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Ecological factors determining the distribution patterns of *Cyrtanthus nutans* R.A.Dyer (Amaryllidaceae) in northwestern KwaZulu-Natal, South Africa

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Background: *Cyrtanthus nutans* R.A.Dyer is a range-restricted species occurring in northwestern KwaZulu-Natal, South Africa and in Eswatini, and is currently classified as Vulnerable in accordance with the IUCN criteria. Land transformation and disturbance of natural habitats have resulted in an ever-increasing fragmentation of the species' range.

Objectives: This manuscript provides a description of some of the abiotic and biotic factors associated with the remaining natural populations of *C. nutans* in the Sour Sandveld and Moist Tall Grassland Bioresource Groups of northwestern KwaZulu-Natal.

Methods: An investigation was conducted in the northwestern KwaZulu-Natal region to determine the effect that key ecological and anthropological determinants have in influencing the distribution and survival of the species. Data collected included sites of occurrence, estimated population numbers, elevation, ecological factors (soils/geology, climate, veld composition), and human/animal activities.

Results: The northwestern KwaZulu-Natal *C. nutans* populations were found to occur primarily in untransformed veld within the Moist Tall Grassveld, Dry Highland Sourveld and Sour Sandveld Bioresource Groups. It occurs largely on gradients of < 10% on mid- to lower terrain slopes and predominantly within an altitude range of between 1 100 and 1 300 m a.m.s.l.

Conclusion: *C. nutans* occurs in a narrow altitudinal range and has a preference for soils with high nitrogen and organic carbon and low phosphorus and acidity levels.

Keywords: autecology, Dundee fire lily, plant species distribution.

Introduction

Almost a quarter of the ± 20 700 vascular plant taxa indigenous to the Republic of South Africa are threatened with extinction or are of conservation concern (Von Staden et al. 2013; SANBI 2020). Almost all ecosystems in southern Africa have been modified or transformed by human activity (Macdonald 1989), and southern African plant diversity faces several pressures and multiple threats from both sustainable and unsustainable agricultural practices, urbanisation and mining in addition to the uncontrolled spread of alien invasive plants and illegal plant harvesting (Macdonald 1989; Scott-Shaw 1999). The east coast province of KwaZulu-Natal (KZN) is home to 5 261 vascular plant taxa, of which almost 14% are categorised as threatened or of conservation concern (SANBI 2020).

Cyrtanthus nutans R.A.Dyer (Amaryllidaceae), is a deciduous geophyte that reproduces vegetatively or by seed after a short spring flowering period. It is currently classified as Vulnerable B1ab(iii), according to the National Red List categories, with an extent of occurrence (EOO) of 6 067 km^2 in only four locations (SANBI 2020).

The first documentation of *C. nutans* in KZN was by Dr L.E. Codd in 1952, who collected the plants for cultivation. He found the plants and described them as abundant in an area of approximately 8 km^2 in the Vants Drift area (latitude 28° 10'S and longitude 30° 31'E), near Dundee. Two years later, Dyer (1954) formally recorded the presence of the plants and taxonomically described the species. The area of occurrence fell within what is now known as the Umzinyathi District Municipality (DM), and were subsequently found in a small area in the adjoining Uthukela DM. This comprises the study area, which extends over some 1 450 km^2.

Ten years later the species was located in Eswatini [Swaziland], on the hills around Mbabane above the Komati River, Piggs Peak, by Gordon McNeil (McNeil 1967; Reid & Dyer 1984) and has recently been documented as occurring in the mountains above Barberton, Mpumalanga, South Africa (SANBI 2020).

Distribution patterns of *C. nutans* were briefly described in the Dundee area in 2011 (Scott-Shaw 2011: pers. comm.). Indications were that the species was not as abundant as described in the 1952 Dyer report. The probable causes or factors for a reduction in population are not known. Furthermore, in 2006, the unsuccessful translocation of a *C. nutans* population from a housing development project in the Umzinyathi DM emphasised the lack of information on the specific habitat preferences of the plants. Following these events, informal observations of *C. nutans* were noted, which eventually led to annual Spring recordings of flowering plants, from 2012 onwards, of distribution sites in Dundee, KZN and surrounding areas. A formal re-evaluation of the Dundee *C. nutans* distribution was undertaken from 2014 onwards, which form the current study (Ruddle 2018).

Materials and methods

Study area description

The study area is characterised by relatively high elevations, sandy soils, sourveld grasslands and sparsely scattered paperbark thorn trees (*Vachellia sieberiana*). The Bioresource Groups (BRG) that occur in the area are Dry Highland Sourveld, Moist Tall Grassveld, Sour Sandveld and Mixed Thornveld (Camp 1999). The area is typically a summer rainfall region (October to March) with a long-term mean annual rainfall of 749 mm annum^{-1}. Long term annual rainfall records for the period 1968 to 2016 indicated that the highest and lowest annual recorded rainfall during this period occurred during 2012/2013 and 2014/2015 respectively and occurred during the study period (Agrometeorology 2019).

Data collection

Over a four-year period (2013–2016) during the spring months of September to mid-December, which covers the flowering period of *C. nutans*, areas within the district municipalities were randomly traversed by motor vehicle and on foot, identifying sites of occurrence. The number of flowering plants, latitude/longitude co-ordinates, altitude and gradient were recorded, and the presence or absence of fire/herbivores or human activities and land use were documented.

Vegetation species composition surveys were carried out at *C. nutans* sites according to a method described by Camp and Hardy (1999). A 50 × 50 m square was marked at each site. Within the square, a W-shaped path was traversed, using a sharp stick, of approximately 1.2 m in length, 50 spike-point observations were made. The nearest grass species to the point was identified and recorded.

Soil samples were taken at sites on the basis that no evidence of historical disturbance was noted but were a good representative of the known geology of the area. Using a Dutch auger, samples were taken at a depth of 0–30 cm (Sample A: topsoil, excluding organic material) and depth 30–60 cm (Sample B: sub-soil). The chemical soil analyses were carried out in accordance with standard practices (Manson & Roberts 2001) at the Cedara Feed and Soil Laboratory of the KwaZulu-Natal Department of Agriculture, Environmental Affairs and Rural Development, which is an accredited laboratory.

Data analysis

Co-ordinates of sites of *C. nutans* occurrence were mapped onto a 1:50 000 digital topographical map and Bioresource Group vegetation map (Ezemvelo KZN Wildlife 2009). The condition of the herbaceous component survey per site was compared with that of a benchmark site to calculate a veld condition per site (Camp & Hardy, 1999). A benchmark site is the most productive of its kind in terms of the highest possible sustained animal production within the Bioresource Groups (BRG) and are pre-described by Camp and Hardy (1999). Climatic data for the study were sourced from the Agricultural Research Council (ARC) (Agrometeorology 2019) weather station, based at the Dundee Research Station (Comp 30109).

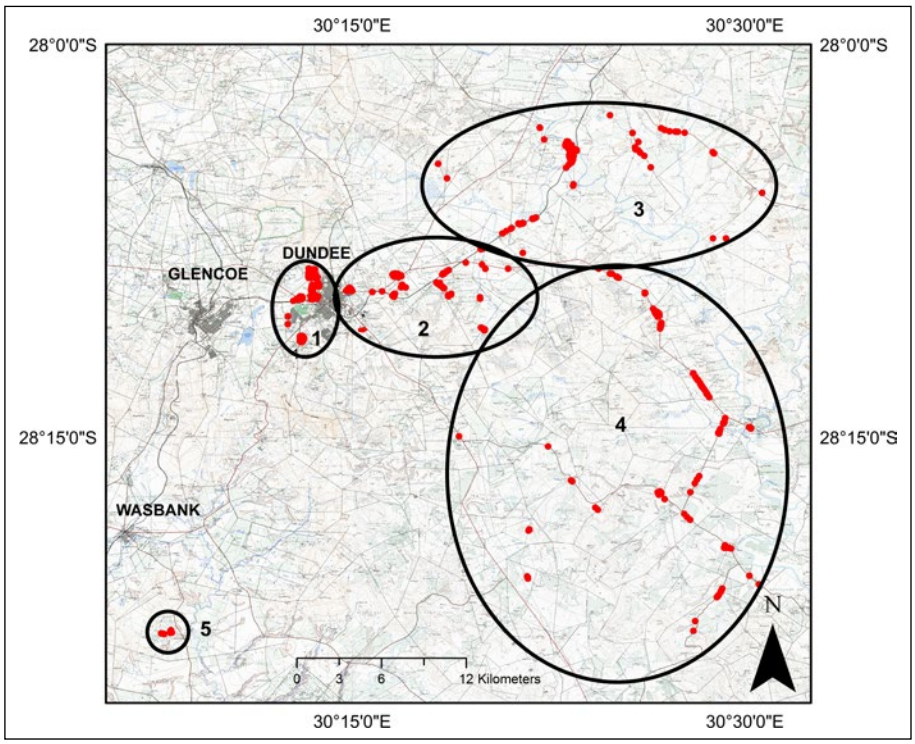

Figure 1. Range and distribution of *C. nutans* in five main areas within northwestern KwaZulu-Natal (Area 1 = Dundee central; Area 2 = eastern Dundee; Area 3 = northeastern Dundee; Area 4 = Rorkes Drift and Area 5 = Wasbank).

Results and discussion

Sites of occurrence

During the study period, a total of 27 sites, where *C. nutans* plants occurred, were found over an area of approximately 1 450 km^2. In Umzinyathi DM, plants were only located in two of the four Local Municipalities (LM); namely, Endumeni LM and Msinga LM. In Uthukela they were only located in the adjoining Indaka LM near Wasbank. The sites of occurrence were classified into five main groups, according to population densities and basic land use type; namely, Area 1 – urban; Area 2 – semi-urban/industrial/agriculture; Area 3 – semi-urban and agriculture; Area 4 – commercial agriculture; and Area 5 – mixed wildlife/cattle rangeland (Figure 1).

Description of sites of occurrence

Topography

The *C. nutans* populations were recorded at an altitude range of between 1 031 and 1 459 m a.m.s.l. in an area extending over 1 450 km^2. The great majority of plants (97.98%) occurred within the 1 100–1 300 m altitude range (Figure 2).

Slopes and gradients

Most of the *C. nutans* populations were found on relatively flat grassveld areas with gradients of less than 15° overall (mid- to foot slopes); 75% of the *C. nutans* populations were found on gradients of less than 10% with no preference for a particular facing slope.

Gradients play a fundamental role in water drainage and the subsequent formation of soils and nutrient deposits on the lower slopes (Gordon 2017; pers. com.). The soil fertility environment of *C. nutans* is not currently known, however established populations at certain sites may indicate its favourability for the species. Soil acidity levels, clay percentages and nutrient levels based on the soil sample readings, provide an indication of a favourable soil environment (Gordon 2017; pers. com.).

Geological and soil data

Soil sampling was undertaken in four of the five main areas indicated in Figure 1. The dominant parent rock at the sites was dolerite, with only two sites underlain with shale or sandstone (Table 1). Nitrogen levels

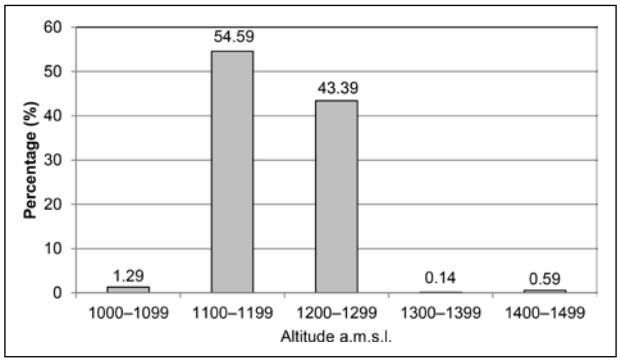

Figure 2. Percentage of *C. nutans* plants per 100 m a.m.s.l. altitude range.

Table 1. Site geological and soil data

Area		1	2	3	4	Mean values
Number of flowering plants counted		3 039	5 428	11 416	1 433	
Parent material	**Soil layer**	Dolerite/ shale	Dolerite/ shale	Dolerite sandstone	Sandstone	
Nitrogen N%	Topsoil	0.19–0.20	0.16–0.21	0.09–0.16	0.10	0.16
	Subsoil	0.10–0.15	0.11–0.12	0–0.050	0.03	0.1–0.22
Phosphorous P (mg L^{-1})	Topsoil	6–7	5–7	5–7	7	6
	Subsoil	5	3–5	5	5	5
Potassium K (mg L^{-1})	Topsoil	92–100	164–228	136–172	172	154
	Subsoil	36–55	118–133	109–113	133	102
Calcium Ca (mgL^{-1})	Topsoil	642–745	539–1 625	303–1 919	355	866
	Subsoil	553–757	488–1 901	175–2 738	245	953
Magnesium Mg (mg L^{-1})	Topsoil	249–278	185–836	102–1 496	136	481
	Subsoil	259–284	274–1106	71–1 867	115	627
Total Cations (cmol L^{-1})	Topsoil	5.97–6.43	5.13–15.46	2.88–22.31	3.47	8.86
	Subsoil	5.34–6.39	5.05–18.93	1.92–29.38	2.79	10.33
Acid saturation (%)	Topsoil	4–7	0–6	0–3	4	3.1
	Subsoil	2–6	0–1	0–9	10	3.5
pH (KCl)	Topsoil	4.1–4.5	4.1–5.2	4.6–5.1	4.3	4.5
	Subsoil	4.3–5.0	5.0–5.8	4.2–5.3	4.0	4.9
Clay (%)	Topsoil	22.0–50.0	20.5–29.5	15.0–34.5	18.5	27.3
	Subsoil	22.5–52.5	25.5–35.5	9.0–39.0	21.5	29.1
Organic Carbon (%)	Topsoil	2.05–2.86	1.68–2.63	1.77–1.78	0.9	1.98
	Subsoil	0.87–2.37	0.73–1.60	0.08–0.96	0.52	1.01

were high (>0.16%) in all except one site in Area 3, where subsoil nitrogen levels were too low to measure due to low organic carbon percentages. Low acidity (< 10% acid saturation), high organic carbon percentages (>1.8%) and tolerance of a wide range of textures (15 to 50% clay) and low phosphorous levels appears to be adequate for *C. nutans* plants.

Vegetation data

Cyrtanthus nutans were primarily found within the Moist Tall Grassveld (20% of plants counted) and Sour Sandveld (79% of plants counted) with minimal occurrence in Dry Highland Sourveld (1% of plants counted) (Figure 3).

The veld condition assessment for Area 5 was not conducted as further access to the property was unattainable. No clear picture arises from veld conditions compared with number of flowering plants counted since *C. nutans* was found in areas where veld conditions ranged from relatively low (22%) to relatively high (one site indicated a veld condition of 100%). A high percentage of sites (40–100%) had been burnt or grazed prior to plant emergence (Table 2).

Population size

Most of the flowering plants were located in Area 3 (53%) and Area 2 (25%), with fewer populations in Area 1 (14%), Area 4 (7%) and Area 5 (1%). As the study progressed, fewer new sites plant populations and flowering plants were identified (Table 3).

Anthropological influences

Large scale fragmentation of an already restricted range was evident with the distribution of *C. nutans*. Population sites were distributed primarily on the periphery

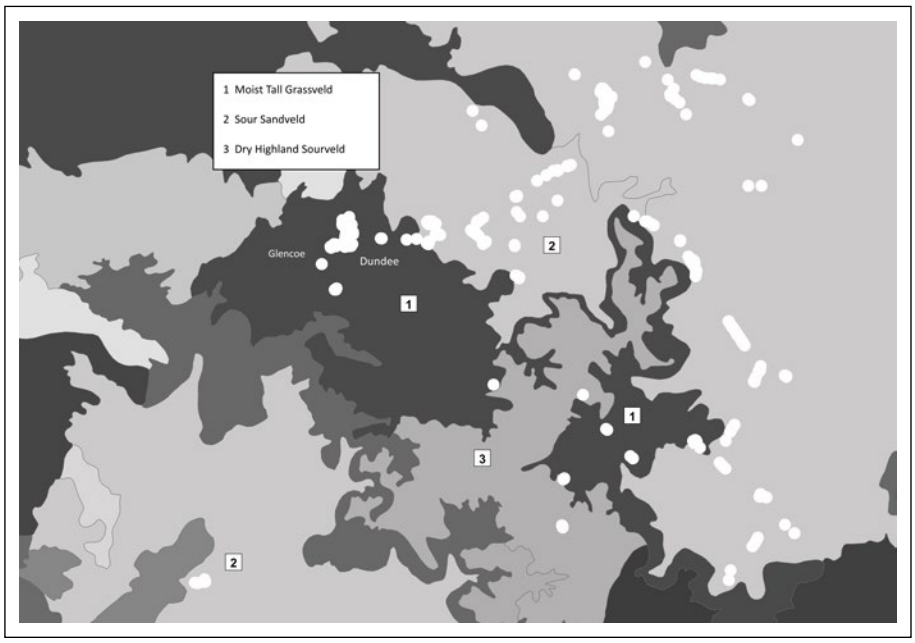

Figure 3. *C. nutans* sites located within the Bioresource Groups.

of arable land, in natural veld situated outside of fenced agricultural properties, along road reserves that had not been graded/cleared, and in the narrow band of railway reserves; these areas were not conducive to land transformation. Areas utilised for low intensity grazing over long-term periods were predominantly well populated with *C. nutans*. Only sites situated in Areas 1 and 2 (urban and semi-urban) indicated some form of human activity in terms of pedestrian and vehicular thoroughfares, dumping of building materials, graded road reserves and the subsequent damage to plants and habitat fragmentation resulting in smaller isolated pockets of plants.

Conclusions

Abiotic and biotic factors associated with the geographical distribution of *C. nutans* in the Sour Sandveld and Moist Tall Grassland Bioresource Groups of northwestern KwaZulu-Natal have been documented.

Table 2. Site vegetation information

Area	1	2	3	4	5
Number of flowering plants counted	3 039	5 428	11 416	1 433	92
Number of sites	7	8	6	5	1
Mean altitude (m.a.m.s.l)	1 253	1 234	1 195	1 233	1 036
Parent material	Dolerite/ shale	Dolerite/ shale	Dolerite/ sandstone	Sandstone	—
Bio-Resource Group	Moist Tall Grassveld	Moist Tall Grassveld	Sour Sandveld	Dry Highland Sourveld	Sour Sandveld
		Sour Sandveld		Moist Tall Grassveld	
				Sour Sandveld	
Veld condition (%)	40–100	22–60	40–62	44–63	—
Decreaser (%) range	3.8–70.6	0–29.8	0–29.1	0–24	—
Burnt (% of sites)	86%	63%	40%	80%	100%
Grazing activity (% of sites)	86%	75%	60%	40%	100%

Table 3. Population numbers and sites during the study period

	Number of population sites identified						Number of flowering plants identified					
	Area					Total	Area					Total
Year	1	2	3	4	5		1	2	3	4	5	
2013	7	6	1	2	0	16	2 987	1 467	2 146	126	0	6 726
2014	0	2	3	4	1	10	0	1 353	8 123	1 073	92	1 0641
2015	0	2	3	1	0	6	0	2 474	447	111	0	3 032
2016	1	2	1	2	0	6	52	134	700	123	0	1 009
Total	**8**	**12**	**8**	**9**	**1**	**38**	**3 039**	**5 428**	**11 416**	**1 433**	**92**	**21 408**

The species occurs within a narrow altitudinal range on relatively flat grasslands on predominantly dolerite parent rock in soils with moderate nitrogen and organic material, and low phosphorus and acidity levels. Land transformation in the Dundee area has resulted in the fragmentation of *C. nutans* populations into smaller isolated pockets. According to Von Staden (2013), the expansion of both urban and agricultural areas in the Dundee area has resulted in a 9% loss of habitat in the past 24 years and *C. nutans* is threatened by habitat degradation due to crop cultivation and overgrazing.

References

Agrometeorology (ARC-ISCW Agro-Climatology Data Base), 2019, *ARC-Institute for Soil, Climate and Water,* Pretoria, South Africa.

Camp, K.G.T. & Hardy, M.B., 1999, In: Hardy, M.B., & Hurt, C.R., 1999, *Veld in KwaZulu-Natal*, *Agricultural Production Guidelines for KwaZulu-Natal,* Pietermaritzburg: KwaZulu-Natal Department of Agriculture.

Camp, K.G.T., 1999, *A bioresource classification for KwaZulu-Natal*, South Africa.

Dyer, R.A., 1954, *Cyrtanthus. The Flowering Plants of Africa,* 30: t 1182.

Ezemvelo KZN Wildlife, 2009, *Bioresource topography maps,* Ezemvelo KZN Wildlife, Pietermaritzburg, South Africa.

Macdonald, I.A.W., 1989, Man's role in changing the face of southern Africa, in *Biotic Diversity in Southern Africa: Concepts and Conservation. Oxford University Press, Cape Town*, pp. 51–72.

Manson, A.D. & Roberts, V.G., 2000, *Analytical methods used by the soil fertility and analytical services section*. Republic of South Africa, Pietermaritzburg.

McNeil, G., 1967, 'A brief introduction to *Cyrtanthus'*, *Journal of the Royal Horticultural Society:* XCII (4), 180–183.

Reid, C., Dyer, R.A. & American Plant Life Society (La Jolla), 1984, 'A review of the southern African species of *Cyrtanthus'*, American Plant Life Society.

Ruddle, L.M., 2018, *Ecological characterisation and effects of fire and grazing on Cyrtanthus nutans (R.A.Dyer) in North-Western Kwazulu-Natal, South Africa*, Masters dissertation.

SANBI, 2020, *Statistics: Red List of South African Plants version 2020.1*, available at http://www.redlist.sanbi.org (Accessed: 13 August 2020).

Scott-Shaw, R., 1999, *Rare and threatened plants of KwaZulu-Natal and neighbouring regions*, KwaZulu-Natal Nature Conservation Service.

Von Staden, L., Raimondo, D. & Dayaram, A., 2013, Taxonomic research priorities for the conservation of the South African flora, *South African Journal of Science*, *109*(3-4), 1–10, https://doi.org/10.1590/sajs.2013/1182.