THE DISTRIBUTION, ECOLOGY AND CONSERVATION NEEDS OF *COLOBANTHUS CURTISIAE* WEST

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(with four tables and two text-figures)

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Colobanthus curtisiae is known from only 16 populations, most of less than 100 individuals, in the Midlands and Northeastern Highlands of Tasmania. The species occurs in phytosociologically diverse grassy vegetation from 160 m to 1300 m above sea level. This vegetation is rich in herbs and introduced plants, and has much bare ground. *C. curtisiae* germinants were observed in two grazed sets of permanent quadrats but were absent from ungrazed plots. The species is vulnerable to pasture improvement and land clearance and to the lack of disturbances which create bare ground. It requires protection and appropriare management in the lowland part of its range.
Key Words: ***Colobanthus curtisiae*, endangered plant, germination, grazing, threatened plant, Tasmania.**

INTRODUCTION

The dicotyledonous perennial herb *Colobanthus curtisiae* West was discovered by Rod Fensham in 1985 at Campbell Town Cemetery. This population was eliminated a week later in a cleanup. Several years later populations were located on a roadside at Tunbridge and from Ben Lomond National Park (Davies & Davies 1989), and the species was subsequently described from this material (West 1991). *C. curtisiae* is a Tasmanian endemic small rosette herb in the Caryophyllaceae. It resembles *C. apetala* but differs in its longer and narrower sepals and its colliculate testa patterning (West 1991). It is a grassland and grassy woodland plant. These ecosystems have suffered severe habitat destruction or degradation since the European invasion (Fensham & Kirkpatrick 1989, Fensham 1989, Gilfedder & Kirkpatrick 1995).

C. curtisiae is listed as endangered on both the national and state levels (Endangered Flora Network 1993; Flora Advisory Committee 1994).

This paper maps the known distribution of the species, places it in its environmental and phytosociological context, describes the germination behaviour of one lowland population, reports the responses of the species to different grazing regimes in three lowland populations and draws conclusions on the conservation needs of the species.

METHODS

Distribution, Phytosociology and Environment

Searches were made for additional populations of the species in apparently suitable habitats, the search pattern being modified as newly discovered populations revealed further aspects of its preferences. In some cases, additional populations were found in the course of other investigations. Floristic and site data were recorded for each located population. Quadrats measuring 1 × 10 m were subjectively placed in the least disturbed vegetation in which *C. curtisiae* occurred at each site, and all observable vascular plant taxa within the quadrat noted. Species nomenclature follows Buchanan (1995). Altitude, surface geology, soil surface pH (using a CSIRO soil-testing kit) and soil type were noted or measured in the field. The slope and aspect of each site were determined using a clinometer and compass respectively. Climatic data were derived for each site using the Bioclimatic Prediction System (Busby 1988).

The polythetic divisive technique TWINSPAN (two-way indicator species analysis) (Hill 1979) was used to obtain a sorted table. This table was then manually resorted to improve its organisation, with the aim of placing quadrats with similar species composition close together and species with similar quadrat distributions close together. This was necessary as TWINSPAN is a poor sorter of species and inverts the quadrat sequences on division.

The percentage frequencies of other vascular plant taxa in quadrats with *C. curtisiae* were determined, as were the percentage frequencies for all taxa occurring in the rest of the grassy ecosystem data set (Kirkpatrick *et al.* 1988). A list was made of those species that occurred in 10% or more of quadrats in either of the databases, the list being separated into those occurring more frequently with *C. curtisiae* and those occurring more frequently without *C. curtisiae*. These species were then classified into lifeform groups (shrub or tree; grass, graminoid, geophyte; herbs) and two origin groups (Tasmanian native; other).

Population Monitoring

Population numbers were monitored from 1990–94 at three low altitude locations (table 1) with different grazing management regimes. At Tunbridge, on a roadside which is used on a regular basis as a stock route and where the population numbers less than 50 individuals, seven permanent plots (0.5 × 0.5 m) were established within the population. At the South Esk River site, which is a heavily grazed native pasture with ± 1000 *C. curtisiae* individuals, two transect lines were placed through the population, and 23 contiguous quadrats measuring 0.5 × 0.5 m were monitored. A third population (<100 individuals) was monitored at a site on a Holocene lunette west of Campbell Town. This site had been previously grazed but stock had been excluded

TABLE 1
Localities with *Colobanthus curtisiae*

Locality	Altitude (m)	Geology	Tenure	Species richness	Dominant tree species
Ben Lomond	1300	sandstone	national park	20	above treeline
Buffalo Brook	300	sand	private	19	*Acacia mearnsii*
Campbell Town 1*	160	sand	private	n.a.	*Eucalyptus pauciflora*
Campbell Town 2	310	dolerite	private	26	*E. viminalis*
Campbell Town 3	200	basalt	cemetery	extinct	*E. pauciflora*
Fingal Tier	700	dolerite	state forest	20	*E. amygdalina*
Lagoon of Islands	760	dolerite	HEC	21	*E. obliqua*
Andover	430	sandstone	private	28	*E. pauciflora*
Near Lagoon	240	sand	private	17	*A. dealbata*
Ouse River	400	sandstone	private	10	*E. dalrympleana*
Shannon River 2	360	sandstone	private	14	*E. viminalis*
South Esk River*	180-240	dolerite	private	27	*E. pauciflora*
Shannon River 1	620	dolerite	private	10	*E. rubida*
Swanston	240	sandstone	private	15	*E. pauciflora*
Tunbridge*	240	dolerite	roadside	24	*E. rodwayi*
Valleyfield	n.a.	n.a.	private	n.a.	n.a.
Woodbury	n.a.	sandstone	private	n.a	*E. viminalis*

n.a. = not available.
* Sites where the species was monitored from 1990–94.

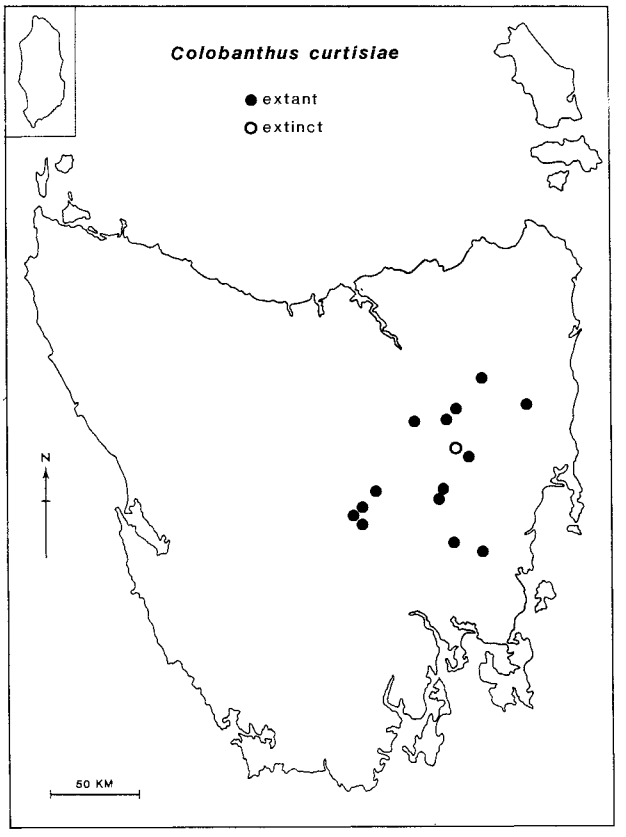

FIG. 1 — Extant and past localities for Colobanthus curtiseae

for several years. A 5 m transect line was placed through the population of *C. curtisiae* and 11 contiguous quadrats measuring 0.4 × 0.4 m were placed at 0.5 m intervals. The number of adult individuals, the number of recent germinants, the number of flowers per plant, and the Braun-Blanquet cover scale (Mueller-Dombois & Ellenberg 1974) for grasses, herbs, exotic plants and bare ground were recorded at yearly intervals. Data were converted to density per square metre.

Germination

Germination tests were conducted on seeds of *C. curtisiae* collected from the South Esk site on 12 February 1991. The seed was stored in bags at ambient room temperature. Germination tests were carried out by placing the seed on moist double layers of filter paper (Whatman No. 1) in 90 mm Petri dishes on 4 June 1991. For each trial there were five replicates of twenty seeds placed in randomised blocks. The seeds were checked twice daily and watered with distilled water when necessary, ensuring that the filter paper was maintained in a moist but not wet condition. The seed was germinated in an incubator in dark conditions, with the seeds being exposed to light when watered. Four temperatures were used for each replicate: 5°, 10°, 15° and 20°C. There was no pre-treatment.

RESULTS

Distribution, Phytosociology and Environment

C. curtisiae was found at 14 additional sites, and survives at two of the previously known sites (fig. 1, table 1). It occurs on gentle slopes between 160 and 1300 m (median = 310 m) in elevation in inland Tasmania. Mean annual rainfall varies

from 530 mm in the lowland Midlands area to more than 1400 mm on Ben Lomond, with a median of 607 mm. The mean temperature of the warmest month varies from 10.5° to 16.1°C, with a median of 15.1°C. The mean temperature of the coolest month varies from 1.6° to 6.5°C. Soils are predominantly sandy loams derived from sandstone or Holocene sands, but the species also occurs on clay loams derived from dolerite and basalt. Rock cover is absent at most sites. The median soil pH is 6 (range 4.5–8.5).

The median native species richness was 19/10m^2 (range 7–32). The median exotic species richness was 6/10m^2 (range 0–11). The median of Tasmanian endemic species richness was 1 (range 1–7).

The native species occurring in more than 40% of the quadrats with *C. curtisiae* were, in order from high to low co-occurrence: *Scleranthus biflorus, Carex breviculmis, Oxalis perennans, Acaena novae-zelandiae* and *Poa labillardierei.* Herbs and introduced taxa proved to have higher frequencies in the *C. curtisiae* data set than in the grasslands and grassy woodlands data set (table 2). The reverse pertained for grasses (table 2).

Bray-Curtis distance values (Minchin 1990) between quadrats varied from a high of 0.9070 between a lowland and an alpine quadrat to 0.2143 between two lowland quadrats. At least four groups of quadrats can be perceived in the sorted table (table 3), although the variation is more or less continuous. Group I is best characterised by the relatively faithful taxa in species group A. The most constant of these taxa are *Wahlenbergia* spp., *Danthonia carphoides* and *Plantago varia.* Group II has many highly faithful taxa, these being in species group C, but none of these is highly constant. Its constant species are *Aira caryophyllea, Oxalis perennans, Scleranthus biflorus, Acaena novae-zelandiae* and *Poa labillardierei.* The relatively faithful species in quadrat group III are in species group K. Of these, only *Elymus scabrus* has a high degree of constancy. Other constant species are *Poa labillardierei, Acetosella vulgaris, Scleranthus biflorus* and *Aira caryophyllea.* The Ben Lomond quadrats form group IV, which is best characterised by the highly faithful and constant *Plantago paradoxa* and *Senecio pectinatus.*

Population Monitoring

Between 1990 and 1994, *C. curtisiae* increased in density in the heavily grazed plots (South Esk), decreased in density in the intermittently grazed plots (Tunbridge) and changed little in the ungrazed plots (Campbell Town) (table 4). Successful establishment of germinants was observed from 1990–94 in the heavily grazed plots (table 4), with the number of new germinants being higher in 1994 than 1990. Germinants were also observed in the occasionally grazed plots, but only in 1994. No germinants were observed in the ungrazed plots. The density of flowers increased between 1990 and 1994 in the heavily grazed plots, while decreasing in the other plots. In 1994, the heavily grazed plots had a higher percentage cover of bare ground, herbaceous plants and exotic species than the other sites (table 4).

Germination

High germination levels of *C. curtisiae* were achieved at 5°C (73% of seed) and 10°C (69%) (figure 2), with only 2% of seeds germinating at 15°C and none at 20°C. Germination at 5°C was delayed until after day 30. The seed of *C. curtisiae* was observed in profusion in an ants nest at the South Esk site. Fifty to 100 seeds can be obtained per inflorescence.

DISCUSSION

C. curtisiae has a wide phytosociological and environmental range, suggesting that the cause of its rarity is not the lack of substantial areas of suitable physical environment, at least before the European invasion. Our data from one lowland site indicate that *C. curtisiae* is an easily germinated species with a large seed output, suggesting that reproductive problems are also unlikely to be a cause of its rarity. Our permanent plot observations suggest that it is able to survive and successfully regenerate with a level of stock grazing which renders other threatened taxa of grassy ecosystems, such as *Lepidium hyssopifolium* and *Barbarea australis*, locally

TABLE 2
Composition of lifeform groups associated with *Colobanthus curtiseae**

Lifeform group	More common with *C. curtiseae*		Less common with *C. curtiseae*	
	Observed	Expected†	Observed	Expected†
Trees and Shrubs	5	7	10	8
Grasses	8	12	18	14
Graminoids	5	6	7	6
Geophytes	2	3	4	3
Herbs	37	29	23	31
Introduced species	17	10	4	11

* The number of species in different lifeform and origin groups that are more frequent in vegetation with *C. curtiseae* than in Tasmanian grasslands and grassy woodlands and vice-versa. Only species occurring in more than 10% of the quadrats in at least one of the data sets are included.
† As in Chi-squared.

TABLE 3
Sorted table for quadrats with *Colobanthus curtisiae*

Group	I	II	III	IV
	1 1 1	1 1	1 1	11
Quadrat (1)	127	85694480	31327	56
A				
+Schoenus absconditus	11-	1----1--	-----	--
Wahlenbergia spp.	111	---1----	-----	--
Danthonia carphoides	111	---1----	-----	--
Plantago varia	111	1-------	----1	--
Pentapogon quadrifidus	-11	--------	-----	--
Convolvulus erubescens	-11	--------	-----	--
Wahlenbergia stricta	-11	--------	-----	--
Hibbertia riparia	-11	--------	-----	--
Lissanthe strigosa	-11	--------	-----	--
**Trifolium glomeratum*	-11	--------	-----	--
Stipa semibarbata	-11	--1-----	-----	--
Wurmbea dioica	-11	--1-----	-----	--
Acaena ovina	-11	--1-----	-----	--
B				
Hypoxis glabella	1--	1---1---	1----	--
**Briza minor*	-1-	1-1-1---	-----	--
Dichondra repens	-11	--1--1--	----1	--
Themeda triandra	-11	1--11--1	-----	--
Leptorhynchos squamatus	-11	1-1-1--1	-----	--
Chrysocephalum apiculatum	-11	1--11--1	1----	--
Poa hookeri	-11	--1-----	11---	--
C				
Lomandra nana	---	-11-----	-----	--
**Centaurium erythraea*	---	1-1-----	1----	--
Astroloma humifusum	---	--11----	1----	--
**Parentucellia viscosa*	---	--1-1--1	-----	--
**Trifolium subterraneum*	---	--1-1--1	-----	--
Hovea linearis	---	--1-1--1	-----	--
**Plantago coronopus*	---	--1-11-1	-----	--
**Bromus mollis*	---	--1-1-1-	-----	--
Ehrharta stipoides	---	--1111-1	1----	--
Lomandra longifolia	---	--1-11-1	1--1-	--
**Trifolium pratense*	---	----1--1	-----	--
**Cerastium glomeratum*	---	---1--11	-----	--
**Erophila verna*	---	----1-11	-----	--
**Aphanes arvensis*	1--	----1-11	-----	--
Pimelea humilis	-1-	---11---	----1	--
Crassula sieberiana	-1-	----11--	-----	--
Gnaphalium collinum	1--	-----11-	-1---	--
D				
**Moenchia erecta*	---	--1-----	1----	--
+Hibbertia hirsuta	---	---1----	1----	--
E				
Cotula alpina	1--	--------	-----	-1
Hydrocotyle sibthorpioides	1--	--------	-----	-1
Baeckea gunniana	1--	--------	-----	1-
Euchiton traversii	1--	--------	-----	1-
Gonocarpus tetragynus	1--	--------	----1	--
Carex inversa	-1-	--------	----1	--
F				
**Hypochoeris radicata*	11-	111-1--1	11-1-	--
**Aira caryophyllea*	111	11111111	111-1	--
Oxalis perennans	-11	-1111111	11--1	--
**Trifolium dubium*	-11	11--1-11	11--1	--
Scleranthus biflorus	-11	11-11111	11111	--
G *Hypericum gramineum*	-11	--1-----	-1-11	--
**Leontodon taraxacoides*	-11	---1-1--	11--1	--
H				
+Colobanthus curtisiae	111	11111111	11111	11
Carex breviculmis	111	--1-1111	-1-11	11
I				
Acaena novae-zelandiae	---	1-1111-1	--111	1-
Poa labillardierei	---	--111111	1-111	-1
**Acetosella vulgaris*	-1-	----1111	11-11	--
J				
Pteridium esculentum	---	-1------	---1-	--
Ajuga australis	---	------1-	----1	--
Danthonia pilosa	---	--1-----	----1	--
**Lagenifera stipitata*	---	--1-----	----1	--

Group	I	II	III	IV
	1 1 1	1 1	1 1	11
Quadrat (1)	127	85694480	31327	56
K				
Elymus scabrus	-11	--------	11-11	--
Daviesia ulicifolia	---	--------	11---	--
Pultenaea pedunculata	---	--------	1-1--	--
Luzula spp.	---	------1-	111--	--
Juncus spp.	---	--------	111--	--
Geranium sessiliflorum	---	--------	-11--	--
Schoenus apogon	---	--------	--11-	--
Lagenifera huegelii	---	------1-	-1-1-	--
**Anthoxanthum odoratum*	---	-----1--	-1--1	--
Acaena echinata	---	--------	-1--1	--
Veronica gracilis	---	---1----	-1-1-	--
**Holcus lanatus*	---	--1-----	-1-11	--
Geranium solanderi	---	--1----1	--111	--
L				
Epilobium spp.	---	--------	--111	11
Ranunculus lappaceus	---	--------	----1	1-
Oreomyrrhis eriopoda	---	--------	----1	-1
M				
Senecio pectinatus	---	--------	-----	11
+Plantago paradoxa	---	--------	-----	11

Species occurring in only one quadrat

11: *Agrostis parviflora, Cardamine spp., +Eucalyptus amygdalina, Hydrocotyle capillaris, +Lomatia tinctoria, Poa rodwayi, Veronica calycina, Viola cleistogamoides, Wahlenbergia gracilenta*
2: *Carex iynx, Ptilotus spathulatus, Stipa mollis, Stipa scabra, *Vulpia myuros*
17: *Danthonia laevis, Danthonia setacea*
5: **Erodium cicutarium*
6: *+Australopyrum pectinatum, Microtis spp., Thelymitra spp.*
9: *Danthonia caespitosa, Hibbertia serpyllifolia, Lepidosperma gunnii, Opercularia ovata, Opercularia varia, Wahlenbergia gymnoclada*
14: **Bromus diandrus, Carex tasmanica*
4: *Eucalyptus pauciflora*
8: *Callitriche umbonata, *Cirsium vulgare, Luzula flaccida, *Myosotis discolor, *Stellaria media*
10: **Cardaria draba, *Hypochoeris glabra*
13: *Banksia marginata, Hibbertia prostrata*
1: *Asperula conferta, Galium spp., Taraxacum aristum*
3: *Asperula gunnii, Eucalyptus rubida, Juncus australis*
12: **Agrostis capillaris, *Cerastium fontanum, *Trifolium repens*
7: *Arthropodium milleflorum, Epilobium hirtigerum, Glycine spp., Isolepis nodosa, Linum marginale, *Petrorhagia prolifera, Poranthera microphylla, Pratia pedunculata, Pratia spp., Senecio glomeratus, Viola hederacea*
15: *Drosera arcturi, Eriostemon verrucosus, Geranium potentilloides, Gonocarpus serpyllifolius, Helichrysum rutidolepis, +Leptospermum rupestre, +Monotoca empetrifolia, +Orites acicularis, Poa gunnii, Poa costiniana, +Richea acerosa, +Richea gunnii, *Taraxacum officinale*
16: *Agrostis venusta, Bellendena montana, Carpha alpina, Deyeuxia monticola, Leucopogon hookeri, Microseris lanceolata, Ranunculus decurvus, Ranunculus sessiliflorus, Senecio gunnii*

* = introduced species
\+ = Tasmanian endemic species
(1) read quadrat numbers vertically

TABLE 4
Mean and standard error of *Colobanthus curtisiae* and ground cover types per square metre under different management regimes

Location	1990	1994
C. curtisiae/m^2		
South Esk R.	176.9 ± 42.2	278.0 ± 59.8
Tunbridge	143.8 ± 86.9	38.4 ± 11.6
Campbell Town	30.1 ± 15.5	40.9 ± 12.9
new germinants/m^2		
South Esk R.	2.45 ± 1.09	8.70 ± 1.79
Tunbridge	0	2.68 ± 1.86
Campbell Town	0	0
flowers/m^2		
South Esk R.	284.0 ± 62.7	470.4 ± 95.4
Tunbridge	25.0 ± 25.0	1.8 ± 1.8
Campbell Town	137.5 ± 44.3	61.9 ± 28.7
percentage cover of grass (Braun-Blanquet+)		
South Esk R.	3.17 ± 0.16	3.26 ± 0.18
Tunbridge	3.00 ± 0.38	3.57 ± 0.37
Campbell Town	3.82 ± 0.23	4.45 ± 0.34
percentage cover of herbs (Braun-Blanquet)		
South Esk R.	4.04 ± 0.25	3.91 ± 0.22
Tunbridge	3.86 ± 0.34	3.71 ± 0.52
Campbell Town	3.55 ± 0.28	2.27 ± 0.19
percentage cover of bare ground (Braun-Blanquet)		
South Esk R.	3.13 ± 0.25	3.87 ± 0.22
Tunbridge	1.71 ± 0.52	1.29 ± 0.29
Campbell Town	3.18± 0.38	2.91 ± 0.21
percentage cover of exotic species (Braun-Blanquet)		
South Esk R.	3.26 ± 0.20	3.22 ± 0.21
Tunbridge	0.86 ± 0.34	1.29 ± 0.18
Campbell Town	3.18± 0.18	2.18 ± 0.23

1 = <1% cover, 2 = 2-5% cover, 3 = 6-25% cover, 4 = 26-50% cover, 5 = 51-75% cover, 6 = 76-100% cover

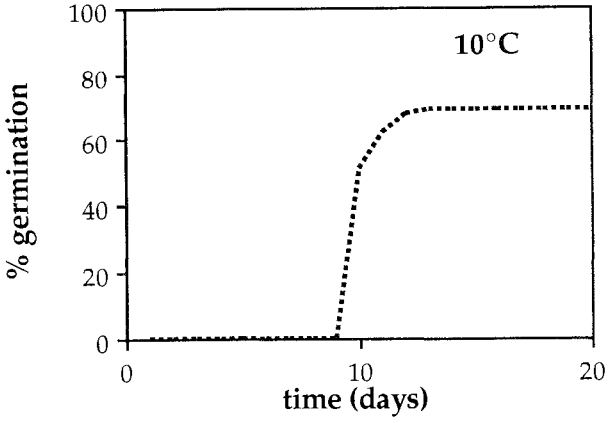

FIG. 2 — Germination curve for Colobanthus curtiseae *at 10°C*

extinct (Cropper 1987; Gilfedder 1994). However, these observations also indicate that bare ground may be necessary for its regeneration. Heavy cattle and sheep grazing provide this bare ground through much of its present range, while in some parts of its range, such as the Tunbridge Tiers Stock Route, individuals regenerate in the bare patches associated with tree roots.

The very limited present distribution of the species is almost certainly due to the loss of most of the Tasmanian grassland and grassy woodland on non-rocky soils within its range to improved pasture and cropland (Fensham & Kirkpatrick 1989). This loss is on-going (Kirkpatrick 1991), so the species deserves to be regarded as endangered, especially given that most of the 16 surviving populations consist of less than 100 individuals.

The major surviving lowland populations of the species need to be protected from pasture improvement and land clearance by mechanisms such as covenanting, management agreements or reservation. Where areas supporting populations have been heavily grazed by stock, it would be prudent to ensure that this form of disturbance continues.

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