

HOW CAN WE BE SURE WHETHER A PLANT IS NATURALISED, AND WHEN DOES IT MATTER?

PETER WARDLE

Research Associate, Landcare Research, P.O. Box 69, Lincoln

INTRODUCTION

Several articles in this Journal impinge on ecological and taxonomic relationships between naturalised* and native plants, and set me wondering about how we can be sure that a plant is truly introduced*. In expressing these thoughts I am indebted to the volumes of the Floras of New Zealand, especially those dealing with naturalised plants, i.e. Volume III (Healy & Edgar 1980), Volume IV including the preface (Webb et al. 1988), and Volume V (Edgar & Connor 2000). Unacknowledged information about species, including original sources, is from these volumes.

When we claim that a vascular plant species is a New Zealand native, we mean that either it evolved here or that its propagules arrived without direct or indirect human assistance. Naturalised species, in contrast, are descended from propagules that were brought to New Zealand, deliberately or accidentally, by humans or their agents, such as ships, planes and livestock. To a large extent, the success of introductions has been related to modification of physical and biological environments, again through humans and their agents.

On the world scene, the scale of introductions has been related to the intensity of economic globalization, a process that began, not in the 1990s, but with the first movement of humans out of Africa. The Neolithic revolution provided a great boost, as humans with their crops, animals and associated weeds spread from Eurasia into the New World and across Polynesia. Polynesian immigration onwards to New Zealand, being from the tropics to a temperate region, was not conducive to massive naturalisation of plants; the floodgates of introductions from the rest of the world began to open with Cook's first voyage in 1769. As globalisation speeds up, so probably will the rate of introduction, increasing resources

* I use the terms introduced and naturalised, to respectively indicate a process and a result.

devoted to interception notwithstanding; recently introduced sea squirts and 'rock-snot' bear witness.

THE IMPLICATIONS OF NATIVE VERSUS NATURALISED

To explore the implications of a plant being regarded as naturalised, I first consider the implications of being regarded as native. Some 85% of our 2300 native vascular plant species are endemic, and the remainder are mostly shared with Australia. However, whether endemic or merely indigenous, the vast majority belong to genera that occur in other regions and nearly all the rest belong to small endemic genera that have ancestors of wider distribution. Although some New Zealand species have dispersed to other regions, whether against the prevailing winds to Australia, e.g. *Chionohebe ciliolata*, or downwind to South America, e.g. koromiko (*Hebe salicifolia*), our native flora is ultimately almost wholly descended from immigrant ancestors. Pole (1994) suggested that the ancestors of almost the whole of the New Zealand flora arrived through transoceanic dispersal after separation from Gondwanaland some 80 million years ago, and this opinion, considered provocative at the time, is receiving considerable support from DNA studies; see, for example, Wagstaff (2005).

PLANTS CLASSIFIED ACCORDING TO THE LIKELIHOOD OF BEING NATIVE OR NATURALISED

Our vascular plant species can be divided into three successive groups with respect to their taxonomic differentiation. **Group 1** comprises the endemic species, many of which evolved from ancestral species within New Zealand. Others evolved from an ancestral species in another region, with either the ancestral species or the derivative New Zealand species, or both, having undergone significant evolution since separation. Alternatively, the ancestral population may have become extinct. **Group 2** species are present in both New Zealand and elsewhere, but as recognisably different taxa such as subspecies.

Group 3 comprises species that appear identical in New Zealand and elsewhere, although there may be differences not yet detected. Taxonomic revisions have already led to some entities, previously regarded as natives in Groups 2 or 3, being now regarded as including both native and introduced taxa. Examples are the grasses formerly lumped as *Agropyron scabrum*, which are now known to include several native species of *Elymus* as well as

E. scaber (R. Br.) Á. Löve which is considered to be naturalised from Australia. Research may reveal similar situations, e.g. in the extremely variable *Pseudognaphalium luteoalbum* (Molloy 2005a).

Group 1 species are native to New Zealand, being unlikely to have arrived and speciated since Polynesian, let alone European, settlement. This may also apply to Group 2, though the high rates of speciation that are being revealed in the New Zealand flora have to be considered, and also that evolution is occurring in naturalised plants of distant origin, such as browntop (Lee et al. 1983), ryegrass (Harris 2001), sorrel (Harris 1970), and white clover (Williams 1987); and by the same token native plants are, though natural selection, evolving to occupy habitats created by human activity – an example is fire-adapted forms of manuka (Harris 2000). Group 3 includes species believed to be self-introduced and therefore regarded as native, and naturalised species that arrived through human agency.

CRITERIA FOR CONSIDERING A PLANT INTRODUCED

Six criteria are invoked to indicate that presence in New Zealand most likely results from human agency:

Criterion 1 is that species shared with distant regions such as Europe were very probably introduced into New Zealand. Nevertheless dispersal, either direct or via ‘stepping stones’ between these distant regions was occurring spontaneously before human-assisted dispersal began. This is shown by a handful of northern species that either occur as New Zealand natives distinguishable at infraspecific level (e.g. *Carex pyrenaica*, *Trisetum spicatum*, *Deschampsia cespitosa*), or are represented by relatives (e.g. Eurasian dandelions by the austral *Taraxacum magellanicum*). Exchange over a longer time scale is shown by the many New Zealand endemic species in genera shared with the Northern Hemisphere (e.g. in *Ranunculus*, *Myosotis*, *Festuca*).

Criterion 2 is that non-endemic plants first recorded later than the earliest botanical collections or records are probably introduced. Nevertheless, some such species have been considered self-introduced and therefore indigenous. The orchid *Cryptostylis subulata*, first recorded in Northland in 1975 (Johns & Molloy 1983), and *Epilobium gunnianum* first recorded in the Buller district in 1953 (Raven & Raven 1976) are examples. In contrast, *Scirpus polystachyus* and *Polygonum prostratum* are considered naturalised,

although the former and the only South Island record of the latter, from a South Westland lake shore and sea beach respectively, seem as well-positioned to have been spontaneous arrivals from Australia as *Sprengelia incarnata* in southwestern Fiordland (first collected in 1967) and *Eremophila debilis* (syn. *Myoporum debile*) and *Pomaderris apetala* (tainui), both with toeholds on the coast near Kawhia. All three have been accepted as native, despite Maori folklore indicating that *P. apetala* was introduced from Polynesia. More recently, "a persuasive argument" that *E. debilis* was introduced has been accepted by Webb et al. (1995).

Conversely, a few species recorded as native in Hooker (1864; 1867) and resting on even earlier records have later been considered naturalised, mostly on the basis of growing in modified habitats (see Criterion 3 below). Examples are *Bidens pilosa*, *Sonchus oleraceus* and *Hibiscus trionum* with records back to 1772, 1832 and 1840 respectively. Yet other species figuring in early records have retained their native status, despite growing in modified habitats, e.g. *Hibiscus diversifolius*, *Solanum americanum*, the pink-flowered form of *Calystegia sepium*, *Pelargonium inodorum*, *Cotula australis* and *C. coronipifolia*, though for the first four the possibility of early Polynesian introduction is raised.

Alternanthera denticulata neatly illustrates how difficult it can be to assign native or naturalised status among recent additions to the flora (Heenan 2004). This otherwise Australian species is well adapted for dispersal by waterfowl. The earliest records are from relatively unmodified swamps in Northland, but are soon followed by records from modified habitats. The authors favour a native status but accept that it could be naturalized or even both native and naturalized according to locality.

Criterion 3 is that naturalised species grow in human-created environments, but this criterion is far from watertight. On one hand, there are open environments such as rail embankments and city footpaths that are colonized by pioneering species intolerant of competition. On the other hand, there are more closed environments, such as lawns, pastures and exotic forests, that have been more or less densely sown or planted with desired species and therefore perhaps more resistant to invasion by weedy pioneers, but likely to support introduced species with long histories as 'camp followers' of horticulture, agriculture or silviculture.

Human-created open environments may not differ much physically from natural open environments, such as braided riverbeds, dunes and low-altitude screes that are also freely colonized by naturalised plants as well as a suite of native pioneers; indeed, such environments probably provided the entry points for many self-introduced ancestors of our native flora. In contrast, the more closed human-created environments can be subject to management practices that create conditions unusual in natural environments, such as nutrient levels that are naturally reached only near bird colonies.

There has been significant 'leakage' of naturalised species from man-made environments into native vegetation e.g. *Mycelis muralis* and *Hypochoeris radicata* into beech forest and native grassland respectively, and of native species in the reverse direction, e.g. bracken into pastures, tree ferns into pine forests, *Epilobium nummularifolium* into rockeries, and *Solanum laciniatum* (poroporo) into gardens, which can also be invaded by native trees from nearby reserves (Doody 2005). Lawns, despite intensive management, are host to a number of native plants, including *Hydrocotyle* spp., *Oxalis exilis* and *Leptinella* spp. that otherwise occur in native turf communities (Horne et al. 2005; Molloy 2005b). Moreover, few New Zealand environments are now truly unmodified by human agency. Lowland wetlands have been especially subjected to modification, and are highly receptive to invasion by introduced plants. Yet *Polygonum salicifolium* and *Alternanthera sessilis* (nahui) are regarded as indigenous, although I doubt that any botanist has seen either in an unmodified swamp.

Pastures provide habitats for species of *Juncus* and *Rytidosperma*, the former being mainly characteristic of wet sites and the latter of dry sites. Thirteen of the *Juncus* species shared with Australia are considered to be indigenous to New Zealand, and six to be naturalised. This contrasts with *Rytidosperma* species shared with Australia, nine of which are considered to be naturalised and only three to be native. Most New Zealand orchids are considered to be self-introduced from Australia and therefore native, including *Chiloglottis gummii* which was first recorded in 1981 from a larch plantation (Johns & Molloy 1983).

Criterion 4 applies to species known to have been deliberately or accidentally introduced. Yet there are debatable cases, such as the Australian *Pittosporum undulatum* which has spread from plantings, but one Northland population seems to be self-introduced. This provides a parallel

to endemic species that are native in one part of New Zealand, and vigorously naturalised in other parts, e. g. taupata (*Coprosma repens*), pohutukawa (*Metrosideros excelsa*) and the lacebark *Hoheria sexstylosa*.

Criterion 5 concerns species recorded from one or a few restricted localities, or known to have recently spread from such localities, for example several of the *Juncus* species mentioned above. However, since self-introduced species, such as those with limited occurrences near western coasts, also initially have restricted occurrences, this criterion is diagnostic for naturalised status only if supported by other criteria. Twelve orchid species that are clearly self-introduced from Australia occur as such small, isolated populations that their successful establishment is not yet guaranteed (De Lange & Molloy 1995). These are *vagrant* species, a status that represents an interesting phase between first introduction and successful establishment either as native or naturalized species.

Criterion 6 depends on biological criteria, especially barriers to reproduction, as in *Myriophyllum aquaticum* which is present in New Zealand only as female clones that escaped from cultivation. However, reproductive barriers imposed by the absence of one sex have a habit of being overcome in time, as in the willow *Salix glaucophylloides*. This may have also happened among founding populations of native species that arrived through long-distance dispersal. Another barrier is dependence on specialist pollinators, as in the case of red clover and bumble bees; but unless the dependence is absolute, it would be expected to be overcome in time, as may have happened among the ancestors of the many native plants that now depend on the generalist pollinators characteristic of New Zealand.

THE LUCK OF THE BIRD PEOPLE

Compared with botanists, ornithologists have an easy time in regard to whether species are naturalised or native. If it was liberated from a cage brought from overseas it is naturalised. If it flew across the Tasman sea in either prehistoric or recent times it is native, even the waxeye, spurwing plover and welcome swallow, that mainly occupy human-modified environments. But what about the black swan which is probably a re-introduction of a native species that became extinct after Polynesian settlement (Worthy & Holdaway 2002)?

CONCLUSIONS

There can be no doubt that the great majority of the 1500 or more vascular plant species regarded as naturalised are indeed so. However, the naturalised status of *individual* species is a matter of probability. Perhaps only for those that escaped into the wild from known, and usually deliberate, introductions is the probability 100%. For the remainder, the probability of being native as opposed to naturalised increases with increasing proximity of the presumed parent population to New Zealand, with increasing age of the first record, with the possession of propagules conducive to long-dispersal, with increasing genetic difference from the nearest relatives in other regions, and with an increasing degree of 'naturalness' of its New Zealand habitat. Species shared with Australia provide most room for doubts concerning native or naturalised status.

The distinction between native and naturalised is clearly of scientific interest, but does the distinction matter for purposes of conservation management? Probably not, when a presumably naturalised plant is not displacing or in competition with native species. Definitely yes, where a species is undoubtedly naturalised, and different genetically in life form and in ecological characteristics, from native species being displaced. Between there may be a grey area, concerning the level of conservation priority that should be set and the kind of management that should be adopted for taxa of disputed or uncertain nativity.

ACKNOWLEDGEMENTS

I thank Warwick Harris and Peter Heenan for their helpful comments and suggestions.

REFERENCES

- De Lange, P. J.; Molloy, B. P. J. 1995: Vagrancy within New Zealand orchids: what are the conservation priorities? *New Zealand Botanical Society newsletter* 40: 13-14.
- Doody, Brendan. 2005: Is kahikatea (*Dacrycarpus dacrydioides*) a weed: the rise and subsequent demise (?) of native seedlings in gardens. *Canterbury Botanical Society Journal* 39: 13-22.
- Edgar, E.: Connor. H. E. 2000: Flora of New Zealand Volume V. Gramineae. Manaaki Whenua Press, Lincoln, New Zealand. 650 pp.

- Harris, W. 1970: Yield and habit of New Zealand populations of *Rumex acetosella* at three altitudes in Canterbury. *New Zealand Journal of Botany* 8: 114-131.
- Harris, W. 2001: Formulation of pasture seed mixtures with reference to competition and succession in pastures. Pp. 149-174. *in*: Competition and succession in Pastures. Ed. Tow, P.G.; Lazenby, A. CAB International, Wallingford.
- Harris, W. 2002: Variation of inherent seed capsule splitting in populations of *Leptospermum scoparium* (Myrtaceae) in New Zealand. *New Zealand Journal of Botany* 40: 405-417.
- Healy, A. J.; Edgar, E. 1980: Flora of New Zealand Volume III. Adventive Cyperaceous, Petalous & Spathaceous Monocotyledons. Government Printer, Wellington, New Zealand.
- Heenan, P. B. 2004: *Alternanthera denticulata* (Amaranthaceae) in New Zealand: a new addition to the native or naturalized flora?. *New Zealand Journal of Botany* 42: 739-745.
- Hooker, J. D. 1864 & 1867: Handbook of the New Zealand Flora. Parts 1 and 2. Reeve, London.
- Home, Ben; Stewart, G.; Meurk, C.; Ignatieva, M.; Braddick, T. 2005: The origin and weed status of plants in Christchurch lawns. *Canterbury Botanical Society Journal* 39: 5-12.
- Johns, J.; Molloy, B. 1983: Native orchids of New Zealand. A. H. & A. W. Reed, Wellington. 124 pp.
- Lee, W. G.; Mark, A. F.; Wilson, J. B. 1983: Ecotypic differentiation in the ultramafic flora of the South Island, New Zealand. *New Zealand Journal of botany* 21: 146-156.
- Molloy, B. 2005a: The flora of "Nancy's Hotel". *Canterbury Botanical Society Journal* 39: 23-27.
- Molloy, Brian. 2005b: Ex-situ conservation of the dwarf button daisy *Leptinella nana*. *Canterbury Botanical society Journal* 39: 28-31.
- Pole, M. 1994: The New Zealand flora – entirely long-distance dispersal? *Journal of Biogeography* 21: 625-635.
- Raven, P. H.; Raven, T. E. 1976: The genus *Epilobium* in Australia: a systematic and evolutionary study. *New Zealand Department of Scientific and Industrial Research Bulletin* 216. 321 pp.
- Wagstaff, S. J.; Breitwieser, I.; Swenson, U. 2005: Evolution and biogeography of *Abrotanella* (Asteraceae): small denizens of the Southern Hemisphere. *Canterbury Botanical Society Journal* 39: 56-64.

- Webb, C. J.; Sykes, W. R.; Garnock-Jones, P. J. 1988: Flora of New Zealand Volume IV: Naturalised Pteridophytes, Gymnosperms, Dicotyledons. Botany Division, Christchurch, New Zealand. 1365 pp.
- Webb, C. J.; Sykes, W. R.; Garnock-Jones, P. J. 1995: Checklist of dicotyledons, gymnosperms, and pteridophytes naturalised or casual in New Zealand: additional records 1988-1993. *New Zealand Journal of Botany* 33: 151-182.
- Worthy, T. E.; Holdaway, R. N. 2002: The Lost World of the Moa. Prehistoric Life of New Zealand. Canterbury University Press. 719 pp.
- Williams, W. M. 1987: Adaptive variation. Pp. 299-321 in: White Clover. Ed. Baker, M. J.; Williams W. M. CAB International, Wallingford.



Cordyline indivisa