Survey of a newly discovered population of *Myosotis colensoi* at a previously undescribed limestone site in Castle Hill Basin, Canterbury

Debra M. Wotton[1, 2] and Jane Gosden[2]

[1]Moa's Ark Research, Paraparaumu, New Zealand. Email: debra.wotton@moasark.co.nz

[2]University of Canterbury, Christchurch, New Zealand. Email: jane.gosden@pg.cantebury.ac.nz

Introduction and methods

Eastern South Island limestone ecosystems are unique hotspots of native plant evolution and diversity (Heenan & Rogers 2019). Their flora includes many herbaceous limestone endemics and a disproportionately high number of threatened species (Heenan & Rogers 2019). Nationwide, almost half (47%) of the specialist limestone taxa are classified as Threatened or Data Deficient; in the eastern South Island, this jumps to an alarming 74% (Rogers et al. 2018). Despite their high biodiversity values, few eastern South Island limestone sites are legally protected or managed for conservation. Quarrying, agricultural modification (including grazing and trampling by livestock as well as oversowing and topdressing), invasion by pests and weeds, and clearance and burning of native forest and shrubland have all contributed to a decline in their ecological integrity. Consequently, many limestone plant taxa in the eastern South Island have undergone dramatic declines in recent decades.

The limestone ecosystems in Castle Hill Basin (Kura Tāwhiti), Canterbury, are physically diverse, including screes and talus, boulder fields, cliffs, scarps, and tors. These ecosystems provide habitat for a diverse flora, including species found nowhere else (McCaskill 1982; Heenan & Molloy 2019). Several limestone sites in Castle Hill Basin are on Public Conservation Land. These include Lance McCaskill Nature Reserve, Kura Tāwhiti Conservation Area, Cave Stream Scenic Reserve, Prebble Hill Scenic Reserve, and Spittle Hill Conservation Area. Nevertheless, large areas of limestone in Castle Hill Basin occur on private or pastoral leasehold land with no protection (e.g., Flock Hill and Gorge Hill). While botanical surveys of limestone ecosystems in Castle Hill Basin date back more than a century (e.g., Wall 1920), some sites remain poorly described.

Myosotis colensoi is a Nationally Critical (de Lange et al. 2018) limestone endemic herb, which has a disjunct distribution in Marlborough and Canterbury (Heenan & Rogers 2019). In Marlborough, *M. colensoi* is confined to Ben More and the Chalk Range (Druce & Williams 1989). In Canterbury, this species is found mostly in Castle Hill Basin with one site near Lake Coleridge. Present-day populations are known from Lance McCaskill Nature Reserve (Wotton 2021), Flock Hill (DMW, pers. obs.), and near Lake Coleridge (CANU 35835; David Norton, pers. comm.).

On 3-4 November 2022, we surveyed a previously undescribed limestone site in Craigieburn Forest Park, Castle Hill Basin, Canterbury. This limestone formation is unnamed, so we have called it "Waterfall Bluff" after the creek that runs below (Figure 1). Our survey focused on *M. colensoi*, which we discovered during this trip, but we also searched for other limestone endemics and threatened species and recorded all vascular plant species we encountered. We counted all *M. colensoi* plants we found, and noted the number of plants that were flowering. We recorded GPS waypoints for individuals or groups of adjacent *M. colensoi* plants. We spent ca. 6 hours at the site, with most time spent in the area where *M. colensoi* plants occurred.

Results

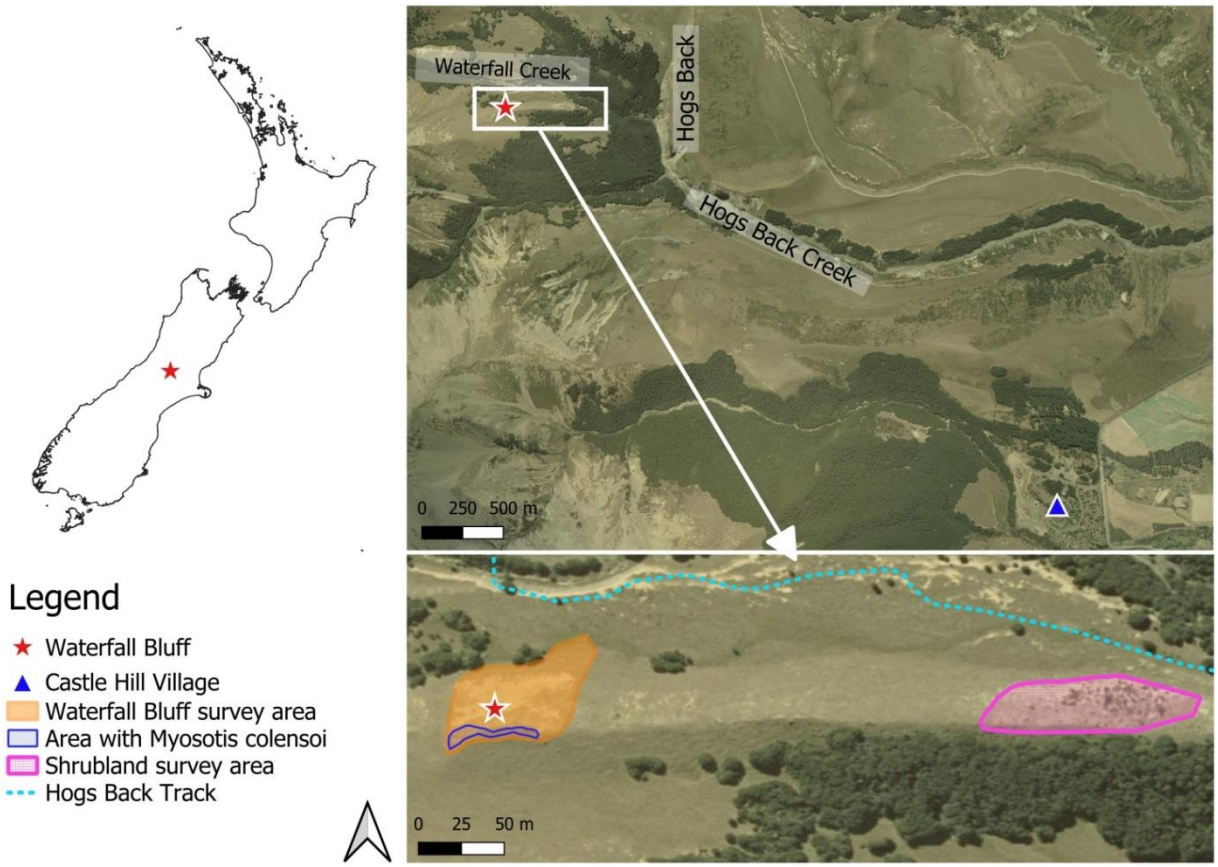

Figure 1. Site map indicating the location of the *M. colensoi* population and vegetation survey areas at the main bluff (Waterfall Bluff) and shrubland.

Limestone formation

Limestone rocks form a steep ridge running from east to west, directly above Waterfall Creek (Figures 1 (above] and 2, p. 48). These rocks have a blocky, fractured structure. There are two bluffs – the larger ("main bluff") is at the western end of the ridge, and a second shallower and less defined bluff occurs towards the eastern end ("eastern bluff" and shrubland site; Figure 3, p. 48). Both bluffs have exposed, blocky limestone talus interspersed with soil on the steep north-facing slopes below. Smaller, scattered limestone rocks are exposed along and below the ridgeline.

Figure 2. View of Waterfall Bluff (middle distance) from Hogs Back Track, Craigieburn Forest Park, Castle Hill Basin, Canterbury. The main bluff (red arrow) is at the far right of the ridge, and the shrubland is in the open talus area on the steep slope on the left below another bluff (yellow arrow). Photo: Jane Gosden.

Figure 3. The main limestone formation at Waterfall Bluff, Castle Hill Basin, Canterbury, with a steep talus slope below. Photo: Debra Wotton.

All the *M. colensoi* plants we found were at the main bluff at the western end of the ridge. On the bluff face, plants were found only between c. 0.4–2.5 m up the rock face, either growing in crevices or on ledges. Most plants were growing on the bluff top or its periphery, either in crevices or in shallow limestone gravel soils.

Vegetation

On the main bluff, *M. colensoi* was the second most frequent native plant species, surpassed in abundance only by *Poa colensoi* (Table 1, p. 52). Shrub cover on the main

bluff was rare, consisting of fewer than five adult *Coprosma propinqua* plants. The limestone talus below the main bluff had few native plant species with hard tussock (*Festuca novae-zelandiae*) being the most common, and scattered weeds, including oxeye daisy (*Leucanthemum vulgare*). A sole mountain wineberry (*Aristotelia fruticosa*) was noted at the base of the talus. Several charred tree stumps occurred on the talus slope below the main bluff. We have not identified the tree species these stumps belonged to, but it may have been mountain beech (*Fuscospora cliffortioides*), which grows adjacent to this slope and covers the eastern end of the Waterfall Bluff limestone ridge.

The limestone ecosystem and *M*. *colensoi* population at Waterfall Bluff are threatened by non-native weeds, especially chewings fescue (*Festuca rubra* subsp. *commutata*) and tussock hawkweed (*Hieracium lepidulum*). Chewings fescue formed a sward around the base of the main bluff but was less abundant here than in other areas. Both chewings fescue and tussock hawkweed had invaded the main bluff itself, although weeds were much less abundant than elsewhere.

Along the Waterfall Bluff ridgeline, native plants were concentrated among smaller rocks, in crevices and on adjacent shallow, gravelly limestone soil (Table 1). Chewings fescue formed a dense sward along the ridge.

The talus slope beneath the eastern bluff had a diverse community of native shrubs including *Pittosporum divaricatum*, *Coprosma pseudocuneata*, C. *propinqua*, *A*. *fruticosa*, and *Phyllocladus alpinus* (Table 1). Some of these shrubs had gnarly and extremely thick trunks, suggesting they were unusually old.

Discussion

To our knowledge, this is the first record of *M*. *colensoi* at Waterfall Bluff. We checked herbarium records, searched the literature, and confirmed this with several botanists with limestone expertise in Canterbury (Nick Head, Alice Shanks, and Peter Heenan, pers. comm. November 2021; David Norton, pers. comm. July 2023). Prior to our survey, there also appears to have been no botanical surveys or plant observations reported for Waterfall Bluff, including a complete absence of iNaturalist observations (https://inaturalist.nz/, accessed 3 November 2022). This is somewhat surprising, as the limestone rocks here have been mapped (Heenan & Rogers 2019), and they are close to a publicly accessible track (although the track was opened only in 2012).

We found an historic record of *M*. *colensoi* in this general area, collected by Walter Brockie (Allan Herbarium, CHR 73467). This specimen has no collection date but was probably collected sometime between 1928 and 1947, when Brockie was working at the Christchurch Botanic Gardens (McCaskill 1982). Brockie states the location of his collection as "head of Hogs Back Creek" and given the scant details on the collection this could mean the plant came from Waterfall Bluff as it is in the vicinity of the Hogs Back ridge and creek. Older herbarium specimens tend to have very generalised locality information on them. While the soils and limestone rocks of Hogs Back and Waterfall Bluff have been described (Speight 1935, O'Connor 1961), we could find no published surveys of the flora at either site. Speight (1935) reported that "a considerable area of bush has, unfortunately, been destroyed by fire" at Waterfall Bluff and Hogs Back, sometime between 1919 and 1933. The charred tree stumps we observed may be remnants from this

Figure 4. *Myosotis colensoi* (Castle Hill forget-me-not) in flower at Waterfall Bluff, Castle Hill Basin, Canterbury in November 2022, with Craigieburn Range in the background. The limestone ecosystem is threatened by invading weeds: chewings fescue (*Festuca rubra* subsp. *commutata*), tussock hawkweed (*Hieracium lepidulum*) and field chickweed (*Cerastium arvense*) can all be seen in this image. Photo: Debra Wotton.

fire and, alongside Speight's (1935) report, show forest and shrubland was previously more extensive at Waterfall Bluff.

The *M. colensoi* population at Waterfall Bluff might be slightly larger than our count, due to the possibility of additional plants that were either overlooked or inaccessible. While the population appears healthy, it is unclear whether recruitment is occurring. Confirmation of recruitment is needed to assess whether the population is self-sustaining, and hence will persist at the site long-term. We found only adult plants, but seedlings would have been difficult to detect at the time of our survey in early November. In Canterbury, *M. colensoi* seedlings apparently emerge in spring (Wotton 2021). In early November, any *M. colensoi* seedlings would have been tiny, with only cotyledons present, and seedlings can also occasionally emerge later in the season (Wotton 2021). Future monitoring at Waterfall Bluff should search for *M. colensoi* seedlings to confirm whether recruitment is occurring at this site.

Myosotis colensoi plants at Waterfall Bluff were much smaller than those at nearby Lance McCaskill Nature Reserve and Flock Hill (DMW & JG, pers. obs.), and appear more similar in size to plants in Marlborough, which usually have only a few rosettes (Heenan & Rogers 2019). However, plants at Waterfall Bluff have lanceolate leaves (this study) like other populations in Castle Hill Basin, while those in Marlborough have elliptic leaves (Heenan & Rogers 2019).

Myosotis colensoi – and the entire Waterfall Bluff limestone ecosystem – is threatened by non-native weeds, especially chewings fescue (which forms dense and extensive swards)

and, to a lesser extent, tussock hawkweed (which occupies crevices in limestone rocks that may otherwise be occupied by *M. colensoi*; Figure 4). *Myosotis colensoi* plants occurred only in those areas where weeds were sparse. *Myosotis colensoi* probably occurred more widely on the Waterfall Bluff limestone formation in the past, in areas where weeds are now abundant (e.g., along the ridge). Other limestone endemics may also have occurred here prior to widespread weed invasion. Non-native grass swards are even denser along nearby Hogs Back (DMW & JG, pers. obs.), but it is possible that *M. colensoi* and/or other limestone endemics are still present in localised areas where weeds are sparser.

A longer-term threat to the *Myosotis* population on Waterfall Bluff is the presence of European Broom (*Cytisus scoparius*) in the wider area. We noted several patches of establishing European broom along the Hogs Back Track between the Cheeseman Road end and Waterfall Bluff. It is likely that track users (walkers and mountain bikers) are aiding in the spread of this species into parts of Castle Hill Basin where it has not been recorded previously. Another potential vector of broom seeds is in the track gravels themselves.

Native shrubland and forest previously surrounded lowland and montane limestone sites but this has largely been replaced by non-native vegetation dominated by sward-forming grasses (Heenan & Rogers 2019). Waterfall Bluff provides a unique insight into this lost woody vegetation. Only pockets of remnant tree and shrub species exist on limestone in Castle Hill Basin, and it appears that Waterfall Bluff may hold some of the oldest and more diverse shrublands – although further survey work is required to confirm this. The presence of *P. alpinus* amongst the shrublands makes Waterfall Bluff a particularly interesting site. The discovery of a previously unknown (or forgotten) *M. colensoi* population with more than 100 plants is also an important find, especially for the management of a Critically Endangered plant on Public Conservation Land.

Acknowledgements

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Table 1. Vascular plant species found at Waterfall Bluff. **Key to abbreviations:** Occ, Occassional, Ab, Abundant; NT, Not Threatened; AR-D, At Risk – Declining; T-NC, Threatened – Nationally Critical

Species	**Common name**	**Water-fall Bluff**	**Shrub-land**	**Status**
Acaena caesiiglauca	Piripiri	Occ	Rare	NT
Acaena species	Piripiri	-	Rare	-
Acinos arvensis	Basil thyme	Occ	-	Exotic
Acrothamnus colensoi	-	Occ	-	NT
Agrostis capillaris	Brown top	Ab	-	Exotic
Anaphalioides bellidioides	Hell's bells	Rare	-	NT
Anthoxanthum odoratum	Sweet vernal	Ab	-	Exotic
Arenaria serpyllifolia	Sandwort	-	Occ	Exotic
Aristotelia fructicosa	Mountain wineberry	Occ	Occ	NT
Austroblechnum penna-marina subsp. *alpina*	Alpine hard fern	Occ	-	NT
Austrolycopodium fastigiatum (*Lycopodium fastigiatum*)	Alpine clubmoss	Occ	-	NT
Brachyglottis haastii	-	Occ	Rare	NT
Carex coriacea	Rautahi	Ab	-	NT
Carex edura	Hook sedge	Rare	-	NT
Celmisia gracilenta	Pekapeka	Occ	-	NT
Celmisia lyallii	False speargrass	Rare	-	NT

Celmisia spectabilis subsp. *spectabilis*	Tikumu, common mountain daisy	Occ	-	NT
Centaurium erythraea	Centaury	Occ	Rare	Exotic
Cerastium arvense	Field chickweed	Rare	-	Exotic
Cerastium fontanum	Mouse ear chickweed	Occ	Occ	Exotic
Chionochloa rubra subsp. *cuprea*	Copper tussock	Occ	-	NT
Cirsium arvense	Californian thistle	Rare	-	Exotic
Clematis petriei	-	Rare	Rare	NT
Colobanthus strictus	-	Rare	Rare	NT
Coprosma propinqua	-	Occ	Ab	NT
Coprosma pseudocuneata	-	-	Occ	NT
Cystopteris tasmanica	Bladder fern	-	Rare	
Discaria toumatou	Matagouri	Rare	-	AR-D
Dracophyllum pronum	Trailing neinei	Occ	-	NT
Dracophyllum rosmarinifolium	Inaka	Rare	-	NT
Festuca novae-zelandiae	Hard tussock	Ab	Ab	NT
Festuca rubra subsp. *commutata*	Chewings fescue	Ab	Ab	Exotic
Fuscospora cliffortioides	Mountain beech	Occ	Occ	NT
Gaultheria depressa var. *novae-zelandiae*	Snowberry	Ab	-	NT
Geranium brevicaule	-	Occ	-	NT
Hieracium lepidulum	Tussock hawkweed	Occ	-	Exotic
Holcus lanatus	Yorkshire fog	Ab	-	Exotic
Hyprochaeris radicata	Catsear	Occ	-	Exotic
Juncus effusus var. *effusus*	Soft rush	Occ	-	Exotic
Leucanthemum vulgare	Oxeye daisy	Occ	Occ	Exotic
Linum catharticum	Purging flax	Occ	Occ	Exotic
Luzula rufa var. *rufa*	Red woodrush	Rare	-	NT
Melicytus aff. *alpinus* "Blondin"	-	-	Rare	NT
Melicytus alpinus	Porcupine shrub	Rare	Rare	NT
Microtis uniflora	Onion-leaved orchid	Rare	-	NT
Muehlenbeckia axillaris	Creeping pōhuehue	-	Occ	NT
Myosotis colensoi	Castle Hill forget-me-not	Occ	-	T-NC

Nertera balfouriana	-	Rare	-	NT
Ourisia caespitosa	Creeping mountain foxglove	Rare	-	NT
Ozothamnus leptophyllus	Tauhinu	Ab	-	NT
Phyllocladus alpinus	Mountain toatoa	-	Rare	
Pilosella officinarum	Mouse-ear hawkweed	Ab	Ab	Exotic
Pilosella praealta	King devil	Occ	Occ	Exotic
Pittosporum divaricatum	-	-	Rare	
Poa cita	Wī	Ab	Rare	NT
Poa colensoi	Blue tussock	Ab	-	NT
Podocarpus nivalis	Snow tōtara	-	Rare	
Polystichum vestitum	Punui	Rare	-	NT
Prunella vulgaris	Self-heal	Rare	-	Exotic
Ranunculus reflexus	Kopukapuka	Rare	-	NT
Raoulia subsericea	Turf mat daisy	Occ	-	NT
Rosa rubiginosa	Sweet brier	-	Rare	
Rumex acetosella	Sheep's sorrel	Occ	-	Exotic
Schoenus pauciflorus	Bog rush	Ab	-	NT
Styphelia nesophila	Pātōtara	Occ	-	NT
Taraxacum officinale	Dandelion	Occ	Occ	Exotic
Thelymitra sp.	Sun orchid	Occ	-	NT
Trifolium repens	White clover	Occ	-	Exotic
Verbascum thapsus	Woolly mullein	Occ	Occ	Exotic
Verbascum virgata	Moth mullein	Rare	-	Exotic
Vittadinia australis	White fuzzweed	Rare	-	NT
Wahlenbergia albomarginata subsp. *albomarginata*	Harebell	Rare	-	NT