt & Manning (1998)
Helichrysum woodii N.E.Br. *	NCE-E	Hilliard (1977, 1983)
Hesperantha gracilis Baker *	NCE-E	Hilliard & Burtt (1986)

Stenoglottis inandensis G.McDonald & D.Styles *	NCE-E	McDonald (2008)
Stenoglottis molweniensis G.McDonald ex J.M.H.Shaw	NCE-E	McDonald (2006)
Stenoglottis woodii Schltr. *	NCE-E	McDonald (2006)

Eastern escarpment endemics and floristic elements

Chaenostoma platysepalum (Hiern) Kornhall (= *Sutera platysepala*) *	ECE-E	Hilliard (1999)
Oldenlandia rupicola (Sond.) Kuntze var. *hirtula* (Sond.) Bremek. *	ECE-E	HC
Utricularia sandersonii Oliv. *	ECE-E	HC

1.4 Thicket

Bulbine sp. nov. B cf. *inflata*	NCE-E	Scott-Shaw (1999). Incorrectly referred to as *B. inflata* in this work and by Mucina & Rutherford (2006)
Turraea streyi F.White & Styles *	ECE-E	White & Styles (1986)

Appendix 2. List of non-graminoid species recorded in grassland at Cato Ridge with collecting numbers, where applicable

Numbers after names of species are those of collections lodged at the KwaZulu-Natal Herbarium (NH). Each number represents a different collection and unless otherwise indicated have been lodged under the collector name D.G.A. Styles (a few not so indicted collected jointly with Mkhipheni Ngwenya of the KwaZulu-Natal Herbarium).

Key: * = alien species; + = recorded outside of plots; # = present in grassland-wetland interface, not typical of dryland grassland

ACANTHACEAE

Adhatoda densiflora (Hochst) J.C.Manning 4255, 4372
Asystasia gangetica (L.) T.Anderson var. *micrantha* Nees +
Barleria meyeriana Nees
Barleria ovata E.Mey. ex. Nees
Blepharis integrifolia (L.f.) E.Mey. ex Schinz 4394
Chaetacanthus burchellii Nees 4421, 4601, 4982
Chaetacanthus sp. nov. = D.G.A. Styles 3822, 3919, 3950, 3972, 3973 (NH)
Crabbea hirsuta Harv. 3834, 3897, 3906, 3929, 3931, 3937
Hypoestes forskaolii (Vahl.) R.Br.
Justicia flava (Vahl) Vahl
Justicia protracta (Nees) T.Anderson subsp. *protracta*
Ruellia baurii C.B.Clarke
Ruellia cordata Thunb.
Thunbergia atriplicifolia E.Mey. ex Nees
Thunbergia venosa C.B.Clarke 5120, 5241

AGAPANTHACEAE

Agapanthus campanulatus F.M.Leight subsp. *campanulatus* 4050

ALLIACEAE

Tulbaghia acutiloba Harv. +
Tulbaghia ludwigiana Harv.

AMARANTHACEAE

Chenopodium album L. * +
Kyphocarpa trichinioides (Fenzl) Lopr. 3910, 4623

AMARYLLIDACEAE

Boophone disticha (L.f.) Herb.
Crinum macowanii Baker +
Cyrtanthus breviflorus Harv. +
Cyrtanthus contractus N.E.Br. 4373

Cyrtanthus obliquus (L.f.) Aiton

ANTHERICACEAE

Chlorophytum cooperi (Baker) Nordal
Chorophytum krookianum Zahlbr. + #

APIACEAE

Afrosciadium caffrum (Meisn.) P.J.D.Winter 4410, 4603
Afrosciadium natalense (Sond.) P.J.D.Winter 4382, 4406, 4604
Alepidea peduncularis A.Rich. 5082
Centella asiatica (L.) Urb.
Centella coriacea Nannf. +
Centella glabrata L. var. *natalensis* Adamson 4426, 4485, 5114
Lichtensteinia interrupta (Thunb.) Sond. 4599, 5083
Pimpinella caffra (Eckl. & Zeyh.) D.Dietr

APOCYNACEAE

Asclepias albens (E.Mey.) Schltr.
Asclepias cucullata (Schltr.) Schltr.
Asclepias cultriformis (Harv. ex Schltr.) Schltr. +
Asclepias dregeana Schltr. var. *dregeana*
Asclepias flexuosa (E.Mey.) Schltr. 4436
Asclepias gibba (E.Mey.) Schltr. var. *gibba* +
Aspidoglossum gracile (E.Mey.) Kupicha 4564, 4980
Aspidoglossum ovalifolium (Schltr.) Kupicha +
Brachystelma barberae Harv. ex. Hook.f. +
Brachystelma gerrardii Harv. +
Brachystelma pulchellum (Harv.) Schltr. 4551
Brachystelma pygmaeum (Schltr.) N.E.Br. subsp. *flavidum* (Schltr.) R.A.Dyer
Brachystelma rubellum (E.Mey) Peckover 4552
Brachystelma sandersonii (Oliv.) N.E.Br.
Ceropegia crassifolia Schltr. var. *crassifolia*
Cryptolepis oblongifolia (Meisn.) Schltr.
Gomphocarpus physocarpus E.Mey. +
Huernia hystrix (Hook.f.) N.E.Br. var. hystrix
Pachycarpus appendiculatus E.Mey. 3846 +
Pachycarpus asperifolius Meisn.
Pachycarpus concolor E.Mey subsp. *concolor* +
Pachycarpus coronarius E.Mey
Pachycarpus natalensis N.E.Br. 4500
Pachycarpus sp. aff. *dealbatus* E.Mey. +
Pachycarpus scaber (Harv.) N.E.Br.
Periglossum mackenii Harv. +
Raphionacme galpinii Schltr.
Raphionacme hirsuta (E.Mey.) R.A.Dyer ex E.Phillips
Schizoglossum peglerae N.E.Br.
Tacazzea apiculata Oliv. + (unusually growing in open grassland)
Xysmalobium involucratum (E.Mey.) Decne +
Xysmalobium undulatum (L.) Aiton f. var. *undulatum*

ANACAMPSEROTACEAE

Talinum caffrum Adans. +

ANACARDIACEAE

Searsia dentata (Thunb.) F.A.Barkley
Searsia discolor (E.Mey. ex Sond.) Moffett
Searsia pentheri (Zahlbr.) Moffet +

Searsia pyroides (Burch.) Moffett var. *integrifolia* (Engl.) Moffett
Searsia rehmanniana (Engl.) Moffet

ARACEAE

Stylochaeton natalensis Schott

ARALIACEAE

Cussonia spicata Thunb.

ASPARAGACEAE

Asparagus africanus Lam. 4362
Asparagus racemosus Willd. 5092 +

ASPHODELACEAE

Aloe ferox Mill.
Aloe kraussii Baker
Aloe maculata All.
Aloe parviflora Baker 3908, 4022
Bulbine capitata Poelln. 4395
Bulbine natalensis Baker +
Kniphofia buchananii Baker 4027
Kniphofia gracilis Harv. ex Baker 4026
Kniphofia laxiflora Kunth 4051, 4504, 4553
Kniphofia tysonii Baker subsp. *tysonii* 3954 + #
Trachyandra gerrardii (Baker) Oberm.
Trachyandra saltii (Baker) Oberm. var. *saltii* 3859, 3972, 3987, 4002, 4004

ASTERACEAE (COMPOSITAE)

Ageratum conzyoides L. * +
Ageratum houstonianum Mill. * +
Artemisia afra Jacq. ex Wild +
Aster bakerianus Burtt Davy ex C.A.Sm.
Aster pleiocephalus (Harv.) Hutch. 4251 +
Athrixia phylicoides D.C. 4513, 5228
Berkheya bipinnatifida (Harv.) Roessler subsp. *bipinnatifida*
Berkheya erysithales (DC.) Roessler +
Berkheya insignis (Harv.) Thell.
Berkheya maritima J.M.Wood & M.S.Evans +
Berkheya rhapontica (DC.) Hutch. & Burtt-Davy subsp. *rhapontica*
Berkheya setifera DC.
Berkheya speciosa (DC.) O.Hoffm. subsp. *speciosa*
Berkheya umbellata DC.
Bidens sp. * +
Callilepis laureola DC. 4371, 4385
Chromolaena odorata DC. * +
Cineraria atriplicifolia DC. 3962
Cirsium vulgare (Savi) Ten. * +
Conyza aegyptiaca (L.) Aiton +
Conyza albida Spreng. *
Conyza bonariensis (L.) Cronquist * +
Conyza canadensis (L.) Cronquist * +
Conyza chilensis Spreng. 3981, 4047 *
Conyza obscura DC. 3925, 4043
Conyza pinnata (L.f.) Kuntze 4441, 4898, 5135 +
Conyza ulmifolia (Burm.f.) Kuntze 4080
Cotula nigellifolia (DC.) K.Bremer & Humphries var. *nigellifolia* 5102 + #
Crassocephalum picridifolium S.Moore + #
Dicoma anomala Sond. subsp. *cirsioides* Harv.
Eclipta prostrata (L.) L 4018 * + #
Euryops laxus (Harv.) Burtt-Davy 4268
Felicia erigeroides DC. +

Gazania krebsiana Lessing 3927, 3947, 4044, 4266, 4338

Gazania linearis (Thunb.) Druce var. *linearis* +

Gerbera kraussii Sch.Bip.

Gerbera natalensis Sch.Bip.

Gerbera piloselloides (L.) Cass.

Gnaphalium austroafricanum Hilliard 4017, 4472 + #

Helichrysum acutatum DC. 4085, 4515, 5251

Helichrysum adenocapum DC. subsp. *adenocarpum* 4131

Helichrysum allioides Less. 4256

Helichrysum appendiculatum (L.f.) Less. 3864, 4012, 4036, 4049, 4052, 5230

Helichrysum asperum (Thunb.) Hilliard & Burtt var. *comosum* (Sch.Bip.) Hilliard 3820, 3823

Helichrysum aureonitens Sch.Bip. 4509

Helichrysum aureum (Houtt.) Merr. var. *monocephalum* (DC.) Hilliard 3953, 4264

Helichrysum auriceps Hilliard 4011, 4035, 4048, 4054 4049, 3836, 4407, 4422

Helichrysum caespititium (DC.) Harv. 4462

Helichrysum candolleanum H.Buek. +

Helichrysum cephaloideum DC. 4593

Helichrysum confertifolium Klatt. 3940 5252

Helichrysum griseum Sond. 4510, 5232

Helichrysum herbaceum (Andrews) Sweet +

Helichrysum krebsianum Less. 3881, 4560, 5088, 5234

Helichrysum longifolium DC. 5235

Helichrysum natalitium DC. #

Helichrysum nudifolium (L.) Less var. *nudifolium* 5231

Helichrysum nudifolium (L.) Less var. *pilosellum* (L.f.) Beentje

Helichrysum nudifolium (L.) Less. var. *oxyphyllum* (DC.) Beentje

Helichrysum pallidum DC. 4431, 5233

Helichrysum panduratum O.Hoffm. var. *panduratum*

Helichrysum pannosum DC. 5242

Helichrysum platypterum DC. 5229

Helichrysum ruderale Hilliard & B.L.Burtt 4985

Helichrysum rugulosum Less. 3919, 3979

Helichrysum spiralepis Hilliard & B.L.Burtt

Helichrysum stenopterum DC. + #

Helichrysum umbraculigerum Less. 3945

Hypochaeris radicata L. *

Lactuca indica L.

Lactuca sp. 5094

Laggera crispata (Vahl) Hepper & J.R.I.Wood

Macledium zeyheri (Sond.) S.Ortíz subsp. *argyrophyllum* (Oliv.) S.Ortíz +

Melanthera scandens (Schumach. & Thonn.) Roberty subsp. *dregei* (DC.) Wild 5103 + #

Microglossa mespilifolia (Less.) B.L.Rob.

Nidorella auriculata DC. 4053

Oligocarpus calendulaceus (L.f.) Less +

Osteospermum imbricatum L. subsp. *nervatum* (DC.) Norl. var. *nervatum* 3946

Othonna natalensis Sch.Bip. 4263, 4344

Phymaspermum acerosum (DC.) Kallersjo

Phymaspermum pinnatifidum (Oliv.) Kallersjo 4424

Pseudognaphalium luteo-album (L.) Hilliard & B.L.Burtt 4495 +

Pseudognaphalium oligandrum (DC.) Hilliard & B.L.Burtt 4556 +

Relhania pungens L'Hér. subsp. *angustifolia* (DC.) K.Bremer 5239

Schistostephium griseum (Harv.) Hutch. 4454

Schistostephium heptalobum
Schistostephium rotundifolium (DC.) Fenzl ex Harv. +
Senecio albanopsis Hilliard 3832, 3848, 4034, 4050, 4081 (last collection Styles & Ngwenya)
Senecio brevidentatus M.D.Henderson 4527, 4529
Senecio bupleurioides DC. 4271, 4345, 4986
Senecio cf. *sandersonii* Harv. 4008, 4383, 4449, 4453, 5113
Senecio chrysocoma Meerb. +
Senecio coronatus (Thunb.) Harv 4520
Senecio discodregeanus Hilliard & B.L.Burtt 5128
Senecio dregeanus DC. +
Senecio erubescens var. *dichotomus* DC. 3980, 3988, 3995, 4270, 4522
Senecio exuberans R.A.Dyer 3831, 3847, 5084, 5116
Senecio glaberrimus DC. 4262, 4346, 4985
Senecio gregatus Hilliard + #
Senecio heliopsis Hilliard & B.L.Burtt 4425, 4498
Senecio inornatus DC. 3993, 4007, 5126
Senecio latifolius DC.
Senecio lygodes Hiern + #
Senecio macrocephalus DC. +
Senecio madagascariensis Poiret *
Senecio oxyriifolius DC.
Senecio polyanthemoides Sch.Bip. +
Senecio rhyncholaenus DC. +
Senecio speciosus Willd. 4414, 4450
Senecio umgeniensis Thell. 42 694 359
Senecio variabilis Sch.Bip.
Seriphium plumosum L. +
Sonchus sp.
Tagetes minuta L. *
Tenrhynea phylicifolia (DC.) Hilliard & B.L.Burtt 4130
Tolpis capensis (L.) Sch.Bip. 4562, 4596
Ursinia tenuiloba DC. 4247
Vernonia capensis (Houtt.) Druce
Vernonia dregeana Sch.Bip. ex Walp. 4539
Vernonia galpinii Klatt 4428, 4987
Vernonia hirsuta (DC.) Sch.Bip. ex Walp.
Vernonia myriantha Oliv. & Hiern. +
Vernonia natalensis Oliv. & Hiern 4358
Vernonia oligocephala (DC.) Sch.Bip. ex Walp. 4537

BASELLACEAE

Andredera cordifolia (Ten.) Steenis * +

BORAGINACEAE

Cynoglossum sp. 4259, 4390
Ehretia rigida (Thunb.) Druce subsp. *rigida*

BRASSICACEAE

Cleome monophylla L.
Heliophila elongata (Thunb.) DC.
Heliophila rigidiuscula Sond. 4487 +

CAMPANULACEAE

Wahlenbergia denticulata (Burch.) A.DC. 3818, 3821
Wahlenbergia grandiflora Brehmer 4455
Wahlenbergia krebsii Cham. subsp. *krebsii* 4013, 4021, 4033, 4045, 4460
Wahlenbergia madagascariensis A.DC.

CAROPHYLLACEAE

Dianthus zeyheri Sond. subsp. *natalensis* Hooper 4518
Pollichia campestris Aiton
Polycarpaea corymbosa (L.) Lam. var. *corymbosa* +
Silene burchellii Otth subsp. *multiflora* J.C.Manning & Goldblatt 4389, 4542b
Silene gallica L. 4547 *
Silene undulata Aiton subsp. *polyanytha* J.C.Manning & Goldblatt 3942, 4524a

CELASTRACEAE

Gymnosporia buxifolia (L.) Szyszyl. +
Gymnosporia glaucophylla Jordaan
Gymnosporia heterophylla (Eckl. & Zeyh.) Loes +

COLCHICACEAE

Littonia modesta Hook. +

COMBRETACEAE

Combretum molle R.Br. ex G.Don

COMMELINACEAE

Commelina africana L. var *krebsiana* (Kunth) C.B.Clarke 5133
Commelina africana L. var. *lancispatha* C.B.Clarke 4442
Commelina cf. *eckloniana* Kunth 4489, 4600
Commelina erecta L. +
Commelina modesta Oberm. 3977
Cyanotis robusta Oberm. 4083
Cyanotis speciosa (L.f.) Hassk.

CONVOLVULACEAE

Convolvulus natalensis Bernh. ex. Krauss
Evolvulus alsinoides (L.) L.
Ipomoea crassipes Hook. 4598
Ipomoea magnusiana Schinz
Ipomoea obscura (L.) Ker Gawl. var. *obscura* 4548 +
Ipomoea pellita Hallier f. 3926, 4380, 4516a
Ipomoea simplex Thunb.
Ipomoea sinensis (Desr.) Choisy subsp. *blepharosepala* (Hochst. ex A.Rich.) Verdc. exA.Meeuse
Trochomeria saggitata (Harv. ex Sond.) Cogn.
Xenostegia tridentata (L.) D.F.Austin & Staples subsp. *angustifolia*

CRASSULACEAE

Crassula alba Forssk. var. *alba*
Crassula capitella Thunb. subsp. *meyeri* (Harv.) Toelken
Crassula lanceolata (Eckl. & Zeyh.) Endl. ex Walp. subsp. *transvaalensis* (Kuntze) Toelken 3975, 4038
Crassula nudicaulis L. var. *nudicaulis* +
Crassula obovata Harv. var. *obovata* 4084
Crassula pellucida L. subsp. *brachypetala* (Drege ex Harv.)
Crassula perfoliata L. var. *heterotricha* (Schinz) Toelken +
Crassula sp. nov. = D.G.A. Styles & M. Ngwenya 4082 (NH)

Crassula vaginata Eckl. & Zeyh. subsp. *vaginata*
Kalanchoe rotundifolia (Haw.) Haw +
Kalanchoe thyrsiflora Harv. +

CURCURBITACEAE

Cucumis hirsutus Sond. +
Cucumis zeyheri Sond. 4387
Momordica foetida Schumach. 4971 +

DIPSACACEAE

Cephalaria oblongifolia (Kuntze) Szabo 3834, 4069
Scabiosa columbaria L. 4420

DROSERACEAE

Drosera natalensis Diels +

EBENACEAE

Diospyros lycioides Desf. subsp. *sericea* (Bernh.) De Winter

ERICACEAE

Erica cerinthoides L. var. *cerinthoides* 5238
Erica natalitia Bolus var. *natalitia* +

EUPHORBIACEAE

Acalypha depressinerva (Kuntze) K.Schum. 4507.
Acalypha glandulifolia Buchinger ex. Meisn. 4440
Acalypha peduncularis E.Mey. ex Meisn. 3893, 4378, 4404, 4410, 4437, 4501, 4532
Acalypha punctata Meisn. ex Krauss 4339, 4384, 4386, 4405, 4434, 4435, 4484, 4502
Acalypha villicaulis Hochst. 4466
Adenocline pauciflora Turcz.
Clutia cordata Bernh.
Clutia hirsuta (Sond.) Müll.Arg.
Clutia sp. +
Euphorbia gueinzii (Pax) N.E.Br.
Euphorbia pulvinata Marloth
Euphorbia striata Thunb. var. *striata*
Jatropha hirsuta Hochst. var. *hirsuta* 4456, 5097
Tragia meyeriana Müll.Arg.

FABACEAE

Abrus laevigatus E.Mey. 5095
Acacia nilotica (L.) Willd. Ex Delile subsp. *kraussiana* (Benth.) Brenan
Aeschynomene micrantha DC. 4457
Alysicarpus rugosus (Willd.) DC. subsp. *perennirufus* J.Leonard 4568, 4988
Argyrolobium ascendens Walp.3895, 3917
Argyrolobium baptisioides Walp. 4267, 4365
Argyrolobium cf. *humile* E.Phillips 4398
Argyrolobium harveyanum Oliv. 4403
Argyrolobium longifolium (Meisn.) Walp. 3478, 4508
Argyrolobium rotundifolium T.J.Edwards
Argyrolobium stipulaceum Eckl. & Zeyh. 3920, 4368
Aspalathus chortophila Eckl. & Zeyh.
Chamaecrista capensis (Thunb.) E.Mey. var. *flavescens* 3862

Chamaecrista mimosoides (L.) Greene 3958, 5123

Chamaecrista plumosa E.Mey. 4031

Chamaecrista plumosa E.Mey. var. *erecta* (Schorn & Gordon-Gray) 3865, 3960

Chamaecrista plumosa E.Mey. var. *plumosa* 3817, 3833, 3850, 3879, 3909, 3971, 5086, 5132a

Chamaecrista sp. 3998, 4025

Crotalaria dura J.M.Wood & M.S.Evans subsp. *dura* 4481

Crotalaria globifera E.Mey. 4479

Crotalaria lanceolata E.Mey. subsp. *lanceolata*

Crotalaria macrocarpa E.Mey. subsp. *macrocarpa* 3873 +

Dalbergia obovata E.Mey.

Desmodium dregeanum Benth.

Desmodium gangeticum (L.) DC.

Desmodium setigerum (E.Mey.) Benth ex Harv.

Dichilus reflexus (N.E.Br.) A.L.Schutte 4493 +

Dichrostachys cinerea (A.DC.) Wight & Arn.

Dolichos angustifolius Eckl. & Zeyh.

Dolichos trilobus L. subsp. *transvaalicus* Verdc. 3880, 3984, 5089

Eriosema cordatum E.Mey. +

Eriosema kraussianum Meisn. 4369

Eriosema parviflorum E.Mey. subsp. *parviflorum*

Eriosema populifolium Benth. ex Harv. subsp. *populifolium* 4477

Eriosema preptum C.H.Stirt. 4452, 4594

Eriosema salignum E.Mey. 4402, 4451

Eriosema superpositum C.H.Stirt. ined.

Erythrina humeana Spreng. +

Erythrina lysistemon Hutch. +

Indigastrum fastigiatum (E.Mey.) Schrire 3866, 4079

Indigofera dimidiata Vogel ex Walp. +

Indigofera hilaris Eckl. & Zeyh. var. *hilaris* 4591

Indigofera inandensis Baker f. ex Schrire 5122, 5237

Indigofera punctata Thunb. +

Indigofera rubroglandulosa Germish. 4432, 4570, 4592, 5115, 5117

Indigofera sp. nov. A 4253, 5231

Indigofera sp. nov. B 5091

Indigofera tristis E.Mey 3867

Indigofera vicioides Jaub. & Spach var. *rogersii* (R.E.Fr.) J.B.Giilett

Indigofera williamsonii (Harv.) N.E.Br.

Indigofera woodii Bolus var. laxa Bolus 4051

Lotononis calycina (E.Mey.) Benth. 3928, 3985

Lotononis cf. *pulchra* 3857, 3989, 4028, 4397, 5133

Lotononis corymbosa (E.Mey.) Benth. 4274, 4347

Lotononis solitudinis Duemmer

Lotus discolor E.Mey. subsp. *discolor*

Macrotyloma axillare (E.Mey.) Verdc. 3874, 4488, 4567, 4987

Macrotyloma maranguense (Taub.) Verdc. 3837

Pseudarthria hookeri Wight & Arn. var. *hookeri*

Rhynchosia caribaea (Jacq.) DC. +

Rhynchosia cooperi (Harv. ex. Baker f.) Burtt Davy 3890, 3894, 3983, 4364, 4430

Rhynchosia densiflora (Roth) DC. subsp. *chrysadenia* (Taub.) Verdc. 3888

Rhynchosia hirsuta Eckl. & Zeyh.

Rhynchosia nervosa Benth. & Harv. var. *nervosa*
Rhynchosia sp. 3951
Rhynchosia totta (Thunb.) DC. var. totta 3854, 4396
Rhynchosia villosa (Meisn.) Druce 4589
Sphenostylis angustifolia Sond. 4506
Tephrosia capensis (Jacq.) Pers. 4977
Tephrosia elongata E.Mey. var. *elongata*
Tephrosia longipes Meisn. subsp. *longipe*s 3842, 3855
Tephrosia macropoda (E.Mey.) Harv. var. *diffusa* (E.Mey.) Shrire
Tephrosia macropoda (E.Mey.) Harv. var. *macropoda* 3841
Tephrosia polystachya E.Mey. var. *hirta* Harv. 3943
Tephrosia semiglabra Sond. 3843, 3856, 4078
Tephrosia shiluwanensis Schinz 4032 + #
Teramnus labialis (L.f.) Spreng subsp. *labialis*
Trifolium burchellianum Ser. subsp. *burchellianum* 3916
Trifolium sp. * +
Vigna unguiculata (L.) Walp. subsp. *protracta* (E.Mey) 3902
Vigna *unguiculata* (L.) Walp. subsp. *tenuis* (E.Mey.) Marechal var. ovata (E.Mey.) B.J.Pienaar 3904, 4388, 4494 +
Vigna unguiculata (L.) Walp. subsp. *tenuis* (E.Mey.) Marechal var. tenuis 3915, 4461, 4492 +
Vigna vexillata (L.) A.Rich. var. *angustifolia* (Schumach. & Thonn.) Baker 3990, 4536
Vigna vexillata A.Rich. var. *vexillata* 3992, 3994, 4030, 4037, 3875 3913, 4491, 4535
Zornia capensis Pers. subsp. *capensis* 3853
Zornia linearis E.Mey. 3936

JUNCAGINACEAE

Triglochin bulbosa L.

GENTIANACEAE

Sebaea grandis (E.Mey.) Steud.
Sebaea natalensis Schinz
Sebaea sedoides Gilg
Sebaea sp. nov. 5121 + #

GERANIACEAE

Geranium flanaganii R.Knuth. 4480
*Pelargonium alchemilloid*es (L.) L'Her. 4317, 4984
Pelargonium luridum (Andrews) Sweet
Pelargonium pulverulentum Sims
Pelargonium schlechteri R.Knuth

GESNERIACEAE

Streptocarpus polyanthus Hook. subsp. *polyanthus*

GUNNERACEAE

Gunnera perpensa L. + #

HYACINTHACEAE

Albuca setosa Jacq. 4590
Dipcadi sp. 4563 +
*Drimia calcarat*a (Baker) Stedje +
Drimia cooperi Baker (Baker) 4342
Drimia depressa (Baker) Jessop

Drimia elata Jacq.
Eucomis autumnalis (Mill.) Chitt. 4988
Eucomis comosa (Houtt.) Wehrh. + #
Ledebouria apertiflora (Baker) Jessop
Ledebouria ovatifolia (Baker) Jessop
Ledebouria cooperi (Hook.f.) Jessop
Ledebouria leptophylla (Baker) S. Venter
Ledebouria zebrina (Baker) S. Venter +
Litanthus pusillus Harv. +
Ornithogalum cf. *juncifolium* Jacq. 4472
Ornithogalum graminifolium Thunb. +
Ornithogalum tenuifolium F.Delaroche subsp. *tenuifolium* +
Schizocarpus nervosus (Burch.) Van der Merwe
Scilla kraussii Baker
Scilla natalensis Planch.

HYPERICACEAE

Hypericum aethiopicum Thunb. subsp. *sonderi* (Bredell) N.Robson 4273, 4374, 4439
Hypericum lalandii Choisy 3982 +

HYPOXIDACEAE

Empodium elongatum (Nel) B.L.Burtt
Hypoxis acuminata Baker 4413, 4530, 4533
Hypoxis angustifolia Lam. var. buchananii Baker
Hypoxis argentea Harv. ex. Baker var. *sericea* Baker 3868, 3903, 3941, 4000, 4023, 4257
Hypoxis colchicifolia Baker 4595
Hypoxis filiformis baker
Hypoxis galpinii Baker 3828, 4531, 4356
Hypoxis hemerocallidea Fisch., C.A.Mey. & Ave-Lall. 4531
Hypoxis multiceps Butchinger ex. Baker
Hypoxis rigidula Baker 4272
Hypoxis rigidula Baker var. *pilosissima* Baker
Hypoxis rigidula Baker var. *rigidula*

IRIDACEAE

Aristea abyssinica Pax
Aristea ecklonii Baker +
Aristea torulosa Klatt 3878, 3991
Dierama argyreum L.Bolus 3827, 4348
Dierama pallidum Hilliard 3863, 4001
Freesia laxa (Thunb.) Goldblatt & J.C.Manning subsp. *laxa*
Gladiolus dalenii Van Geel subsp. *dalenii* +
Gladiolus ecklonii Lehm.
Gladiolus inandensis Baker
Gladiolus longicollis Baker
Gladiolus sericeovillosus Hook.f. subsp. *sericeovillosus*
Hesperantha lactea Baker +
Moraea elliotii Baker +
Moraea natalensis Baker 4275
Tritonia disticha (Klatt) Baker subsp. *rubrolucens* (R.C.Foster) M.P.de Vos +
Tritonia lineata (Salisb.) Ker Gawl. var. *lineata* 4261
Watsonia densiflora Baker

LAMIACEAE

Aeollanthus parvifolius Benth.
Ajuga ophrydis Burch. ex Benth. 4482
Endostemon obtusifolius (E.Mey. ex Benth.) N.E.Br. +
Leonotis intermedia Lindl.

Leonotis leonorus (L.) R.Br.
Leucas martinicensis (Jacq.) R.Br. *
Ocimum obovatum E.Mey. ex Benth. subsp. *obovatum* 4379
Orthosiphon suffrutescens (Thonn.) J.K.Morton
Plectranthus hadiensis (Forssk.) Schweinf. ex. Spreng. var. *tomentosus* (Benth.) Codd
Plectranthus hadiensis (Forssk.) Scweinf. ex. Spreng. var. *hadiensis* 4376, 4496
Plectranthus hadiensis (Forssk.) Scweinf. ex. Spreng. *var. nov.* 5087
Pychnostachys reticulata (E.Mey.) Benth + #
Rabdosiella calycina (Benth.) Codd
Rotheca hirsuta (Hochst.) R.Fern. 4254
Stachys aethiopica L.
Stachys natalensis Hochst. var *natalensis* 3896
Stachys sp. 4486, 4549
Syncolostemon parviflorus E.Mey. ex Benth. var. *parviflorus*
Teucrium kraussii Codd

LINACEAE

Linum thunbergii Eckl. & Zeyh. 3957

LOBELIACEAE

Cyphia elata Harv. 5124
Lobelia anceps L.f. + #
Lobelia cochlearifolia Diels 4458, 4483, 4512, 4626
Lobelia flaccida (Presl) A.DC. 4085, 4490, 4515a
Monopsis decipiens (Sond.) Thulin
Monopsis stellarioides (C.Presl.) Urb. subsp. *stellarioides* + #

LYTHRACEAE

Nesaea sagittifolia (Sond.) Koehne var. *sagittifolia* + #
Rotala tenella (Guill. & Perr.) Hiern + #

MAESACEAE

Maesa alnifolia Harv. 5127 +
Maesa lanceolata Forssk.

MELASTOMATACEAE

Dissotis canescens (E.Mey. ex. R.A.Graham) Hook.f. #
Dissotis princeps (Kunth) Triana + #

MESEMBRYANTHEMACEAE
AIZOACEAE)

Delosperma lineare L.Bolus
Delosperma suttoniae Lavis

MOLLUGINACEAE

Limeum viscosum (J.Gay) Fenzl subsp. *viscosum* var. *glomeratum* (Eckl. & Zeyh.) Friedrich 5085
Psammotropha cf. *myriantha* Sond. 3959, 4249

MYRICACEAE

Morella brevifolia (E.Mey. ex C.DC.) Killick
Morella pilulifera (Rendle) Killick
Morella serrata (Lam.) Killick + #

MYRTACEAE

Eugenia albanensis Sond.
Eugenia capensis (Eckl. & Zeyh.) Sond. subsp. *gueinzii* (Sond.) +

OCHNACEAE

Ochna serrulata (Hochst.) Walp.

ORCHIDACEAE

Bonatea porrecta (Bolus) Summerh. +
Brachycorythis ovata Lindl. subsp. *ovata* +
Brachycorythis pubescens Harv. +
Brachycorythis tenuior Rchb.f. +
Corycium nigrescens Sond. 4003\
Disa brevicornis (Lindl.) Bolus
Disa chrysostachya Sw. +
Disa nervosa Lindl. +
Disa woodii Schltr. +
Eulophia adenoglossa (Lindl.) Rchb.f. +
Eulophia clitillifera (Rchb.f.) Bolus +
Eulophia ensata Lindl.
Eulophia hians Spreng. var. *hians* 4250
Eulophia leontoglossa Richb.f.
Eulophia ovalis Lildl. var. *ovalis* 5125 +
Eulophia parviflora (Lindl.) A.V.Hall +
Eulophia streptopetala Lindl. +
Eulophia tenella Rchb.f. +
Eulophia welwitschii (Rchb.f.) Rolfe +
Habenaria clavata (Lindl.) Rchb.f.
Habenaria dives Rchb.f. +
Habenaria epidactidea Rchb. f. 5101 +
Habenaria pseudociliosa Schelpe ex J.C.Manning 4029, 4039 +
Satyrium longicauda Lindl.
Stenoglottis woodii Schltr. +

OROBANCHACEAE

Alectra sessiliflora (Vahl) Kuntze var. *sessiliflora*
Buchnera simplex (Thunb.) Druce 4423, 4566, 5081
Cycnium adonense E.Mey. ex. Benth.
Cycnium racemosum Benth. +
Cycnium tubulosum (L.f.) Engl. subsp. *tubulosum* 5104 + #
Striga bilabiata (Thunb.) Kuntze subsp. *bilabiata*

ONAGRACEAE

Ludwigia octovalvis (Jacq.) P.H.Raven #

OXALIDACEAE

Oxalis smithiana Eckl. & Zeyh.
Oxalis sp. 1
Oxalis sp. 2

PASSIFLORACEAE

Basananthe sandersonii (Harv.) W.J.de Wilde 4367

PEDALIACEAE

Ceratotheca triloba (Bernh.) Hook.f.

PHYLLANTHACEAE

Phyllanthus glaucophyllus Sond.

Phyllanthus heterophyllus E.Mey. Ex Mull.Arg. 4343, 4377, 4419, 4534
Phyllanthus maderaspatensis L.
Phyllanthus meyerianus Mull.Arg. + #
Phyllanthus parvulus Sond.

PLANTAGINACEAE

Plantago lanceolata L. 4463

POLYGALACEAE

Muraltia lancifolia Harv. 4505
Polygala fruticosa P.J.Bergius +
Polygala hottentota C.Presl.
Polygala rehmannii Chodat
Polygala serpentaria Eckl. & Zeyh. +
Polygala transvaalensis Chodat var. *transvaalensis* Paiva 3924
Polygala virgata Thunb. +

POLYGONACEAE

Oxygonum dregeanum Meisn. subsp. *dregeanum* 4523 +
Rumex sagittatus Thunb. +

PROTEACEAE

Protea caffra Mesin. subsp. *caffra*
Protea roupelliae Meisn. subsp. *roupelliae*
Protea simplex E.Phillips 5129

ROSACEAE

Rubus sp. *

RANUNCULACEAE

Clematis brachiata Thunb. +
Ranunculus multifidus Forssk. + #

RUBIACEAE

Agathisanthemum chlorophyllum (Hochst.) Bremek. var. *chlorophyllum* 3911
*Anthospermum herb*aceum L.f.
Anthospermum hispidulum E.Mey. ex Sond 3944
Anthospermum rigidum Eckl. & Zeyh. subsp. *pumilum* (Sond.) Puff 3860, 3898, 3984
Coddia rudis (E.Mey. ex Harv.) Verdc.
Conostomium natalense (Hochst.) Bremek.
Eriosemopsis subanisophylla Robyns 3923, 3996
Galopina sp.
Jasminum multipartitum Hochst.
Kohautia amatymbica Eckl. & Zeyh. 4357
Kohautia virgata (Willd.) Bremek. 3918, 3978, 4020
Oldenlandea sp. 3809
Oldenlandia affinis (Roem. & Schult.) DC. subsp. *fugax* (Vatke) Verdc.
Oldenlandia cephalotes (Hochst.) Kuntze + #
Oldenlandia herbacea (L.) Roxb. var. *herbacea* 3869, 3882, 3922, 4024
Pachystigma venosum Hochst. 5112
Pavetta gardeniifolia A.Rich 5099 +
Pavetta *gracilifolia* Bremek. +
Pentanisia angustifolia (Hochst.) Hochst. 3948, 3956, 4260, 4526
Pentanisia prunelloides (Klotzch ex Eckl. & Zeyh.) Walp. subsp. *prunelloides* 3933, 3961,5096

Pentanisia prunelloides (Klotzsch ex Eckl. & Zeyh.) Walp. subsp. *latifolia* (Hochst.) Verdc.3949, 4516, 5090, 5132
Pygmaeothamnus chamaedendrum (Kuntze) Robyns var. *chamaedendrum*
Richardia brasiliensis Gomes 5098 *
Rubia cordifolia L. subsp. *conotricha* (Gand.) Verdc. +
Spermacoce natalensis Hochst.
Spermacoce senensis (Klotzsch) Hiern
Vangueria infausta Burch. subsp. *infausta* +

RUSCACEAE

Eriospermum cooperi Baker var. *natalense* (Baker) P.L.Perry 3986
Eriospermum flagelliforme (Baker) J.C.Manning
Eriospermum mackenii (Hook.f.) Baker subsp. *mackenii* 4086

RUTACEAE

Agathosma ovata (Thunb.) Pillans

SANTALACEAE

Thesium costatum A.W.Hill var. *costatum* 4392
*Thesium natalen*se Sond. 4399

SCROPHULARIACEAE

Diclis reptans Benth. 4602
Graderia scabra (L.f.) Benth.
Hebenstretia comosa Hochst. 4006
Jamesbrittenia kraussiana (Bernh.) Hilliard 4046
Limosella grandiflora Benth. + #
Lindernia nana (Engl.) Roessler
Lindernia parviflora (Roxb.) Haines + #
Manulea parviflora Benth. var. *parviflora*
Mimulus gracilis R.Br. + #
Nemesia denticulata (Benth.) Grant ex Fourc.
Selago densiflora Rolfe 4464, 5105
Selago hyssopifolia E.Mey 3963 +
Selago tarachodes Hilliard 4386, 4519
Sutera floribunda (Benth.) Kuntze
Tetraselago natalensis (Rolfe) Junell
Zaluzianskya elongata Hilliard & B.L.Burtt 3876, 3885, 3900, 3939, 3974, 4005, 5119
Zaluzianskya natalensis Bernh. 5118

SMILACACEAE

Smilax anceps Willd.

SOLANACEAE

Physalis viscosa L. * +
Withania somnifera (L.) Dunal +
Solanum panduriforme E.Mey.
Solanum sp.

THYMELAEACEAE

Gnidia calocephala (C.A.Mey.) Gilg #
Gnidia kraussiana Meisn. var. *kraussiana* 4252
Gnidia nodiflora Meisn. 3840
Gnidia polyantha Gilg. 3872, 4052
Passerina montivaga Bredenkamp & A.E.van Wyk

TILIACEAE

Abutilon sp. +
Cienfuegosia gerrardii (Harv.) Hochr.
Corchorus asplenifolius Burch.
Grewia occidentalis L. var. *occidentalis*
Hermannia depressa N.E.Br. 3889
Hermannia grandistipula (Burchinger ex. Hochst.) K.Schum. 4438, 4978
Hermannia parviflora Eckl. & Zeyh. 3891, 4393
Hermannia sandersonii Harv. 3479, 4257
Hibiscus aethiopicus L. var. *ovatus* Harv. 3914, 4412, 4540, 4976
Hibiscus cannabinus L. + #
Hibiscus pusillus Thunb.
Hibiscus trionum L. +
Melhania didyma Eckl. & Zeyh.
Sida dregei Burtt Davy
Sida rhombifolia L. subsp. *rhombifolia* +
Sida sp. +
Triumfetta pilosa Roth. +

VERBENACEAE

Lantana camara L. *
Lantana rugosa Thunb.
Lippia javanica (Burnm.f.) Spreng.
Verbena aristigera S.Moore * +
Verbena bonariensis L. 4514 * +
Verbena cf. *brasiliensis* Vell. 5111 * +
Verbena officinalis L. * +

VIOLACEAE

Hybanthus enneaspermus (L.) F.Muell. var. *enneaspermus* 4429

VITACEAE

Cyphostemma cirrhosum (Thunb.) Desc. ex Wild & R.B.Drumm. subsp. *cirrhosum*
Cyphostemma natalitium (Szyszyl.) J.J.M.van der Merwe
Rhoicissus tridentata (L.f.) Wild & R.B.Drumm. subsp. *cuneifolia* (Eckl. & Zeyh.) Urton

The following collections were made that were either not resolved to species or infraspecific taxon, but which if included in the list above would cause duplication.

Acalypha sp. 3930, 3935
Afrosciadium sp. 4370
Commelina africana L. 3852, 3976, 4569
Commelina sp. 4561
Conyza sp. 3905
Hypoxis sp. 4465, 4468, 4469, 4470
Indigofera sp. 3899, 5130
Ornithogalum sp. 3997, 4565
Oxalis sp. 3921, 4990
Pentanisia prunelloides (Klotzsch ex Eckl. & Zeyh.) Walp 4265, 4363
Polygala sp. 3892, 4375, 4381
Vigna unguiculata (L.) Walp. 3912, 4019
Vigna vexillata A.Rich. 4360
Wahlenbergia sp. 3886, 3901, 3928, 3932, 3999, 5134

Appendix 3. Abundance results for species found in plots according to geology. These cover the greatest number of species up to or after 30 from which percentages change on Natal Group sandstone, Dwyka Group tillite and megacrystic biotite granite

Natal Group sandstone	**%**	**DGT (excluding Thornridge Farm)**	**%**	**DGT (Thornridge Farm)**	**%**	**Megacrystic biotite granite**	**%**
Tephrosia macropoda (E.Mey.) Harv. var. macropoda	3.501	*Chaetacanthus burchellii* Nees	4.237	*Ajuga ophrydis* Burch. ex Benth.	4.512	*Lotononis corymbosa-pulchra*	6.130
Commelina africana L.	3.170	*Agathisanthemum chlorophyllum* (Hochst.) Bremek. var. *chlorophyllum*	2.9	*Agathisanthemum chlorophyllum* (Hochst.) Bremek. var. *chlorophyllum*	4.44	*Chaetacanthus burchellii* Nees	5.843
Justicia protracta (Nees) T.Anderson subsp. *protracta*	2.725	*Aster bakerianus* Burtt Davy ex C.A.Sm.	2.881	*Chaetacanthus burchellii* Nees	4.367	*Euryops laxus* (Harv.) Burtt-Davy	4.598
Chaetacanthus burchellii Nees	2.593	*Gerbera kraussii* Sch.Bip.	2.853	*Corchorus asplenifolius* Burch.	3.712	*Ocimum obovatum* E.Mey. ex Benth. subsp. *obovatum*	4.310
Zornia capensis Pers. subsp. capensis	2.356	*Berkheya umbellata* DC.	2.635	*Hypoxis hemerocallidea* Fisch., C.A.Mey. & Ave-Lall.	3.566	*Agathisanthemum chlorophyllum* (Hochst.) Bremek. var. *chlorophyllum*	4.119
Eriosema salignum E.Mey.	2.243	*Tephrosia macropoda* (E.Mey.) Harv. var. *macropoda*	2.512	*Crabbea hirsuta* Harv.	3.493	*Anthospermum rigidum* Eckl. & Zeyh. subsp. *pumilum* (Sond.) Puff	3.352

Cyanotis speciosa (L.f.) Hassk.	2.214	*Senecio glaberrimus-latifolius*	2.265	*Blepharis integrifolia* (L.f.) E.Mey. ex Schinz	3.057	*Crabbea hirsuta* Harv.	3.352
Agathisanthemum chlorophyllum (Hochst.) Bremek. var. chlorophyllum	2.157	*Graderia* scabra (L.f.) Benth.	2.208	*Hibiscus aethiopicus* L. var. ovatus Harv.	2.984	*Aster bakerianus* Burtt Davy ex C.A.Sm.	2.874
Tetraselago natalensis (Rolfe) Junell	2.157	*Senecio bupleurioides* DC.	2.199	*Senecio coronatus* (Thunb.) Harv	2.984	*Helichrysum longifolium* DC.	2.682
Anthospermum rigidum Eckl. & Zeyh. subsp. *pumilum* (Sond.) Puff	1.987	*Hypoxis hemerocallidea* Fisch., C.A.Mey. & Ave-Lall.	2.047	*Orthosiphon suffrutescens* (Thonn.) J.K.Morton	2.838	*Scabiosa columbaria* L.	2.682
Chamaecrista plumosa E.Mey. var. *plumosa*	1.921	*Hypericum aethiopicum* Thunb. subsp. *sonderi* (Bredell) N.Robson	1.867	*Argyrolobium ascendens-humile*	2.547	*Tephrosia macropoda* (E.Mey.) Harv. var. macropoda	2.299
Indigofera rubroglandulosa Germishuizen sensu lato	1.788	*Vernonia natalensis* Oliv. & Hiern	1.858	*Thunbergia atriplicifolia* E.Mey. ex Nees	2.183	*Thesium costatum* A.W.Hill var. *costatum*	2.299
Argyrolobium rotundifolium T.J.Edwards	1.268	*Thunbergia atriplicifolia* E.Mey. ex Nees	1.763	*Zornia capensis* Pers. subsp. *capensis*	2.111	*Zornia capensis* Pers. subsp. *capensis*	2.299
Acalypha glandulifolia Buchinger ex. Meisn.	1.192	*Indigofera sp. nov.* B (= DGA Styles 5091 NH)	1.725	*Senecio glaberrimus-latifolius*	2.038	*Helichrysum krebsianum* Less.	2.203
Berkheya umbellata DC.	1.192	*Vernonia oligocephala* (DC.) Sch.Bip. ex Walp.	1.649	*Gerbera kraussii* Sch.Bip.	1.892	*Rhynchosia totta* (Thunb.) DC. var. *totta*	2.011

Helichrysum krebsianum Less.	1.126	*Indigofera rubroglandulosa* Germishuizen sensu lato	1.64	*Ruellia baurii* C.B.Clarke	1.892	*Commelina africana* L.	1.916
Chamaecrista plumosa E.Mey. var. *erecta* (Schorn & Gordon-Gray)	1.079	*Acalypha peduncularis* E.Mey. ex Meisn.	1.564	*Wahlenbergia krebsii* Cham. subsp. *krebsii*	1.747	*Euphorbia gueinzii* (Pax) N.E.Br.	1.916
Vigna unguiculata (L.) Walp.	1.050	*Acalypha glandulifolia* Buchinger ex. Meisn.	1.516	*Abrus laevigatus* E.Mey.	1.674	*Hypericum aethiopicum* Thunb. subsp. *sonderi* (Bredell) N.Robson	1.820
Senecio glaberrimus-latifolius	1.031	*Senecio umgeniensis* Thell.	1.469	*Commelina africana* L.	1.674	*Polygala transvaalensis* Chodat var. *transvaalensis* Paiva	1.820
Hypoxis argentea Harv. ex. Baker var. *sericea* Baker	1.022	*Helichrysum krebsianum* Less.	1.431	*Helichrysum krebsianum* Less.	1.601	*Indigofera rubroglandulosa* Germishuizen sensu lato	1.724
Delosperma lineare L.Bolus	1.012	*Ocimum obovatum* E.Mey. ex Benth. subsp. *obovatum*	1.422	*Ocimum obovatum* E.Mey. ex Benth. subsp. *obovatum*	1.601	*Pentanisia angustifolia* (Hochst.) Hochst.	1.724
Senecio albanopsis Hilliard	1.012	*Rhynchosia totta* (Thunb.) DC. var. totta	1.204	*Indigofera sp. nov.* B (= DGA Styles 5091 NH)	1.601	*Hypoxis hemerocallidea* Fisch., C.A.Mey. & Ave-Lall.	1.628
Indigofera williamsonii (Harv.) N.E.Br.	0.956	*Zornia capensis* Pers. subsp. capensis	1.194	*Centella asiatica* (L.) Urb.	1.528	*Senecio umgeniensis* Thell.	1.628
Senecio variabilis Sch.Bip.	0.956	*Hypoxis argentea* Harv. ex. Baker var. *sericea* Baker	1.166	*Sebaea sedoides* Gilg	1.528	*Helichrysum appendiculatum* (L.f.) Less.	1.533

Crassula pellucida L. subsp. *brachypetala* (Drege ex Harv.)	0.937	*Lotononis corymbosa-pulchra*	1.147	*Aster bakerianus* Burtt Davy ex C.A.Sm.	1.383	*Linum thunbergii* Eckl. & Zeyh.	1.533
Aeschynomene micrantha DC.	0.889	*Cyanotis speciosa* (L.f.) Hassk.	1.128	*Cyanotis speciosa* (L.f.) Hassk.	1.31	*Aeschynomene micrantha* DC.	1.437
Helichrysum griseum Sond.	0.852	*Scabiosa columbaria* L.	1.033	*Polygala hottentota* C.Presl.	1.31	*Alepidea peduncularis* A.Rich.	1.437
Gerbera kraussii Sch.Bip.	0.804	*Helichrysum pallidum* DC.	1.014	*Stachys natalensis* Hochst. var *natalensis*	1.31	*Ruellia cordata* Thunb.	1.437
Sphenostylis angustifolia Sond.	0.804	*Adhatoda densiflora* (Hochst) J.C.Manning	0.995	*Scabiosa columbaria* L.	1.164	*Wahlenbergia krebsii* Cham. subsp. *krebsii*	1.437
Helichrysum aureum (Houtt.) Merr. var. *monocephalum* (D.C.) Hilliard	0.757	*Syncolostemon parviflorus* E.Mey. ex Benth. var. *parviflorus*	0.986	*Vernonia natalensis* Oliv. & Hiern	1.164	*Tephrosia semiglabra* Sond.	1.341

Appendix 4. Abundance of species only in plots on Natal Group sandstone, not on Dwyka Group tillite, and vice versa. Species indicated with an asterisk * were found at Thornridge Farm only and may be elements more typical of KwaZulu-Natal Hinterland Thornveld/Eastern Valley Bushveld.

Natal Group sandstone	**%**	**Dwyka Group tillite**	**%**
Chaetacanthus sp. nov. = D.G.A. Styles 3822, 3919, 3950, 3972, 3973 (NH)	0.643	*Rhynchosia cooperi* (Harv. ex. Baker f.) Burtt Davy	0.637
Wahlenbergia madagascariensis A.DC.	0.625	*Orthosiphon suffrutescens* (Thonn.) J.K.Morton *	0.327
Crassula lanceolata (Eckl. & Zeyh.) Endl. ex Walp. subsp. *transvaalensis* (Kuntze) Toelken	0.615	*Kniphofia gracilis* Harv. ex Baker	0.260
Oldenlandia herbacea (L.) Roxb. var. herbacea	0.615	*Ruellia baurii* C.B.Clarke *	0.218
Sutera floribunda (Benth.) Kuntze	0.416	*Tritonia lineata* (Salisb.) Ker Gawl. var. *lineata*	0.218
Cineraria atriplicifolia DC.	0.369	*Stachys natalensis* Hochst. var *natalensis*	0.151
Helichrysum asperum (Thunb.) Hilliard & Burtt var. *comosum* (Sch.Bip.) Hilliard	0.284	*Rhynchosia hirsuta* Eckl. & Zeyh. *	0.117
Cryptolepis oblongifolia (Meisn.) Schltr.	0.274	*Eriosema populifolium* Benth. ex Harv. subsp. *populifolium*	0.092
Brachystelma pulchellum (Harv.) Schltr.	0.227	*Kniphofia buchananii* Baker	0.084
Helichrysum caespititium (DC.) Harv.	0.218	*Othonna natalensis* Sch.Bip.	0.075
Tephrosia longipes Meisn. subsp. *longipes*	0.208	*Senecio heliopsis* Hilliard & B.L.Burtt	0.075
Crassula capitella Thunb. subsp. *meyeri* (Harv.) Toelken	0.199	*Hermannia parviflora* Eckl. & Zeyh. *	0.067
Plectranthus hadiensis (Forssk.) Scweinf. ex. Spreng. *var. nov.*	0.199	*Indigofera woodii* Bolus var. *laxa* Bolus	0.067
Lotononis solitudinis Duemmer	0.180	*Polygala rehmannii* Chodat	0.067

Macrotyloma maranguense (Taub.) Verdc.	0.161	*Hermannia depressa* N.E.Br. *	0.059
Brachystelma rubellum (E.Mey) Peckover	0.151	*Buchnera simplex* (Thunb.) Druce	0.050
Passerina montivaga Bredenkamp & A.E.van Wyk	0.151	*Convolvulus natalensis* Bernh. ex. Krauss	0.042
Lindernia nana (Engl.) Roessler	0.132	*Asclepias dregeana* Schltr. var. *dregeana*	0.034
*Commelina m*odesta Oberm.	0.114	*Teramnus labialis* (L.f.) Spreng subsp. *labialis*	0.034
Crassula obovata Harv. var. *obovata*	0.114	*Cienfuegosia gerrardii* (Harv.) Hochr. *	0.025
Gnidia nodiflora Meisn.	0.114	*Drimia depressa* (Baker) Jessop	0.025
Hypoxis angustifolia Lam. var. *buchananii* Baker	0.104	*Adenocline pauciflora* Turcz.	0.017
Oldenlandia affinis (Roem. & Schult.) DC. subsp. *fugax* (Vatke) Verdc.	0.104	*Helichrysum nudifolium* (L.) Less. var. *oxyphyllum* (DC.) Beentje *	0.017
Cyrtanthus obliquus (L.f.) Aiton	0.085	*Phyllanthus maderaspatensis* L.*	0.017
Limeum viscosum (J.Gay) Fenzl subsp. *viscosum* var. *glomeratum* (Eckl. & Zeyh.) Friedrich	0.085	*Pygmaeothamnus chamaedendrum* (Kuntze) Robyns var. *chamaedendrum* *	0.017
Schistostephium griseum (Harv.) Hutch.	0.085	*Senecio discodregeanus* Hilliard & B.L.Burtt	0.017
Streptocarpus polyanthus Hook. subsp. *polyanthus*	0.085	*Ceropegia crassifolia* Schltr. var. crassifolia *	0.008
Agathosma ovata (Thunb.) Pillans	0.076	*Cyphostemma cirrhosum* (Thunb.) Desc. ex Wild & R.B.Drumm. subsp. *cirrhosum* *	0.008
Dolichos trilobus L. subsp. *transvaalicus* Verdc.	0.076	*Cyphostemma natalitium* (Szyszyl.) J.J.M.van der Merwe	0.008
Helichrysum umbraculigerum Less.	0.066	*Disa brevicornis* (Lindl.) Bolus	0.008
Ipomoea magnusiana Schinz	0.066	*Empodium elongatum* (Nel) B.L.Burtt	0.008
Hermannia sandersonii Harv.	0.057	*Eriosema superpositum* C.H.Stirt. ined.	0.008
Jatropha hirsuta Hochst. var. *hirsuta*	0.057	*Melhania didyma* Eckl. & Zeyh. *	0.008
Manulea parviflora Benth. var. *parviflora*	0.057	*Pachycarpus scaber* (Harv.) N.E.Br.	0.008

Wahlenbergia cf. *grandiflora* Brehmer	0.057	*Rhynchosia densiflora* (Roth) DC. subsp. *chrysadenia* (Taub.) Verdc. *	0.008
Clutia hirsuta (Sond.) Müll.Arg.	0.047	*Tephrosia capensis* (Jacq.) Pers.	0.008
Lobelia cochlearifolia Diels	0.047	-	
Selago tarachodes Hilliard	0.047	-	
Brachystelma sandersonii (Oliv.) N.E.Br.	0.038	-	
Erica cerinthoides L. var. *cerinthoides*	0.038	-	
Morella brevifolia (E.Mey. ex C.DC.) Killick	0.028	-	
Thunbergia venosa C.B.Clarke	0.028	-	
Pachycarpus coronarius E.Mey	0.019	-	
Relhania pungens L'Hér. subsp. *angustifolia* (DC.) K.Bremer	0.019	-	
Zornia linearis E.Mey.	0.019	-	
Crassula sp. nov. = D.G.A. Styles & M. Ngwenya 4082 (NH)	0.009	-	

Appendix 5. Abundance results for plots with north- versus south-facing aspects. These cover the greatest number of species up to or after 30 from which percentages change

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North-facing (337.5-22.5 °)	**%**	**South-facing (157.5-202.5 °)**	**%**	**North-facing (292.5-67.5 °)**	**%**	**South-facing (112.5-247.5 °)**	**%**
Justicia protracta (Nees) T.Anderson subsp. Protracta	3.404	*Chaetacanthus burchellii* Nees	3.480	*Chaetacanthus burchellii* Nees	3.477	*Chaetacanthus burchellii Nees*	3.518
Chamaecrista plumosa E.Mey. var. *plumosa*	3.286	*Tephrosia macropoda* (E.Mey.) Harv. var. macropoda	2.886	*Aster bakerianus* Burtt Davy ex C.A.Sm.	2.684	*Agathisanthemum chlorophyllum* (Hochst.) Bremek. var. *chlorophyllum*	2.995
Commelina africana L.	3.286	*Agathisanthemum chlorophyllum* (Hochst.) Bremek. var. *chlorophyllum*	2.419	*Gerbera kraussii* Sch.Bip.	2.638	*Tephrosia macropoda* (E.Mey.) Harv. var. *macropoda*	2.924
Indigofera rubroglandulosa Germishuizen sensu lato	3.228	*Helichrysum krebsianum* Less.	1.952	*Commelina africana* L.	2.531	*Helichrysum krebsianum* Less.	1.933
Zornia capensis Pers. subsp. *capensis*	2.934	*Berkheya umbellata* DC.	1.888	*Tephrosia macropoda* (E.Mey.) Harv. var. *macropoda*	2.486	*Zornia capensis* Pers. subsp. *capensis*	1.743
Cyanotis speciosa (L.f.) Hassk.	2.582	*Gerbera kraussii* Sch.Bip.	1.888	*Agathisanthemum chlorophyllum* (Hochst.)	2.425	*Berkheya umbellata* DC.	1.688

				Bremek. var. *chlorophyllum*			
Tetraselago natalensis (Rolfe) Junell	2.406	*Chamaecrista plumosa* E.Mey. var. *erecta* (Schorn & Gordon-Gray)	1.719	*Indigofera rubroglandulosa* Germishuizen sensu lato	2.211	*Hypoxis hemerocallidea* Fisch., C.A.Mey. & Ave-Lall.	1.553
Sphenostylis angustifolia Sond.	2.347	*Hypericum aethiopicum* Thunb. subsp. sonderi (Bredell) N.Robson	1.697	*Ocimum obovatum* E.Mey. ex Benth. subsp. obovatum	2.074	*Senecio glaberrimus-latifolius*	1.529
Chaetacanthus burchellii Nees	2.230	*Zornia capensis* Pers. subsp. *capensis*	1.655	*Senecio glaberrimus-latifolius*	1.967	*Hypericum aethiopicum* Thunb. subsp. *sonderi* (Bredell) N.Robson	1.498
Eriosema salignum E.Mey.	2.171	*Cyanotis speciosa* (L.f.) Hassk.	1.634	*Zornia capensis* Pers. subsp. *capensis*	1.937	*Gerbera kraussii* Sch.Bip.	1.490
Agathisanthemum chlorophyllum (Hochst.) Bremek. var. *chlorophyllum*	2.113	*Indigofera rubroglandulosa* Germishuizen sensu lato	1.528	*Cyanotis speciosa* (L.f.) Hassk.	1.921	*Commelina africana* L.	1.450
Anthospermum rigidum Eckl. & Zeyh. subsp. *pumilum* (Sond.) Puff	2.113	*Aster bakerianus* Burtt Davy ex C.A.Sm.	1.443	*Sphenostylis angustifolia* Sond.	1.845	*Cyanotis speciosa* (L.f.) Hassk.	1.418
Indigofera williamsonii (Harv.) N.E.Br.	2.113	*Senecio glaberrimus-latifolius*	1.337	*Hypoxis hemerocallidea* Fisch., C.A.Mey. & Ave-Lall.	1.815	*Aster bakerianus* Burtt Davy ex C.A.Sm.	1.331

Senecio bupleurioides DC.	1.878	*Senecio bupleurioides* DC.	1.252	*Vernonia natalensis* Oliv. & Hiern	1.677	*Thunbergia atriplicifolia* E.Mey. ex Nees	1.284
Gerbera kraussii Sch.Bip.	1.819	*Helichrysum pallidum* DC.	1.209	*Senecio bupleurioides* DC.	1.632	*Eriosema salignum* E.Mey.	1.252
Tephrosia macropoda (E.Mey.) Harv. var. macropoda	1.761	*Alepidea peduncularis* A.Rich.	1.167	*Chamaecrista plumosa* E.Mey. var. *plumosa*	1.601	*Justicia protracta* (Nees) T.Anderson subsp. *protracta*	1.252
Ocimum obovatum E.Mey. ex Benth. subsp. *obovatum*	1.702	*Argyrolobium rotundifolium* T.J.Edwards	1.167	*Anthospermum rigidum* Eckl. & Zeyh. subsp. *pumilum* (Sond.) Puff	1.540	*Argyrolobium rotundifolium* T.J.Edwards	1.228
Acalypha glandulifolia Buchinger ex. Meisn.	1.643	*Ocimum obovatum* E.Mey. ex Benth. subsp. *obovatum*	1.125	*Tetraselago natalensis* (Rolfe) Junell	1.479	*Acalypha glandulifolia* Buchinger ex. Meisn.	1.125
Helichrysum acutatum DC.	1.643	*Dianthus zeyheri* Sond. subsp. *natalensis* Hooper	1.103	*Berkheya umbellata* DC.	1.464	*Chamaecrista plumosa* E.Mey. var. *erecta* (Schorn & Gordon-Gray)	1.117
Aster bakerianus Burtt Davy ex C.A.Sm.	1.526	*Senecio albanopsis* Hilliard	1.103	*Justicia protracta* (Nees) T.Anderson subsp. *protracta*	1.449	*Acalypha peduncularis* E.Mey. ex Meisn.	1.109
Pentanisia prunelloides (Klotzch ex Eckl. & Zeyh.) Walp. subsp. *prunelloides*	1.526	*Helichrysum appendiculatum* (L.f.) Less.	1.082	*Eriosema salignum* E.Mey.	1.403	*Anthospermum rigidum* Eckl. & Zeyh. subsp. *pumilum* (Sond.) Puff	1.109

Gazania krebsiana Lessing	1.232	*Hypoxis hemerocallidea* Fisch., C.A.Mey. & Ave-Lall.	1.082	*Thunbergia atriplicifolia* E.Mey. ex Nees	1.388	*Indigofera rubroglandulosa* Germishuizen sensu lato	1.070
Dicoma anomala Sond. subsp. *cirsioides* Harv.	1.174	*Vernonia hirsuta* (DC.) Sch.Bip. ex Walp.	1.061	*Acalypha glandulifolia* Buchinger ex. Meisn.	1.372	*Vernonia natalensis* Oliv. & Hiern	1.062
Hypoxis argentea Harv. ex. Baker var. *sericea* Baker	1.174	*Acalypha glandulifolia* Buchinger ex. Meisn.	1.040	*Graderia scabra* (L.f.) Benth.	1.372	*Hypoxis argentea* Harv. ex. Baker var. *sericea* Baker	1.014
Hypoxis hemerocallidea Fisch., C.A.Mey. & Ave-Lall.	1.174	*Acalypha peduncularis* E.Mey. ex Meisn.	1.018	*Indigofera sp. nov.* B (= DGA Styles 5091 NH)	1.128	*Alepidea peduncularis* A.Rich.	0.967
Cryptolepis oblongifolia (Meisn.) Schltr.	1.056	*Senecio umgeniensis* Thell.	1.018	*Pentanisia prunelloides* (Klotzch ex Eckl. & Zeyh.) Walp. subsp. *prunelloides*	1.128	*Tetraselago natalensis* (Rolfe) Junell	0.967
Lotononis solitudinis Duemmer	1.056	*Vernonia natalensis* Oliv. & Hiern	0.976	*Hypericum aethiopicum* Thunb. subsp. *sonderi* (Bredell) N.Robson	1.083	*Ajuga ophrydis* Burch. ex Benth.	0.935
Aeschynomene micrantha DC.	1.056	*Eriosema salignum* E.Mey.	0.955	*Rhynchosia totta* (Thunb.) DC. var. totta	1.067	*Graderia scabra* (L.f.) Benth.	0.919
Graderia scabra (L.f.) Benth.	0.998	*Syncolostemon parviflorus* E.Mey. ex Benth. var. *parviflorus*	0.955	*Helichrysum acutatum* DC.	1.052	*Berkheya rhapontica* (DC.) Hutch. & Burtt-Davy subsp. *rhapontica*	0.911

Vernonia galpinii Klatt	0.998	*Athrixia phylicoides* D.C.	0.934	*Hypoxis argentea* Harv. ex. Baker var. *sericea* Baker	1.037	*Crassula pellucida* L. subsp. *brachypetala* (Drege ex Harv.)	0.895

Appendix 6. Abundance results for species occurring on south-facing aspects (112.5-247.5 °) but not north-facing (292.5-67.5 °), and vice versa

South-facing not north-facing	**%**	**North-facing not south-facing**	**%**
Alepidea peduncularis A.Rich.	0,967	*Brachystelma rubellum* (E.Mey) Peckover	0.213
Sutera floribunda (Benth.) Kuntze	0.777	*Hibiscus pusillus* Thunb.	0.213
Athrixia phylicoides D.C.	0,602	*Rhynchosia hirsuta* Eckl. & Zeyh.	0.213
Chamaecrista plumosa E.Mey. var. *erecta* (Schorn & Gordon-Gray)	0.265	*Commelina africana* L. var *krebsiana* (Kunth) C.B.Clarke	0.183
Helichrysum appendiculatum (L.f.) Less.	0.248	*Asclepias cucullata* (Schltr.) Schltr.	0.122
Crassula pellucida L. subsp. *brachypetala* (Drege ex Harv.)	0.231	*Limeum viscosum* (J.Gay) Fenzl subsp. *viscosum* var. *glomeratum* (Eckl. & Zeyh.) Friedrich	0.122
Zaluzianskya natalensis Bernh.	0.205	*Lantana camara* L.	0.105
Helichrysum appendiculatum_auriceps	0.197	*Chaetacanthus* ***sp.***	0.091
Berkheya rhapontica (DC.) Hutch. & Burtt-Davy subsp. *rhapontica*	0.188	*Coddia rudis* (E.Mey. ex Harv.) Verdc.	0.091
Phymaspermum acerosum (DC.) Kallersjo	0.162	*Ipomoea magnusiana* Schinz	0.076
Acalypha punctata Meisn. ex Krauss	0,143	*Jatropha hirsuta* Hochst. var. *hirsuta*	0.076
Satyrium longicauda Lindl.	0.120	*Aloe maculata* All.	0.061
Aloe parviflora Baker	0,111	*Combretum molle* R.Br. ex G.Don	0.061
Linum thunbergii Eckl. & Zeyh.	0.111	*Huernia hystrix* (Hook.f.) N.E.Br. var. *hystrix*	0.061
Muraltia lancifolia Harv.	0.111	*Hypochaeris radicata* L.	0.061
Silene burchellii Otth subsp. *multiflora* J.C.Manning & Goldblatt	0.111	*Indigofera vicioides* Jaub. & Spach *var. rogersii* (R.E.Fr.) J.B.Giilett	0.061

Agapanthus campanulatus F.M.Leight subsp. *campanulatus*	0,095	*Spermacoce senensis* (Klotzsch) Hiern	0.061
Cineraria atriplicifolia DC.	0.094	*Cienfuegosia gerrardii* (Harv.) Hochr.	0.046
Helichrysum platypterum DC.	0.094	*Laggera crispata* (Vahl) Hepper & J.R.I.Wood	0.046
Phymaspermum pinnatifidum (Oliv.) Kallersjo	0.085	*Crotalaria lanceolata* E.Mey. *subsp.* lanceolate	0.030
*Pimpinella caffra (*Eckl. & Zeyh.) D.Dietr	0.085	*Ipomoea sinensis* (Desr.) Choisy subsp. *blepharosepala* (Hochst. ex A.Rich.) Verdc. ex A.Meeuse	0.030
Centella glabrata L. var. *natalensis* Adamson	0.068	*Lotononis* sp.	0.030
Indigofera tristis E.Mey	0.068	*Macrotyloma axillare* (E.Mey.) Verdc.	0.030
Senecio erubescens var. *dichotomus* DC.	0.068	*Pachycarpus coronarius* E.Mey	0.030
Acalypha peduncularis_punctata	0,063	*Phyllanthus maderaspatensis* L.	0.030
Agathosma ovata (Thunb.) Pillans	0,063	*Pollichia campestris* Aiton	0.030
Commelina sp.	0.051	*Pygmaeothamnus chamaedendrum* (Kuntze) Robyns *var. chamaedendrum*	0.030
Stachys sp.	0.051	*Sida dregei* Burtt Davy	0.030
Gladiolus ecklonii Lehm.	0.043	*Cleome monophylla* L.	0.026
Helichrysum umbraculigerum Less.	0.043	*Argyrolobium ascendens* Walp.	0.015
Indigofera hilaris Eckl. & Zeyh. var. *hilaris*	0.043	*Aspidoglossum gracile* (E.Mey.) Kupicha	0.015
Leonotis leonorus (L.) R.Br.	0.043	*Ceropegia crassifolia Schltr.* var. crassifolia	0.015
Lotononis calycina (E.Mey.) Benth.	0.043	*Convolvulus natalensis Bernh.* ex. Krauss	0.015
Streptocarpus polyanthus Hook. subsp. *polyanthus*	0.043	*Crassula* sp. nov. = D.G.A. Styles & M. Ngwenya 4082 (NH)	0.015
Tenrhynea phylicifolia (DC.) Hilliard & B.L.Burtt	0.043	*Cussonia spicata* Thunb.	0.015

Appendix 7. Most abundant species on all steep and very steep slopes, according to geology (Natal Group sandstone versus Dwyka Group tillite, excluding Thornridge Farm. These cover the greatest number up to or after 30 from which percentages change on Natal Group sandstone and Dwyka Group tillite.

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Natal Group sandstone, south-facing (112.5-247.5 °)	**%**	**Dwyka Group tillite, south-facing (112.5-247.5 °)**	**%**	**Natal Group sandstone, north-facing (292.5-67.5 °)**	**%**	**Dwyka Group tillite, north-facing (292.5-67.5 °)**	**%**
Tephrosia macropoda (E.Mey.) Harv. var. *macropoda*	4.233	*Chaetacanthus burchellii* Nees	3.174	*Tetraselago natalensis* (Rolfe) Junell	5.952	*Chaetacanthus burchellii* Nees	4.810
Chaetacanthus burchellii Nees	3.115	*Berkheya umbellata* DC.	3.174	*Sphenostylis angustifolia* Sond.	4.762	*Indigofera rubroglandulosa* Germishuizen sensu lato	4.577
Agathisanthemum chlorophyllum (Hochst.) Bremek. var. *chlorophyllum*	2.151	*Vernonia oligocephala* (DC.) Sch.Bip. ex Walp.	2.736	*Commelina africana* L.	4.762	*Gerbera kraussii* Sch.Bip.	3.724
Cyanotis speciosa (L.f.) Hassk.	2.099	*Hypoxis hemerocallidea* Fisch., C.A.Mey. & Ave-Lall.	2.554	*Eriosema salignum* E.Mey.	4.101	*Berkheya umbellata* DC.	3.258
Argyrolobium rotundifolium T.J.Edwards	2.065	*Agathisanthemum chlorophyllum* (Hochst.) Bremek. var. *chlorophyllum*	2.517	*Indigofera williamsonii* (Harv.) N.E.Br.	3.704	*Aster bakerianus* Burtt Davy ex C.A.Sm.	2.948

Chamaecrista plumosa E.Mey. var. *erecta* (Schorn & Gordon-Gray)	1.927	*Gerbera kraussii* Sch.Bip.	2.335	*Justicia protracta* (Nees) T.Anderson subsp. *protracta*	3.571	*Thunbergia atriplicifolia* E.Mey. ex Nees	2.715
Berkheya umbellata D.C.	1.893	*Acalypha peduncularis* E.Mey. ex Meisn.	2.298	*Chamaecrista plumosa* E.Mey. var. *plumosa*	3.042	*Tephrosia macropoda* (E.Mey.) Harv. var. *macropoda*	2.638
Justicia protracta (Nees) T.Anderson subsp. protracta	1.876	*Aster bakerianus* Burtt Davy ex C.A.Sm.	2.116	*Cryptolepis oblongifolia* (Meisn.) Schltr.	3.042	*Chamaecrista* sp.	2.405
Helichrysum krebsianum Less.	1.876	*Graderia scabra* (L.f.) Benth.	2.080	*Anthospermum rigidum* Eckl. & Zeyh. subsp. *pumilum* (Sond.) Puff	3.042	*Senecio bupleurioides* DC.	2.405
Indigofera rubroglandulosa Germishuizen sensu lato	1.807	*Senecio bupleurioides* DC.	1.861	*Tephrosia macropoda* (E.Mey.) Harv. var. *macropoda*	2.778	*Sphenostylis angustifolia* Sond.	2.327
Commmelina africana L.	1.704	*Helichrysum pallidum* DC.	1.824	*Oldenlandia herbacea* (L.) Roxb. var. *herbacea*	2.116	*Pentanisia prunelloides* (Klotzch ex Eckl. & Zeyh.) Walp. subsp. *prunelloides*	2.250
Crassula pellucida L. subsp. *brachypetala* (Drege ex Harv.)	1.652	*Senecio glaberrimus-latifolius*	1.824	*Zornia capensis* Pers. subsp. *capensis*	2.116	*Ocimum obovatum* E.Mey. ex Benth. subsp. *obovatum*	2.095
Acalypha glandulifolia Burchinger ex Meisn.	1.618	*Tephrosia macropoda* (E.Mey.) Harv. var. *macropoda*	1.824	*Aeschynomene micrantha* DC.	1.984	*Acalypha glandulifolia* Buchinger ex. Meisn.	2.095

Tetraselago natalensis (Rolfe) Junell	1.600	*Helichrysum krebsianum* Less.	1.715	*Indigofera rubroglandulosa* Germishuizen sensu lato	1.984	*Helichrysum acutatum* DC.	1.939
Eriosema salignum E.Mey.	1.549	*Indigofera sp. nov.* B (= DGA Styles 5091 NH)	1.678	*Brachystelma rubellum* (E.Mey) Peckover	1.852	*Tetraselago natalensis* (Rolfe) Junell	1.939
Helichrysum appendiculatum (L.f.) Less.	1.256	*Thunbergia atriplicifolia* E.Mey. ex Nees	1.678	*Pachystigma venosum* Hochst.	1.587	*Vernonia natalensis* Oliv. & Hiern	1.939
Vernonia hirsuta (DC.) Sch.Bip. ex Walp.	1.256	*Muraltia lancifolia* Harv.	1.678	*Commelina africana* L. var *krebsiana* (Kunth) C.B.Clarke	1.587	*Rotheca hirsuta* (Hochst.) R.Fern.	1.784
Berkheya rhapontica (DC.) Hutch & Burtt-Davy subsp. *rhapontica*	1.239	*Hypericum aethiopicum* Thunb. subsp. *sonderi* (Bredell) N.Robson	1.642	*Agathisanthemum chlorophyllum* (Hochst.) Bremek. var. *chlorophyllum*	1.455	*Agathisanthemum chlorophyllum* (Hochst.) Bremek. var. *chlorophyllum*	1.784
Gerbera kraussii Sch.Bip.	1.239	*Vernonia natalensis* Oliv. & Hiern	1.569	*Cyanotis robusta* Oberm.	1.455	*Graderia scabra* (L.f.) Benth.	1.784
Athrixia phylicoides DC.	1.222	*Berkheya rhapontica* (DC.) Hutch. & Burtt-Davy subsp. *rhapontica*	1.569	*Hypoxis argentea* Harv. ex. Baker var. *sericea* Baker	1.455	*Senecio glaberrimus-latifolius*	1.707
Hypericum aethiopicum Thunb. Subsp. *sonderi* (Bredell) N.Robson	1.170	*Berkheya rhapontica* (DC.) Hutch. & Burtt-Davy subsp. *rhapontica*	1.532	*Senecio albanopsis* Hilliard	1.323	*Cyanotis speciosa* (L.f.) Hassk.	1.629

Zornia capensis Pers. subsp. *capensis*	1.153	*Senecio umgeniensis* Thell.	1.532	*Pentanisia prunelloides* (Klotzch ex Eckl. & Zeyh.) Walp. subsp. *prunelloides*	1.323	*Scabiosa columbaria* L.	1.474
Senecio variabilis Sch.Bip.	1.136	*Acalypha glandulifolia* Burchinger ex Meisn.	1.459	*Acalypha glandulifolia* Buchinger ex. Meisn.	1.190	*Eriosema salignum* E.Mey	1.396
Senecio albanopsis Hilliard	1.136	*Syncolostemon parviflorus* E.Mey. ex Benth. var. *parviflorus*	1.423	*Wahlenbergia madagascariensis* A.DC.	1.190	*Argyrolobium baptisioides* Walp.	1.319
Delosperma lineare L.Bolus	1.136	*Adhatoda densiflora* (Hochst) J.C.Manning	1.386	*Cyanotis speciosa* (L.f.) Hassk.	1.190	*Rhynchosia totta* (Thunb.) DC. var. *totta*	1.319
Senecio glaberrimus_latifolius	1.101	*Scabiosa columbaria* L.	1.240	*Helichrysum acutatum* DC.	1.058	*Senecio umgeniensis* Thell.	1.241
Phymaspermum acerosum (DC.) Kallersjo	1.084	*Cephalaria oblongifolia* (Kuntze) Szabo	1.240	*Acalypha villicaulis* Hochst.	1.058	*Helichrysum auriceps* Hilliard	1.164
Acalypha peduncularis E.Mey ex Meisn.	1.015	*Pentanisia prunelloides* (Klotzsch ex Eckl. & Zeyh.) Walp. subsp. *latifolia* (Hochst.) Verdc.	1.204	*Ocimum obovatum* E.Mey. ex Benth. subsp. *obovatum*	1.058	*Hypoxis hemerocallidea* Fisch., C.A.Mey. & Ave-Lall.	1.086
Alepidea peduncularis A.Rich.	1.015	*Vernonia hirsuta* (DC.) Sch.Bip. ex Walp.	1.204	*Limeum viscosum* (J.Gay) Fenzl subsp. *viscosum* var. *glomeratum* (Eckl. & Zeyh.) Friedrich	1.058	*Albuca setosa* Jacq.	1.086

Hypoxis argentea Harv. Ex. Baker var. *sericea* Baker	0.964	*Lotononis corymbosa_pulchra*	1.204	*Chaetacanthus burchellii* Nees	1.058	*Hypoxis multiceps* Butchinger ex Baker	1.086
Helichrysum griseum Sond.	0.895	*Alepedia peduncularis* A.Rich.	1.204	*Kohautia virgata* (Willd.) Bremek.	0.926	*Anthospermum rigidum* Eckl. & Zeyh. subsp. *pumilum* (Sond.) Puff	1.086

Appendix 8. Most abundant species on level and moderate slopes, according to geology (Natal Group sandstone versus Dwyka Group tillite (excluding Thornridge Farm). These cover the greatest number up to or after 30 from which percentages change on Natal Group sandstone (NGS) and Dwyka Group tillite (DGT).

Natal Group sandstone – south-facing (112.5-247.5 °)	**%**	**Dwyka Group tillite – south-facing (112.5-247.5 °)**	**%**	**Natal Group sandstone –north-facing (292.5-67.5 °)**	**%**	**Dwyka Group tillite – north-facing (292.5-67.5 °)**	**%**
Anthospermum rigidum Eckl. & Zeyh. subsp. *pumilum* (Sond.) Puff	5.409	*Agathisanth-emum chlorophyllum* (Hochst.) Bremek. var. *chlorophyllum*	5.015	*Commelina africana* L.	8.507	*Blepharis integrifolia* (L.f.) E.Mey. ex Schinz	7.24
Zornia capensis Pers. subsp. *capensis*	4.161	*Chaetacanthus burchellii* Nees	4.621	*Chamaecrista plumosa* E.Mey. var. *plumosa*	6.516	*Orthosiphon suffrutescens* (Thonn.) J.K.Morton	4.751
Commelina africana L.	3.467	*Hypoxis hemerocallidea* Fisch., C.A.Mey. & Ave-Lall.	4.228	*Justicia protracta* (Nees) T.Anderson subsp. *protracta*	5.882	*Gerbera kraussii* Sch.Bip.	4.751
Agathisanth-emum chlorophyllum (Hochst.) Bremek. var. *chlorophyllum*	3.329	*Hypericum aethiopicum* Thunb. subsp. *sonderi* (Bredell) N. Robson	3.835	*Zornia capensis* Pers. subsp. *capensis*	4.977	*Corchorus asplenifolius* Burch.	4.525
Justicia protracta (Nees) T.Anderson subsp. *protracta*	3.051	*Gerbera kraussii* Sch.Bip.	3.736	*Eriosema salignum* E.Mey.	3.801	*Senecio glaberrimus_latifolius*	3.62

Vigna unguiculata (L.) Walp.	3.051	*Senecio glaberrimus_ latifolius*	3.736	*Cyanotis speciosa* (L.f.) Hassk.	3.801	*Ocimum obovatum* E.Mey. ex Benth. subsp. *obovatum*	3.394
Eriosema salignum E.Mey.	2.774	*Helichrysum krebsianum* Less	3.343	*Indigofera williamsonii* (Harv.) N.E.Br.	2.986	*Hibiscus pusillus* Thunb.	3.167
Chaetacanthus burchellii Nees	2.635	*Zornia capensis* Pers. subsp. *capensis*	3.245	*Anthospermum rigidum* Eckl. & Zeyh. subsp. *pumilum* (Sond.) Puff	2.896	*Cyanotis speciosa* (L.f.) Hassk.	3.167
Chamaecrista plumosa E.Mey. var. *plumosa*	2.427	*Indigofera sp. nov.* B (= DGA Styles 5091 NH)	3.147	*Gazania krebsiana* Lessing	2.081	*Polygala hottentota* C.Presl.	3.167
Tephrosia macropoda (E.Mey.) Harv. var. *macropoda*	2.358	*Rhynchosia totta* (Thunb.) DC var. totta	3.048	*Tetraselago natalensis* (Rolfe) Junell	1.810	*Agathisanthemum chlorophyllum* (Hochst.) Bremek. var. *chlorophyllum*	2.941
Aeschynomene micrantha DC.	1.942	*Graderia scabra* (L.f.) Benth.	3.048	*Vigna unguiculata* (L.) Walp.	1.810	*Abrus laevigatus* E.Mey.	2.941
Senecio glaberrimus-latifolius	1.872	*Hypoxis argentea* Harv. ex Baker var. *sericea* Baker	2.950	*Crassula lanceolata* (Eckl. & Zeyh.) Endl. ex Walp. subsp. *transvaalensis* (Kuntze) Toelken	1.629	*Ruellia cordata* Thunb.	2.941
Crassula lanceolata (Eckl. & Zeyh.) Endl. ex Walp. subsp.	1.664	*Asclepias flexuosa* (E.Mey.) Schltr.	2.753	*Lotononis solitudinis* Duemmer	1.629	*Rhynchosia hirsuta* Eckl. & Zeyh.	2.715

transvaalensis (Kuntze) Toelken							
Tetraselago natalensis (Rolfe) Junell	1.664	*Aster bakerianus* Burtt Davy ex C.A.Sm.	2.655	*Selago densiflora* Rolfe	1.629	*Stachys natalensis* Hochst. var natalensis	2.715
Senecio albanopsis Hilliard	1.664	*Ajuga ophyrydis* Burch. ex Benth.	2.36	*Abrus laevigatus* E.Mey.	1.629	*Commelina africana* L.	2.715
Helichrysum longifolium DC.	1.595	*Vernonia natalensis* Oliv. & Hiern	2.262	*Chaetacanthus sp. nov.* = D.G.A. Styles 3822, 3919, 3950, 3972, 3973 (NH)	1.538	*Crabbea hirsuta* Harv.	2.715
Cyanotis speciosa (L.f.) Hassk.	1.526	*Vernonia oloigocephala* (DC.) Sch.Bip. ex Walp	2.163	*Tephrosia macropoda* (E.Mey.) Harv. var. *macropoda*	1.448	*Hypoxis hemerocallidea* Fisch., C.A.Mey. & Ave-Lall.	2.489
Helichrysum auriceps Hilliard	1.456	*Thunbergia atriplicifolia* E.Mey. ex Nees	2.163	*Vernonia natalensis* Oliv. & Hiern	1.357	*Aster bakerianus* Burtt Davy ex C.A.Sm.	2.262
Crabbea hirsuta Harv.	1.387	*Cephalaria oblongifolia* (Kuntze) Szabo	2.065	*Agathisanthemum chlorophyllum* (Hochst.) Bremek. var. *chlorophyllum*	1.357	*Zornia capensis* Pers. subsp. *capensis*	2.036
Indigofera williamsonii (Harv.) N.E.Br.	1.318	*Euphorbia striata* Thunb. var. *striata*	1.967	*Indigofera rubroglandulosa* Germishuizen sensu lato	1.357	*Ruellia baurii* C.B.Clarke	1.81

Helichrysum griseum Sond.	1.248	*Spermacoce natalensis* Hochst.	1.672	*Senecio glaberrimus-latifolius*	1.176	*Hibiscus aethiopicus* L. var. *ovatus* Harv.	1.81
Hibiscus aethiopicus L. var. *ovatus* Harv.	1.248	*Dierama* sp.	1.672	*Pachystigma venosum* Hochst.	1.176	*Euryops laxus* (Harv.) Burtt-Davy	1.81
Thunbergia atriplicifolia E.Mey. ex Nees	1.179	*Alepidea peduncularis* A.Rich.	1.475	*Aeschynomene micrantha* DC.	1.176	*Acalypha villicaulis* Hochst.	1.584
Selago densiflora Rolfe	1.110	*Alysicarpus rugosus* (Willd) DC. subsp. *pennirufus* J.Leonard	1.377	*Sphenostylis angustifolia* Sond.	1.176	*Vigna unguiculata* (L.) Walp. subsp. *protracta* (E.Mey)	1.584
Hypoxis argentea Harv. ex. Baker var. *sericea* Baker	1.110	*Acalypha peduncularis* E.Mey. ex Meisn	1.377	*Delosperma lineare* L.Bolus	1.176	*Tephrosia semiglabra* Sond.	1.357
Abrus laevigatus E.Mey.	1.110	*Sebaea sedoides* Gilg	1.377	*Dicoma anomala* Sond. subsp. *cirsioides* Harv.	1.086	*Chaetacanthus* sp.	1.357
Helichrysum caespititium (DC.) Harv.	1.110	*Ocimum obovatum* E.Mey. ex Benth. subsp. *obovatum*	1.278	*Brachystelma pulchellum* (Harv.) Schltr.	1.086	*Rhynchosia totta* (Thunb.) DC. var. *totta*	1.357
Chaetacanthus sp. nov. = D.G.A. Styles 3822, 3919, 3950, 3972, 3973 (NH)	1.040	*Tephrosia macropoda* (E.Mey.) Harv. var. macropoda	1.278	*Hibiscus aethiopicus* L. var. *ovatus* Harv.	0.995	*Argyrolobium ascendens_humile*	1.357
Scabiosa columbaria L.	1.040	*Cyanotis speciosa* (L.f.) Hassk.	1.180	*Euphorbia gueinzii* (Pax) N.E.Br.	0.995	*Chaetacanthus burchellii* Nees	1.131

Aster bakerianus Burtt Davy ex C.A.Sm.	1.040	*Berkheya setifera* DC.	0.983	*Pentanisia prunelloides* (Klotzsch ex Eckl. & Zeyh.) Walp	0.995	I*ndigofera vicioides* Jaub. & Spach var. *rogersii* (R.E.Fr.) J.B.Giilett	0.905
Indigofera rubroglandulosa Germishuizen sensu lato	1.040	*Tritonia lineata* (Salisb.) Ker Gawl. Var. lineata	0.983	*Wahlenbergia denticulata* (Burch.) A.DC.	0.995	Pachystigma venosum Hochst.	0.905
Oldenlandia herbacea (L.) Roxb. var. *herbacea*	0.971	*Polygala transvaalensis* Chodat var. *transvaalensis* Paiva	0.983	*Kohautia virgata* (Willd.) Bremek.	0.995	*Aloe maculata* All.	0.905
Gazania sp.	0.971	*Hibiscus aethiopicus* L. var. *ovatus* Harv.	0.885	*Helichrysum griseum* Sond.	0.995	*Barleria meyeriana* Nees	0.905

Appendix 9. Notes on biogeographically important species found in grasslands at Cato Ridge

Acalypha glandulifolia Buchinger ex. Meisn.	According to Scott-Shaw (1991) *A. glandulifolia* senso stricto "is only associated with Natal Group sandstone" but also occurs with a 500 km disjunction in "mountainous areas of the eastern Transvaal." Although not found to be correct in the Cato Ridge area, broad correspondence in distribution with an escarpment mainly but not entirely comprised of Natal Group sandstone warrants its inclusion here.
Adhatoda densiflora (Hochst) J.C.Manning.	According to Manning and Getliffe Norris (1995) it is a "Natal endemic largely restricted to the Natal midlands and coastal regions below 1 500 m altitude." The distribution does not extend far north and south of Durban (Scott-Shaw 1999).
Afrosciadium natalense (Sond.) P.J.D.Winter.	The distribution occurs from the Pondoland Centre along the coastal escarpment to about Ngoye. At least one record is reported further inland, possibly away from the coastal escarpment. This locality needs to be investigated further, as if not for this the species appears to qualify as an Eastern Scarp Endemic.
Argyrolobium baptisioides Walp.	The species has a disjunct distribution, with one population in the Eastern Cape and one in KwaZulu-Natal. The KwaZulu-Natal population occurs in the south of the province from the coastal escarpment to the midlands. According to Edwards (2005): "Although the Eastern Cape and KwaZulu-Natal forms overlap morphologically, the predominant facies of these areas are different. This in combination with the distributional disjunction, may warrant the recognition of two subspecies."
Brachystelma sandersonii (Oliv.) N.E.Br.	The distribution is mainly on sandy soils along the close KwaZulu-Natal coastal littoral, although plants extend a few km south of the provincial border to the Mzamba River (Styles & Wragg 2007) (pers. obs.). Its unusual occurrence further inland may be linked to the presence of sandy soils derived from the Natal Group sandstone substrate.
Crassula capitella Thunb. subsp. *meyeri* (Harv.) Toelken.	This species has a narrow distribution in the coast and semi-coastal area from about the Mzimkulu River to just north of Durban (Toelken 1985).
Cyrtanthus obliquus (L.f.) Aiton.	This species is treated with other red listed species further below. It is distributed from the southwestern Cape through to KwaZulu-Natal, but

	may only be confined only to sandstone-derived soils. It is very rare in KwaZulu-Natal and there is reportedly only one other known extant population in the province, apart from the one found at Cato Ridge (Scott-Shaw 1999).
Delosperma suttoniae Lavis.	A poorly known KwaZulu-Natal endemic which has only been collected a few times.
Dierama argyreum L.Bolus.	It is confined "to the southern part of KwaZulu-Natal and neighbouring Transkei … between c. 420 and 1 700 m asl" (Hilliard 1991).
Helichrysum asperum (Thunb.) Hilliard & Burtt var. *comosum* (Sch.Bip.) Hilliard	Mainly Eastern Cape and KwaZulu-Natal coastline on sand dunes but "recorded inland up to c. 900 m above sea level, always on sandy soils" (Hilliard 1983). Inland records shown by Hilliard (1983) appear to be in the vicinity of the Mzumbe River escarpment and Cato Ridge. The very sandy Natal Group sandstone-derived soils in the environs of the old Cato Ridge Airfield are the stronghold of this species in this area.
Helichrysum auriceps Hilliard	Nearly endemic to southern half of KwaZulu-Natal, from low to high altitude (Hilliard 1983).
Kniphofia buchananii Baker	Endemic to KwaZulu-Natal, from the coastal escarpment to the midlands (Codd 1968).
Lobelia cochlearifolia Diels.	Endemic to KwaZulu-Natal (Germishuizen *et al.* 2006).
Ruellia baurii C.B.Clarke	A very localized endemic that herbarium records show to be mainly known from the area around Pietermaritzburg.
Senecio dregeanus DC.	Endemic to southern KwaZulu-Natal, from the coast to midlands (Hilliard 1977).
Senecio umgeniensis Thell.	Endemic to KwaZulu-Natal, between 150 and 1 050 m asl (Hilliard 1977).
Thunbergia venosa C.B.Clarke	Endemic to southern KwaZulu-Natal from the coastal escarpment to the midlands (Retief & Reyneke 1984).

Appendix 10. Cape floristic elements at Cato Ridge

10.1. Natal Group sandstone plots

Agathosma ovata (Thunb.) Pillans
Anthospermum herbaceum L.f.
Anthospermum rigidum Eckl. & Zeyh. subsp. *pumilum* (Sond.) Puff
Aristea sp.
Aristea torulosa Klatt
Aspalathus chortophila Eckl. & Zeyh.
Boophone disticha (L.f.) Herb.
Centella asiatica (L.) Urb.
Centella glabrata L. var. *natalensis* Adamson
Corycium nigrescens Sond.
Crassula alba Forssk. var. *alba*
Crassula capitella Thunb. subsp. *meyeri* (Harv.) Toelken
Crassula lanceolata (Eckl. & Zeyh.) Endl. ex Walp. subsp. *transvaalensis* (Kuntze) Toelken
Crassula obovata Harv. var. *obovata*
Crassula pellucida L. subsp. *brachypetala* (Drege ex Harv.)
Crassula sp. nov. = D.G.A. Styles & M. Ngwenya 4082 (NH)
Crassula vaginata Eckl. & Zeyh. subsp. *vaginata*
Erica cerinthoides L. var. *cerinthoides*
Eriospermum cooperi Baker var. *natalense* (Baker) P.L.Perry
Eriospermum flagelliforme (Baker) J.C.Manning
Eriospermum mackenii (Hook.f.) Baker subsp. *mackenii*
Euryops laxus (Harv.) Burtt-Davy
Gladiolus ecklonii Lehm.
Gladiolus sericeovillosus Hook.f. subsp. *sericeovillosus*
Gnidia calocephala (C.A.Mey.) Gilg
Gnidia kraussiana Meisn. var. *kraussiana*
Gnidia nodiflora Meisn.
Gnidia polyantha Gilg.
Hebenstretia comosa Hochst.
Heliophila elongata (Thunb.) DC.
Lichtensteinia interrupta (Thunb.) Sond.
Manulea parviflora Benth. var. *parviflora*
Muraltia lancifolia Harv.
Nemesia denticulata (Benth.) Grant ex Fourc.
Osteospermum imbricatum L. subsp. *nervatum* (DC.) Norl. var. *nervatum*
Oxalis smithiana Eckl. & Zeyh.
Oxalis sp. 2
Passerina montivaga Bredenkamp & A.E.van Wyk
Pelargonium alchemilloides (L.) L'Her.
Pelargonium luridum (Andrews) Sweet
Pelargonium pulverulentum Sims
Pelargonium schlechteri R.Knuth
Phymaspermum acerosum (DC.) Kallersjo
Phymaspermum pinnatifidum (Oliv.) Kallersjo
Protea roupelliae Meisn. subsp. *roupelliae*
Relhania pungens L'Hér. subsp. *angustifolia* (DC.) K.Bremer
Sebaea grandis (E.Mey.) Steud.
Sebaea sedoides Gilg
Selago densiflora Rolfe
Selago tarachodes Hilliard
Sutera floribunda (Benth.) Kuntze
Thesium costatum A.W.Hill var. *costatum*
Thesium natalense Sond.

Trachyandra saltii (Baker) Oberm. var. *saltii*
Ursinia tenuiloba DC.
Wahlenbergia denticulata (Burch.) A.DC.
Wahlenbergia grandiflora Brehmer
Wahlenbergia krebsii Cham. subsp. *krebsii*
Wahlenbergia madagascariensis A.DC.
Wahlenbergia sp.
Zaluzianskya elongata Hilliard & B.L.Burtt
Zaluzianskya natalensis Bernh.

10.2 Dwyka Group tillite plots

Anthospermum herbaceum L.f.
Anthospermum rigidum Eckl. & Zeyh. *subsp. pumilum* (Sond.) Puff
Aristea torulosa Klatt
Aspalathus chortophila Eckl. & Zeyh.
Boophone disticha (L.f.) Herb.
Centella asiatica (L.) Urb.
Centella glabrata L. var. *natalensis* Adamson
Crassula alba Forssk. var. *alba*
Crassula alba Forssk. var. *alba*
Crassula pellucida L. subsp. *brachypetala* (Drege ex Harv.)
Crassula vaginata Eckl. & Zeyh. *subsp. vaginata*
Disa brevicornis (Lindl.) Bolus
Empodium elongatum (Nel) B.L.Burtt
Eriospermum cooperi Baker var. *natalense (Baker)* P.L.Perry
Eriospermum mackenii (Hook.f.) Baker subsp. *mackenii*
Euryops laxus (Harv.) *Burtt-Davy*
Gladiolus ecklonii Lehm.
Gladiolus inandensis Baker
Gladiolus sericeovillosus Hook.f. subsp. *sericeovillosus*
Gladiolus sp.
Gnidia kraussiana Meisn. var. *kraussiana*
Gnidia polyantha Gilg.
Heliophila elongata (Thunb.) DC.
Lichtensteinia interrupta (Thunb.) Sond.
Moraea natalensis Baker
Muraltia lancifolia Harv.
Nemesia denticulata (Benth.) Grant ex Fourc.
Othonna natalensis Sch.Bip.
Oxalis smithiana Eckl. & Zeyh.
Oxalis sp. 1
Oxalis sp. 2
Pelargonium luridum (Andrews) Sweet
Protea caffra Mesin. subsp. *caffra*
Protea simplex E.Phillips
Sebaea sedoides Gilg
Thesium costatum A.W.Hill var. *costatum*
Thesium natalense Sond.
Trachyandra gerrardii (Baker) Oberm.
Trachyandra saltii (Baker) Oberm. var. *saltii*
Tritonia lineata (Salisb.) Ker Gawl. var. *lineata*
Ursinia tenuiloba DC.
Wahlenbergia krebsii Cham. subsp. *krebsii*
Wahlenbergia sp.

Appendix 11. Photographs

Unless otherwise stated, red list status of the depicted plants follows Raimondo *et al.* (2009).

1. Grassland on Natal Group sandstone (KwaZulu-Natal Sandstone Sourveld) north of the N2 national road, with more recently constructed factories behind. Although somewhat degraded by overgrazing and over-burning, large numbers of endemic and red listed species remain.

2. Grassland in mid-summer on Natal Group sandstone south of the N2 national road. Rock pavements and outcrops host a specialist flora including *Brachystelma pulchellum*, *Crassula obovata* var. *obovata*, *Plectranthus hadiensis var. nov*. and *Wahlenbergia madagascariensis*.

3. Grassland Natal Group sandstone south of the N2 national road. The many grey-complexioned herbs are *Helichrysum confertifolium* which may be locally abundant in thin soils on rocky ground where grass cover is consequently sparse.

4. Grassland on Natal Group sandstone south of the N2 national road in the late summer, when grass has grown up. Species-rich grasslands of this size have become very rare within the eThekwini municipal area.

5. Grassland on Dwyka Group tillite just above and south of the N2 national road. This grassland on the edge of the Hill 'n Dale Farm was on east- and south-facing slopes found the contain the highest non-graminoid species diversity and abundance at Cato Ridge.

6. Grassland at Cato Ridge is gravely threatened by industrial and other forms of development. Here, a logistics warehouse is under construction on the northern side of the N2 national road.

7. Grassland is also faces a number of more informal threats, including ranging of cattle without permission onto private land from adjacent townships. This scene is of species-rich grassland on Dwyka Group tillite south of the N2 national road.

8. One or more individuals operate a business baling some of the Cato Ridge grasslands, which appears over-frequent. Here baling is occurring in grassland on Dwyka Group tillite owned by Rainbow Chickens close to a population of endangered *Eriosema populifolium* Benth. ex Harv. subsp. *populifolium*.

9. *Boophone disticha* (L.f.) Herb., red listed as declining, is widespread if uncommon in the Cato Ridge grasslands.

10. *Aloe parviflora* Baker. One of the most diminutive of the grass aloes with few leaves, small pinkish-grey flowers, and tuberculate leaves. This poorly known species is endemic to a small area of south-central KwaZulu-Natal.

11. *Argyrolobium longifolium* (Meisn.) Walp., red listed as vulnerable. Although the tall, willowy appearance and narrow leaves make it distinctive in the later summer, earlier in the season they are short and the leaves may be broader, at which time it can be confused with *A. baptisoides* Walp.

12. *Argyrolobium baptisoides* (Meisn.) Walp., mainly found in grassland on Dwyka Group tillite at Cato Ridge. Edwards (2005) suggests that plants in southern KwaZulu-Natal may be a distinct subspecies.

13. *Brachycorythis tenuior* Rchb.f., one of 25 orchid species recording during the study, is very rare and known from only a few localities in KwaZulu-Natal.

14. *Brachystelma pulchellum* (Harv.) Schltr., red listed as near threatened. It is nearly endemic to the Durban hinterland. It mainly occurs in thin soils on or flanking Natal Group sandstone outcrops, but is here photographed in deeper, sandy soil on the western edge of the old Cato Ridge airfield, north of the N2 national road.

15. *Brachystelma gerrardii* (Harv.) is red listed as endangered. A handful of plants were found in one place on Thornridge Farm, but prior to the study a similar were also encountered just outside of the Cato Ridge Local Area Plan boundary at Hammarsdale.

16. *Brachystelma gerrardii* (Harv.) – whole plant.

17. *Brachystelma sandersoniii* ((Oliv.) N.E.Br. is red listed as vulnerable.

18. *Brachystelma sandersonii* (Oliv.) *N.E.Brown.* (Harv.) – close-up of flowers. Although most Cato Ridge plants have corona lobes typical of this species, some such as the one featured here have inner lobes beginning to project weakly upwards, probably indicating introgression by sister species *B. franksiae* N.E.Brown, which was first described from Camperdown just to the west.

19. These *Chaetacanthus* plants are probably a new species (Prof. Kevin Balkwill, pers. comm.). They occur in skeletal to thin soils associated with extensive Natal Group sandstone outcropping. Early in the season they may be confused with *C. burchellii* Nees, but as they grow out they can readily be distinguished by longer, stoloniferous stems and larger flowers.

Chaetacanthus sp. nov. may be a local endemic. If so, the population is globally threatened by development and transforming land uses at Cato Ridge.

20. Side view of flowers of *Chaetacanthus sp. nov.*

21. The larger flowers of *Chaetacanthus sp. nov.* compared with those of *C. burchellii* Nees.

22. *Adhatoda densiflora* (Hochst.) J.C.Manning (above and right) is known from a small part of south-central KwaZulu-Natal and was one of the more abundant species in Dwyka Group tillite plots.

23. A remarkable occurrence of *Cyrtanthus obliquus* (L.f.) Aiton. at Cato Ridge. The distribution extends from the Western Cape to southern KwaZulu-Natal where it appears to be confined to sandstone-derived soils. Although not red listed nationally by Raimondo *et al*. (2009), it is exceptionally rare and known from only three other populations in KwaZulu-Natal, one of which is extinct. For this reason, it was assessed as being endangered in this province (Scott-Shaw 1999).

A robust *Cyrtanthus* species with large, attractive flowers, threats apart from grazing and over-burning include collecting by medicinal and private collectors.

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24. Flowers of *Cyrtanthus obliquus* (L.f.) Aiton.

25. *Dierama pallidum* Hilliard. Red listed as vulnerable, this species is only known from the Durban escarpment to Pietermaritzburg. At Cato Ridge it was found in grassland on Dwyka Group tillite and Natal Group sandstone.

26. *Delosperma suttoniae* Lavis. This is a poorly known species endemic to KwaZulu-Natal where known from only a few collections. Plants were found on and flanking Natal Group sandstone pavements and outcrops, much designated for transforming land use. In this habitat, it sometimes grows with *D. lineare* L. Bolus, a species with white flowers that is far more common at Cato Ridge.

27. *Crotalaria dura* J.M.Wood & M.S.Evans subsp. *dura*, red listed as near threatened. Endemic to a small part of south-central KwaZulu-Natal, mainly encompassing the coastal escarpment, it is frequently confused with *C. globifera* E.Mey. which is far more common and sometimes sympatric. However, the keel petal of *C. dura* M.Wood & M.S.Evans, is rotund, without the distally straight and elongate beak of *C. globifera* E.Mey.

28 Remarkable occurrence of *Eriosema populifolium* Benth. ex Harv. subsp. *populifolium* at Cato Ridge, red listed as endangered. Colonies have a preference for deeper soils derived from Dwyka Group tillite, although sometimes flanking tillite outcrops as evident here.

29. The carmine flowers of *Eriosema populifolium* Benth. ex Harv. are together with those of *E. distinctum* N.E.Br., the largest in the genus.

30. Dense, clonal growth of *Eriosema populifolium* Benth. ex Harv are a distinctive feature of the species.

All or nearly all of the plants shown may comprise genetically identical material. Stirton & Gordon-Gray (1978) record that "rootstocks cover extensive areas". One plant had "a rhizome system that was unearthed intact for over 40 metres."

All populations at Cato Ridge occur on Dwyka Group tillite derived soils south of the N2 national road. There are only two subpopulations but one is very large, comprising thousands of stems that occur over hundreds of metres.

31. Silky yellow or white hairs on the leaves of *Eriosema populifolium* Benth. ex Harv. serve distinguish it from the somewhat similar *E. cordatum* E.Mey.

This feature is well seen in the material gathered for lodging at the KwaZulu-Natal Herbarium (below left).

The variously trifoliate and unifoliate leaves mean the Cato Ridge plants straddle the two currently recognized subspecies and the validity of these distinctions may need to be reviewed in the light of this new material.

32. *Eriosema. cordatum* E.Mey. a common species (although localized at Cato Ridge) sometimes confused with *E. populifolium* Benth. ex Harv. from which it differs in the smaller yellow to rarely orange flowers, different indumentum and non-clonal growth form.

33. *Rhynchosia villosa (*Meisn.) Druce, (left and left below) is a handsome and robust, trailing legume which in its vegetative features resembles some species of *Eriosema.* At Cato Ridge plants may grow in close proximity to *E. populifolium* Benth. ex Harv, subsp. *populifolium.*

34. *Drimia cooperi (Baker) Baker* (below), showing inflorescence, flowers and bulb. Although blackened by fire, the bulb is, at least below ground, pale yellow. Rare in the Cato Ridge grasslands, this species is red listed as vulnerable.

35. *Eulophia adenoglossa (Lindl.)* Rchb. f., while not a very striking orchid, is exceptionally rare and known from only a handful of localities in KwaZulu-Natal (Linder & Kurzweil 1999; McMurtry *et al.* (2008). It was found as a few plants in two places at Cato Ridge.

36. *Eriosemopsis subanisophylla* Robyns, cited as a Pondoland Centre endemic (Van Wyk & Smith 2001) and red listed as vulnerable.

However, plants extend northwards in primary grassland north of Pondoland along the coastal escarpment as far north as Durban. At Cato Ridge, it is nearly entirely confined to Natal Group sandstone areas and is severely threatened by the intensification of development north of the N2 national road, where the population mainly occurs.

37. *Helichrysum asperum (Thunb.)* Hilliard & Burtt *var. comosum* (Sch. Bip.) Hilliard is endemic to KwaZulu-Natal. It is usually found along beaches but is known from a few inland localities up to 900 m a.s.l. "always on sandy soils" (Hilliard 1983). At Cato Ridge, it was found only in sparse grassland on Natal Group sandstone, mainly north of the N2 national road.

The occurrence at Cato Ridge, of *Brachystelma sandersonii* Oliv. (N.E.Br.), another species mainly associated with the coastal littoral, may reflect the same phenomenon, namely sandy soils associated with Natal Group sandstone providing an edaphically similar substrate that enabled migration further inland.

38. *Helichrysum griseum* Sond. has a limited distribution in eastern South Africa. It was found to be one of the 30 most abundant species in grassland on Natal Group sandstone (and much less common on Dwyka Group tillite). It may have diagnostic value, particularly for grassland on Natal Group sandstone and so referable to KwaZulu-Natal Sandstone Sourveld. Inflorescences are at first pink to deep pink (below), but this complexion fades as they grow out (left).

39. *Helichrysum pannosum* DC. (above) is red listed as endangered. Here plants are still growing out, but become taller with lemon-yellow flower bracts in the early winter. This species prefers south- and east-facing slopes where damper and grassy growth often scrubbier.

40. *Hermannia sandersonii* Harv. (left) is red listed as vulnerable and is mainly known from the high parts of the Durban escarpment. This is one of the earliest flowering grassland species, with flowers often appearing in the later winter before rains arrive or the leaves are well developed. It was only found in grassland on Natal Group sandstone.

41. *Indigofera inandensis* Baker f. ex Schrire ined. Is endemic to the Durban area and closely related to *I. tristis* E.Mey. (also in the Cato Ridge grasslands), the latter a larger plant with less spindly and elongate peduncles that also prefers damper, scrubbier grassland.

42. *Indigofera rubroglandulosa* Germishuizen is part of a complex that includes *I. hilaris* Eckl. & Zeyh., *I. sp. nov.* A and *I sp. nov.* B, all of which are all found at Cato Ridge.

I. rubroglandulosa Germishuizen was found to be one of the 30 most common non-graminoid species in grassland on Natal Group sandstone and closely flanking Dwyka Group tillite (but is mainly absent from drier grassland on tillite at Thornridge Farm).

43. *Indigofera sp. nov.* A is mainly known from collections from the Durban hinterland, together with a few more from the Pondoland Centre. This is one of the earliest flowering species, often making a striking display in recently burned grassland before the arrival of spring rains. At Cato Ridge, it appears to occur only in grassland on Natal Group sandstone.

I. sp. nov. A is closely related to *I. rubroglandulosa* Germishuizen but is "a lower growing, decumbent to ascending (less woody) form; it is distinguished by spreading, U-shaped hairs (i.e. a crisped strigose indumentum) along the stems, and the tips of the hairs spread beyond (i.e. are longer than) the short stem glands which are only visible below and scattered within the indumentum. Hairs are mostly appressed and the stem glands mostly visible above the indumentum (i.e. longer than the hairs) in *I. rubroglandulosa*. It also has fewer leaflets" (Dr Brian Schrire, pers. comm.).

44. *Indigofera sp. nov. B*, closely related to *I. hilaris* Eckl. & Zeyh, has leaflets that "are very narrow and sharply pointed and many times longer than wide, the leaves often ascending and hugging the stems" (Dr Brian Schrire, pers. comm.).

45. *Pachycarpus coronarius E.Mey.* Cato Ridge is the only locality north of the Pondoland Centre from which known (Smith1980, 1988). A remarkable seven species of *Pachycarpus* were found at Cato Ridge, with *P. coronarius* E.Mey only in grassland on Natal Group sandstone.

46. *Pachycarpus* sp. at Cato Ridge with identity not satisfactorily resolved. Although resembling *P. dealbatus* E.Mey. it differs in its s-shaped corona lobes, possibly making it an undescribed taxon (Dr Ashley Nicholas, pers. comm.).

Unfortunately, the small population was destroyed by grazing during the currency of the study, but not before material was lodged at the KwaZulu-Natal Herbarium.

47. *Phymaspermum pinnatifidum* (Oliv.) Kallersjo is cited as a KwaZulu-Natal Sandstone Sourveld endemic in Mucina & Rutherford (2006).

According to Hilliard (1977) it is known: "only from Umzinto to the Durban "between 600 and 900 m a.s.l." where it forms colonies in grassland over sandstone.

At Cato Ridge, it was only found in grassland on Natal Group sandstone, usually on south-facing aspects.

48. Although some difficulty was experienced in relating the varietal concepts of Codd (1985) back to material of *Plectrathus hadiensis* (Forssk.) Scweinf. ex. Spreng found at Cato Ridge, plants illustrated below were referred to *P. hadiensis* (Forssk.) Scweinf. ex. Spreng. var. *hadiensis*. They are quite common in very rocky grassland on both Dwyka Group tillite and Natal Group sandstone.

49. Plants referred to as *Plectranthus hadiensis* (Forssk.) Scweinf. ex. Spreng. *var. nov.* These plants are only found in skeletal soils upon and on the edges of Natal Group sandstone pavements and outcrops. They differ from *P. hadiensis* (Forssk.) Scweinf. ex. Spreng. *var. hadiensis* (which may occur in rocky grassland in deeper soils nearby) in smaller, more glaucous leaves and grown-out stems that have a longer decumbent habit. The inflorescences become longer and flowers more richly coloured purple.

50. *Schizoglossum peglerae* N.E.Br., (above and below left) is red listed as endangered. This is a very rare, small species known from only a handful of localities between Kentani and Nkandla (Kupicha 1994; Scott-Shaw 1999). At Cato Ridge two plants were found together in rocky grassland on Dwyka Group tillite and another elsewhere on Natal Group sandstone.

51. *Senecio albanopsis* (Hilliard) (below right), appears to be endemic to the Pondoland Centre and the KwaZulu-Natal coastal escarpment to the north (Hilliard 1977). At Cato Ridge, it may be locally common in rocky grassland on Natal Group sandstone although very rare on Dwyka Group tillite.

52. *Senecio albanopsis* (Hilliard) (below right), heads up to 20, with c. 8 rays each, calyculus bracts few and less than a quarter the length of the involucral bracts (Hilliard 1977).

53. *Senecio exuberans* R.A.Dyer (below), is an endangered species without ray florets known only from a small area between the Durban escarpment and Pietermaritzburg. It is also inconspicuous until it flowers in December and January. It is scattered throughout the Cato Ridge grasslands but is more frequent on Natal Group sandstone.

54. *Streptocarpus polyanthus* Hook. subsp. *polyanthus.* Although also occurring at forest margins, it is unusual in the genus in growing on protected, usually south-facing rock outcrops in open grassland.

According to Hilliard (1971), large-flowered plants consistent with the original depiction occur: "over a comparatively small area centering on Inchanga where thousands of plants grow in the shelter of sandstone outcrops on steep, grassy hillsides." However, nearly 50 years later this sight can no longer be seen due to degradation and destruction of grasslands in this area.