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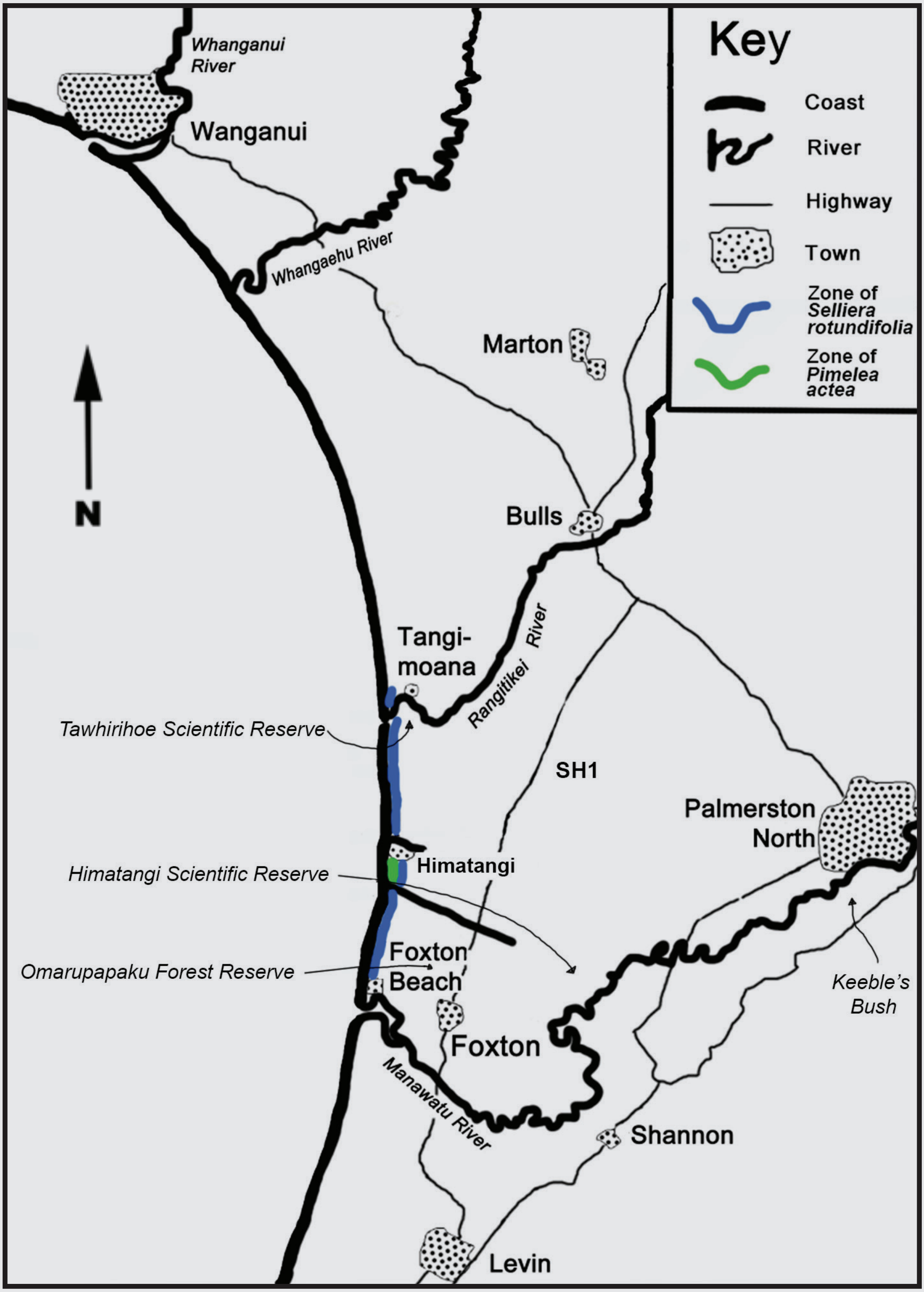

Figure 1. The Manawatū Plains and the distributions of its two endemic species, *Pimelea actea* and *Selliera rotundifolia* between Foxton Beach and Tangimoana.

Endemic Plants of the Manawatū Dunes

Jill Rapson

Those driving the long, straight reaches of State Highway 1 across the Manawatū Plains won't see a single remnant of native vegetation, and in fact, won't even pass near one, creating the impression that our landscape is devoted solely to anthropic activities such as agriculture and urbanisation. But hidden away in the nooks and crannies of an otherwise flat and rather monotonic landscape are small remnants of native vegetation, testaments to a surprisingly varied and dynamic environmental history. These include the forests of Omarupapaku and Himatangi just off SH1, as well as Keeble's Bush, situated outside Palmerston North, which are all remnants of the lowland podocarp-broadleaved forest which once clothed most of the inner plains and foothills (Esler 1988). Closer to the beach, itself a legal but unfrequented road, forest cannot survive, and instead there are dunelands consisting of mobile sand around small patches of native herbaceous vegetation. Sadly, these coastal charms were mostly ignored by early botanists and explorers. Instead it took the post-WWII generation of scientists, including John Carnahan, who completed his PhD at Massey Agricultural College, Des Cowie from Soil Bureau of the then DSIR, and Alan Esler, botanist at the newly elevated Massey University, to boost our understanding of the past state of native flora and vegetation along this coast (Carnahan 1957; Cowie 1963; Esler 1969, 1970).

Amongst this ever-changing habitat reside two floristic gems, unacknowledged by the general public, even those not dedicated to rapid transit. These are the local endemic plants *Selliera rotundifolia* (round-leaved remuremu; Goodeniaceae), and *Pimelea actea* (which has no common name, unless you call it the Manawatū sand pimelea or, less accurately, sand swale daphne; Thymelaeaceae).

Endemic plants are those restricted to a specified area of our planet. Over 2500 species of higher plants (ferns, fern allies, gymnosperms and angiosperms) are restricted to New Zealand and grow naturally nowhere else. Some of those endemics are local endemics, in that they only occur in small portions of New Zealand. For example, there are 96 species restricted to north of the kauri line (about the longitude of Thames), and 20 to the Volcanic Plateau (Wardle 1991). But only seven are known from the lower North Island (Peter de Lange, Science Advisor, Department of Conservation in Wellington (DoC)), and for two of those the coastal dunes of the Manawatū are their only habitats on Earth (Figure 1). No other endemic plants are known to be restricted to the Manawatū.

The Manawatū's endemic plant inhabitants

Pimelea actea

Not quite so iconic as the kiwi (and thus not so vulnerable to sponsorship), our two rare endemic plants yet have charms of their own. *Pimelea actea* is a sub-shrub, so-called because it isn't even very good at being a shrub (Figure 2). It is short-lived, probably to less than a decade (a guess based on years of observation), and about 40 cm tall. It has thin, wiry stems which are weakly branched and often hairy when young, and leafless when older. Leaves are a soft blue-green, usually smaller than half a centimetre and rather rounded. The flowers are white, tubular at the base, with five lobes at the tip. They are dioecious, meaning both sexes are present in the same flower, which is unusual for this family, the daphne family, Thymelaeaceae. Thus there may be some tendency for plants to self-pollinate, something which is often not good for a species' genetic health, as does happen to its close relative and fellow dune plant, *Pimelea villosa* ssp. *arenaria* (AKA *Pimelea arenaria*; Dawson *et al*. 2005). The fruit is a shining white sphere up to 4mm, with the shrivelled style still on the top, and is often in clusters of 3-4. Each fruit contains 1-2 seeds. The method of dispersal is a mystery, but birds, water and even lizards have been proposed (Burrows 2008).

The most conspicuous thing about *Pimelea actea* is how inconspicuous it is. An individual plant is extremely hard to find, even when one knows roughly where to look. This may be the reason the species has become so rare – no-one even knows it is there. In fact, *Pimelea actea* was first recorded as recently as 1993 from the Turakina River mouth by Tony Druce, a roving botanist based at Botany Division, DSIR, Taita, with a real gift for taxon-spotting. Its first "tag" name was *Pimelea* "Turakina" (Burrows, 2001). It died out at Turakina two decades ago and was retagged *Pimelea* "Himatangi". That location is its only strong-hold today, and both of the known remaining wild populations are to be found within a few km of the village. (Two nearby populations are thought to have died out in the last three years.) Subsequently it received its official scientific name, *Pimelea actea*, from Thymeleaceous expert Colin Burrows of the University of Canterbury (Burrows 2008; "akte" is Greek for coast).

Selliera rotundifolia

Selliera rotundifolia is rather different in that it is extremely easy to find along the Manawatū coast between the mouths of the Manawatū and Rangitikei Rivers (Figures 1, 3). There it replaces its New Zealand-wide relative, *Selliera radicans*, though forms at its range extremes may be hard to assign to one species or the other. In fact, *Selliera rotundifolia* is a segregate from *Selliera radicans* (Heenan 1997), meaning that specialists have decided it is indeed a different species, an idea which Alan Esler and then fellow Massey botanist, John Ogden, had explored years earlier (Ogden 1974). It is a creeping herb to about 5 cm tall, but generally half that. As its name sensibly suggests, its leaves are round, and about 0.5 cm wide, while its flower, in the standard format

Figure 2. *Pimelea actea.* A) Dune habitat being surveyed for vegetation; B) a medium-sized plant hidden in plain sight (forming the left-hand vertex of an equilateral triangle with the pink ribbons) amongst rushes and dead leaves of exotic pampas grass; C) a healthy plant of the shorter form; D) copious fruiting.

of the family Goodeniaceae, is strongly zygomorphic (bilaterally symmetrical), with generally five white, strap-like lobes held to one side. (*Selliera radicans* is called half star after the shape of the flowers.) Its fruit is a small green ball up to about 7mm, with a crown of green teeth on top, persisting from the sepals at the base of the flower, and producing 5-10 seed each. It is found in open depressions in the sand, living close to the water table and only slightly exposed to deposition of aeolian (wind-borne) sand.

Endemic homes

Both these species are inhabitants of dune slacks. Slacks are depressions running at (almost) right angles to the shore, which are formed by wind erosion during the movement of mobile dunes. This process of stripping dry sand down to wet, is called ablation, and lowers the depression's floor to the water table. Water tables are lowest in summer, so storm events then can cause significant ablation episodes, removing 10-50 cm of sand, especially in weakly vegetated slacks. In the winter the water table rises again, and the newly-formed slacks fill up with water (Murphy, Singers and Rapson, in press). Thus, slack floras need to be tolerant of submergence.

Selliera rotundifolia can be found as an early coloniser in almost every slack along the Foxton-Tangimoana portion of the Manawatū coast. It is reasonably easily cultivated, flowering and setting fruit in the glasshouse. Nick Singers, conducting experiments as part of his Massey masterate research (Singers 1997), noted that *Selliera rotundifolia* seems more tolerant of submergence than *Selliera radicans*, with the former having more buoyant leaves and persistently releasing bubbles of oxygen, showing it could photosynthesise even when under water. By contrast *Pimelea actea* is the only native shrub which seems at home on the slightly better-drained margins of the slack, while the vegetation there is still short and sparse. However, its populations are so small and localised that it is unwise to draw firm conclusions based on what might only be the last habitat in which it has any viability at all.

Eventually slacks naturally infill with aeolian sand, a process which takes an average of 28 years according to Masterate student Sylvia Villacis Lozada, who mapped changes in dune slack wetlands from decades of aerial photographs (Villacis Lozada 2015). Consequently, natural succession (an ecological process whereby one plant community inevitably replaces another in response to natural environmental changes induced by the first community) to larger, more dominant plants of drier habitats, means that both our endemic species eventually die out of any particular slack they occupy. This is one of the factors which keeps them both localised and rare.

Research on these species

The existence of these two endemic species gives rise to many questions, only some of which have received anything like answers to date. That is simultaneously the frustration and the joy of science!

Why is naming taking so long?

Mostly the answer to this question is the perpetual one of dollars. There are very few specialists paid to sort out the names of New Zealand's plants and they are usually busy on their own study subjects. So, one has to wait until someone who is keen to work on your problem has time to do so. For example, Colin Burrows from University of Canterbury was the New Zealand specialist on the genus *Pimelea*, and it took him many years to complete his studies on it, including the naming (via publication) of *Pimelea actea*. In the meantime, other botanists make do with tag names, and accumulate what evidence they can to assist in understanding and differentiating between species.

Is *Selliera rotundifolia* a valid species?

Researching a taxon doesn't stop just because it has been elevated to specific rank. Recently another masterate student at Massey University, Kay Pilkington, investigated *Selliera*'s taxonomy in more detail (Pilkington 2014). Her work, comparing DNA microsatellites of different populations from three accepted taxa, gave strong support for the designation of *Selliera rotundifolia* as a distinct species, with at least one population being reproductively isolated. But her study also found that roundness of leaves was not a very reliable character to differentiate between the species, as this character has apparently evolved at least twice from separate populations of *Selliera radicans.* One population is now our species, *Selliera rotundifolia*, while the other, at the northern end of the Manawatū Plains Ecological District appears able to still undergo hybridisation with *Selliera radicans*. Perhaps this is, or will become, another (untagged) taxon as its habitat is cliff rather than dune!

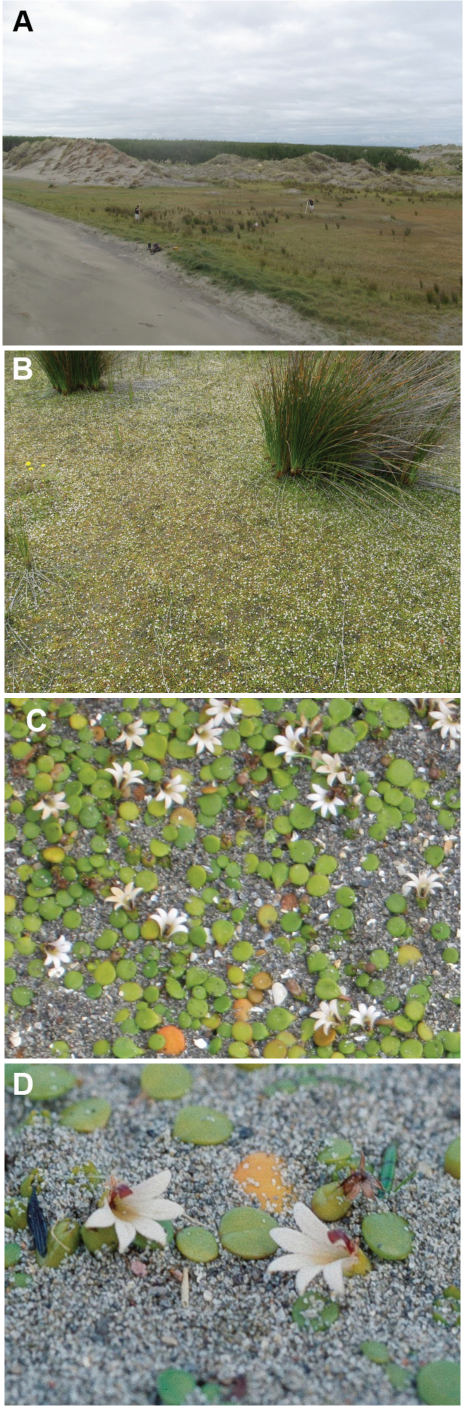

Figure 3. *Selliera rotundifolia*. A) Typical habitat in a dune slack being measured for topography; B) a sheet of plants on the floor of a slack amongst tufts of *Ficinia nodosa* or club sedge; C) a bright display of half-stars; D) close-up of flowers, showing their zygomorphy and purple, sheathed stigmas.

What do we know about the ecology of *Selliera rotundifolia*?

Here ecology is best understood by comparisons with other species in the same habitat or with congeners (members of the same genus). Fortunately, Massey masterate students have been using both approaches. Nick Singers, growing *Selliera* (he called it *S. radicans* at that time) found it had similar Relative Growth Rates in "normal" and water-logged conditions, but made little growth when submerged, so it was only partially tolerant of high water tables. Of the dune slack plants tested, it was the most tolerant of sand burial, its shoot/root biomass ratio not changing even when buried to 1.3 times its own height (Singers 1997).

Melanya Yukhnevich compared the congeners across the range of sites they occur in and observed that *Selliera rotundifolia*'s leaves were 25% thicker than those of *Selliera radicans*, while the former was tolerant of water to greater depths (mean of 32 cm) than the latter (22.5 cm; Yukhnevich 2016). *Selliera rotundifolia* was also associated with vegetation which is 70% shorter and with 63% fewer exotics around it and 44% more dune slack species. Preliminary analysis of experiments suggests the surface area of *Selliera radicans* is less responsive than its congener to all burial and nutrient treatments, especially the low-nutrient, open conditions of the dune slack (Figure 4). *Selliera rotundifolia* out-grows *Selliera radicans* only under shady conditions (under thin sand?) and relatively shallow water levels. These and Nick's results suggest that our local endemic is better adapted to large shallow dune slacks which are relatively pristine, while *Selliera radicans* is more adapted to marshy estuarine environments.

Do rarer plants need more urgent study?

The rarer species, *Pimelea actea*, has received little attention, despite being so rare; its official designation is "Threatened, Nationally Critical" (de Lange *et al.*, 2013). The problems of studying rare plants are partly because they are hard to find, partly because they may be remnants of formerly more widespread species persisting at range extremes which do not really suit them, and partly because even scientists are scared just to touch them, in case that is more stress than they can handle! In most cases rare species are coping with their current environment, even if that environment is disturbed, and action, even conservation-oriented, may simply be the final stressor which pushes them to extinction. So, any change to the *status quo* needs to be carefully thought through in advance of any action. Monitoring well-considered changes and hoping that management works (the so-called "adaptive management" approach) is best. And of course, there is the perennial issue of the shortage of both experts and dollars.

What do we know about the ecology of *Pimelea actea*?

We can learn a lot by studying congeners of our rare species. Phil Dawson, another Massey masterate student, studied a larger shrubby sand daphne, *Pimelea villosa* ssp. *arenaria* (Dawson *et al*. 2005), which inhabits the rear of the foredunes. He discovered that the populations showed a cohort structure, so that the larger plants were over-represented on

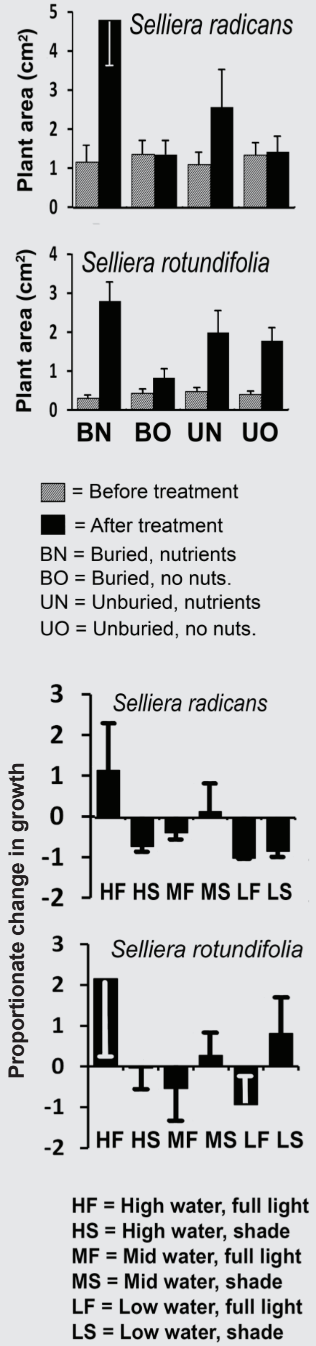

Figure 4. Preliminary comparison of congeners *Selliera radicans* and *Selliera rotundifolia* in response to experimental conditions simulating those experienced in the natural environment. From Yukhnevich (2015).

the dunes. Fruit and seed production was plentiful, but very few seedlings recruited to contribute to future populations. The long-term consequence is that the older plants progressively die (of natural causes), but with few youngsters coming on, the species becomes increasingly rare. No cause for this regeneration failure was obvious, but predation by introduced mice is suspected. *Pimelea actea* may be experiencing the same fate, but to a greater degree.

Massey student Matt Krna (taking a break from his PhD research on carbon dynamics of tussocks!) and I have explored population structure of *Pimelea actea* by mapping and measuring both persisting populations (Table 1). Over several days we carefully examined a grid of quadrats, each 5×5 m in size, at each site. We found less than 200 plants in total, with the largest being 65 cm tall while 41% were seedlings, i.e., less than 3 cm tall. Plants in the first population were taller, but with fewer growing shoots (with a tuft of young leaves above a stretch of leafless stem). It is unclear whether the difference in mean height and shoot number of the two populations means they are genetically different, or if it is due to different environmental pressures (such as damage by off-road vehicles), or if it is simply irrelevant.

Plants tended to occur together, with only five singletons. In population 1, two small neighbouring individuals less than 30 cm tall and occupying a surface area of about 800 cm^2, had underneath them a crop of 24 seedlings less than 2 cm tall (showing in Figure 5, their size/frequency graphs, as the tallest of the bars). Probably they were part of that year's seed crop, having simply fallen off the plant and germinated where they fell, rather than being taken by dispersers. However, none of these plants could be relocated two years later due to the microsite being overwhelmed by exotic grasses.

Table 1: Characteristics of two populations of *Pimelea actea* in the 2010/2011 summer.

	Population 1	**Population 2**
Number of individuals found	85	114
Average number of plants in a 5×5 m quadrat containing *Pimelea actea* plants	5.4	18.5
Mean height of individuals (cm)	12.6	6.2
Mean number of growing shoots per plant	7.0	11.6

Both populations have a high proportion of seedlings, but these largely fail to recruit to larger size classes (Figure 5). This would suggest high seedling mortality is endangering this rare species as for its larger congener above. Ten other quadrats contained twelve standing-dead plants identifiable as *Pimelea actea* by their thin, wiry stems with hairy, ridged nodes. Most dead plants were on top of a small dune (to about 50 cm tall), and so presumably died of drought (Figure 5), another threat to long-term survival.

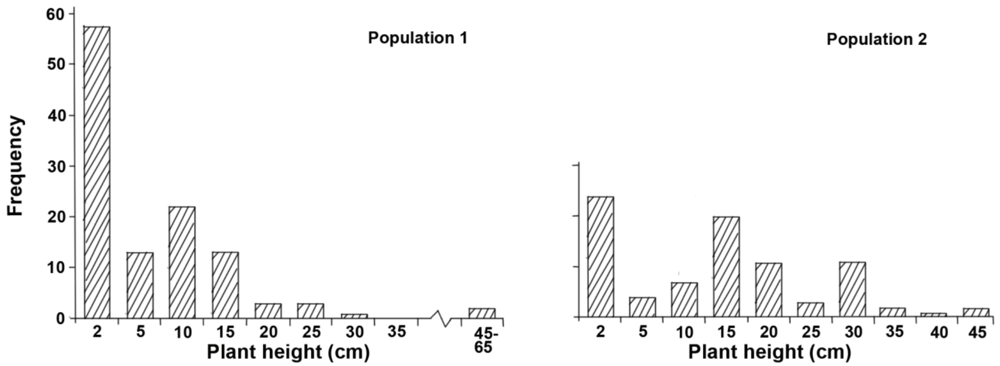

Figure 5. Size-frequency graphs of the two *Pimelea actea* populations. Each category bar is labelled by its upper height limit or its range.

Unfortunately, the idea arose, during subsequent visits, that opening up the vegetation to find and work on these plants also allows herbivores access to them, particularly rabbits. Although members of the Thymelaeaceae family are rather unpalatable, it is possible that tender young shoots are acceptable, especially when cleared of protective vegetation. Certainly, herbivory seems a logical explanation for the total disappearance of many known plants, not even skeletons remaining. This may be an instance where working towards saving a rare species actually increases its danger.

Another threat to survival is the dynamism of the environment, as mobile dunes can gradually roll over dune slacks, burying all vegetation, both short and tall (Figure 6). It is tough being *Pimelea actea*.

Can the range of *Pimelea actea* be extended?

Several attempts have been made to extend *Pimelea actea*'s range via plants propagated in cultivation. Many cuttings taken from a population near Himatangi were cultivated at Talisman Nursery near Otaki, Otari Gardens in Wellington and Massey University. Some were introduced into the Department of Conservation's flagship dune reserve, Tawhirihoe, near Tangimoana, by Massey masterate student Nick Singers. The first plantings in late 1995 produced only one stable population, which persisted for about two decades until 2010, and even gave rise to another population in a nearby wetland constructed in 1996 (Singers 1998), that population also persisting for about twenty years. Vivienne McGlynn (a former Massey masterate student, but then a DoC botanist) planted over 30 well-grown individuals into a wetland in the Reserve in ~2003, though most of these were rumoured to have appeared at the local farmers' market the subsequent week; their fates are unknown (but predictable). No *Pimelea actea* plants are now known from within the Reserve, even those placed in rabbit-proof cages disappearing (except for pathetic little skeletons) over the dry summer of 2015/2016.

Currently plants grown at Otari Gardens in Wellington are being used for re-introductions into the mud flats of the

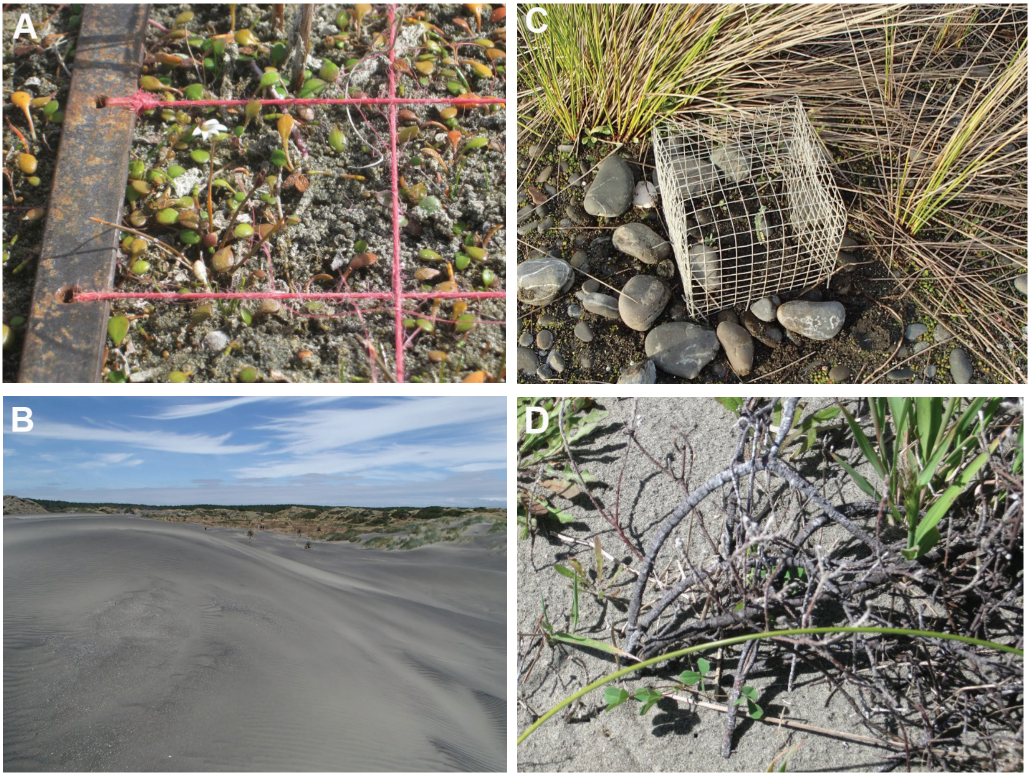

Figure 6. A) a 5×5 cm sub-quadrat, containing plants of *Selliera rotundifolia* amongst specimens of the dune slack herbs *Eleocharis neozelandica*, *Isolepis basilaris* (both on the rare plants' list) and *Lilaeopsis orbicularis* (tape-measure plant); **B**) a migratory dune progressively burying a dune slack and its rare residents at Tawhirihoe Scientific Reserve; **C**) an exclosure cage protecting a seedling of *Pimelea actea* from herbivory (but not from drought); **D**) the skeleton of a once-vigorous *Pimelea actea* (stems to 8 mm thick) amongst exotic weeds, and probably dead due to a dry summer.

Waitotara River, Tapuarua Conservation Area, north of Whanganui (La Cock 2015, 2016). But the plants being used have been propagated from the cliff-face population previously known from Castlecliff, Whanganui, and they are struggling to establish in the estuary, and may even represent a different genetic- or morpho-type from the *Pimelea actea* now known from Himatangi. In any planting, the newcomers cannot live forever and need nearby suitable habitat to disperse into and dispersers to get there. It is currently not clear how to engineer or manage this, and perhaps nature is best left to try and sort this out for herself.

What is so special about the Manawatū dunes?

Some plants are endemic to other dune regions of New Zealand, and indeed our two native dune-builders, *Spinifex sericeus* (called simply spinifex; Poaceae) and *Ficinia spiralis* (AKA *Desmoschoneus spiralis*, called pingao; Cyperaceae) are both endemics, and are widespread throughout much of New Zealand. But there are very few herbaceous plants endemic to smaller portions of our country's dunelands. (The situation is different for plants in the stable habitats of coastal cliffs.) Instead, the dunes appear to be occupied by herbs which are less restricted in terms of their habitat preferences, such as *Isolepis basilaris* (Cyperaceae) and *Eleocharis neozelandica* (Cyperaceae; Singers 1997; Yukhnevich 2015; Rapson *et al.* 2016; Murphy, Singers and Rapson in press). To have two species simultaneously endemic to the Manawatū dunes is very irregular, and science is struggling to come up with explanations.

The question is also somewhat inapposite for *Pimelea actea* which was not originally recorded from the Manawatū dunes (was it hiding here though?), and may have evolved elsewhere; it was formerly much more widespread according to Peter de Lange, DoC. But if it is able to disperse well, why is it struggling so much today to keep moving with the dunes? Is the duneland simply not the ideal habitat for it, rather the reverse – perhaps it should not be on dunes at all? And what role does human-generated disturbance play in its troubling history?

For *Selliera rotundifolia,* an obvious suggestion is that the dune environment in the Manawatū is so recent, dynamic and disturbed, that the conditions have favoured its rapid speciation. In fact the Manawatū Plains as we know them were simply not in existence 10,000 years ago (Clement, Sloss and Fuller 2010). The coastal area currently occupied by both our species is designated the Waiterere dune-building phase (Cowie 1963), and this didn't start to build until 150 years ago, after European settlement. It seems highly unlikely that *Selliera rotundifolia* evolved in that time! Instead, as the coast prograded (grew outwards), it may have migrated coast-wards from former dune slacks located closer to today's hills, assuming that the dynamics of those systems always provided slack habitats.

As a flow-on question, are there other species which have been lost from the Manawatū lowlands during the almost total clearance of its native vegetation, going extinct before we even knew they were there? Very few native plant species are known to be extinct, but maybe we haven't been looking in the right way in the right places. That just makes our local endemics all the more precious.

What does the future hold?

The future for *Selliera rotundifolia* seems predictable. It is currently too common to be endangered, even though it is extremely localised. Of course, its habitat is under threat from agricultural development of the dunes, currently delayed by the dynamism of the environment, but increasingly expanding coastwards. Even that habitat may disappear under heightened sea levels such as are projected for this coast under climate warming scenarios. Then *Selliera* would track inwards along with its habitat as long as the dunes themselves are allowed to move in response to sea levels, and do not clash with farms, plantations and urban areas.

The situation for *Pimelea actea* is considerably more bleak, as its population is so small and currently viability is so poor. Without active intervention, and perhaps even despite that, it seems likely to go extinct, at least in the wild, over the next few years.

Acknowledgements

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