Biological Summaries of Bindweeds (*Calystegia*) and Other Climbers

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1. Introduction

Land development and associated vegetation clearance has resulted in the transformation of natural ecosystems along riparian margins to predominantly pasture. Riparian margins are the interface between terrestrial and aquatic ecosystems and their vegetation performs an important role in maintaining and enhancing water quality and providing habitat in these ecosystems. Consequently, regional councils have invested significant resources into riparian revegetation programmes to help landowners mitigate the effects of intensive land use on water quality and loss of indigenous vegetation. One problem they are encountering is the invasion of these sites by low-growing climbing vines – principally the adventive great bindweed (*Calystegia silvatica*), pink bindweed (*C. sepium*) and old man's beard (*Clematis vitalba*) – and the native large-leaved muehlenbeckia (*Muehlenbeckia australis*).

Hawke's Bay Regional Council asked Landcare Research to summarise these species' biology and ecology from the literature and make suggestions for their control and possible future research to improve control methods. This Envirolink report deals with the biology and ecology of these plants, and a second report will cover control methods.

2. Objective

- Provide a summary from the literature of the ecology and biology of *Calystegia* species, *Clematis vitalba*, and *Muehlenbeckia australis.*

3. Methods and Data Sources

The primary data sources used were online databases and floras. The data sheets for individual species were prepared following the format of Esler et al. (1993). Although *M. australis* is a native species some would consider it surprising to see it described in the same way as well-recognised non-native weeds; however, this format offers a convenient way to summarise the biology and impacts of the species. The reader is referred to Esler et al. (1993) for the details of the scoring system. In essence, there are 15 categories that summarise the performance of a plant for characteristics that determine either its biological success (maximum 21) or harmful impacts, i.e. its weediness (maximum 24).

In most cases, data sources or scientific papers or other reports are included in the bibiography following the scores for the relevant species. The score sheet for *Clematis vitalba* is directly from Williams & Champion (2007) without modification.

4. Results

4.1 *Calystegia* taxonomy and weediness

In New Zealand there are five species of *Calystegia* listed by Webb et al. (1988); *C. soldanella*, *C. marginata* and *C. tuguriorum* are native, and *C. silvatica* and *C. sepium* are adventive. However, the taxonomy and geographic origins of *Calystegia* are confused (Ogden 1978). There are at least two recognisable forms of *C. sepium*, a 'pink flowered bind weed' that is probably native but also part of a wide cosmopolitan species, and a 'small white-flowered bindweed' that is probably introduced (Webb et al. 1988). These authors give very similar descriptions for both species, but point out that in New Zealand *C. silvatica* can be distinguished from *C. sepium* by its larger flowers. Hybridisation is also reported, both in Europe, where *C. sepium* and *C. silvatica* are considered only subspecies of each other by some authors, and in New Zealand, where they are treated as distinct species. *C. sepium* is native to 31 European countries in contrast to 13 for *C. silvatica*, and the latter is also considered naturalised in the British Isles (http://www.ecoflora.co.uk/).

Outside of agriculture, most New Zealand authors referring to an environmental weed of this group have used the name *Convolvulus arvensis,* whereas the correct name for the species to which they have generally been referring is *Calystegia silvatica* (Howell 2008). Porteous (1993) is a notable exception. It should be noted that field bindweed (*Convolvulus arvensis*) is a very important agriculture weed about which a great deal has been written.

Both *Calystegia sepium* and *C. silvatica* are listed as weeds for Australia by Randall (2002), but only by name. There are no accounts of either species as environmental weeds anywhere in the world that I can find. However, because *C. sepium* is a weed of agriculture, there is some reference to it in the weed literature. In the absence of any significant biological or weed information in the literature relevant to the present account, it is taken that data for *C. sepium* is relevant to *C. silvatica.* In this account, the term bindweed is used to cover both these species. However, there may be one important difference between these two species. In Britain, *C. sepium* is typically 'dominant' whereas *C. silvatica* is only 'common'. Further, *C. sepium* is reported as having both short-term and long-term persistent seed banks (http://www.ecoflora.co.uk) whereas *C. silvatica* is recorded as having only a short-term seed bank (http://www.ecoflora.co.uk/). However, the database authors indicate such cases where there is no definite entry; this may be just a case of absent data.

4.2 Species comparisons

In comparison to the other vines discussed here, *Calystegia* spp. have previously received little attention from conservation interests. This is principally because they have not been seen as weeds of established native vegetation in New Zealand. For example, in comparison to damage that can be caused to a bush patch, by old man's beard (*Clematis vitalba*) the effects of bindweeds on the margins would be considered trivial and short term; they are barely mentioned in the New Zealand-wide Scenic Reserve Surveys covering hundreds of patches of native vegetation, many of them vulnerable to weed invasions. These herbaceous climbers, and to a lesser extent *M. australis*, have come to notice only since the widespread undertaking of revegetation projects (e.g. Porteous 1993). Only where the valued vegetation is relatively short in stature, and where some expense has been invested in procuring and maintaining it, have these herbaceous climbers been considered weeds. Such undertakings are essentially gardening on a large scale and as bindweeds are common garden weeds, their increasing profile is understandable.

Preventing weeds from arriving at sites is usually the cheapest form of control, but the natural dispersal of all three taxa in question is impossible to curtail (Table 1). However, dispersal of bindweed by stolon fragments can be minimised by preventing the dumping of garden rubbish, and by cleaning farm machinery, and if possible keeping infestations away from waterways.

Because bindweeds are light-demanding herbs, they can establish and persist only where there is sufficient site disturbance to maintain a low-statured 'climbing frame'. In contrast, the other climbers can persist at a site for decades. Bindweed also has limited capacity to smother vegetation taller than about 4 m, whereas the other vines can be problems in much taller vegetation. Old man's beard, in particular, can persist in the canopy of a forest patch long after the gaps or edges have become sufficiently armoured to prevent further marginal ingress of weeds.

Recovery from a buried seed bank is a feature of old man's beard, whereas muehlenbeckia has only a short-term seed bank. It appears *C. sepium* does have a long-term seed bank, up to 10 years in one reported case, but no definite statement can be made about *C. silvatica*.

The differing dispersal syndromes of the three species affect the likelihood of their establishing in different situations. Because of the unspecialised nature of bindweed seeds, these are not carried very far from the parent plant other than as a contaminant or in flood material, like rhizome portions. Being wind dispersed, old man's beard can be carried very long distances. Water dispersal is also important for riverine infestations. Old man's beard can also establish on much poorer substrates, such as river gravels, than either of the other two. As birds are the primary dispersers of muehlenbeckia, fruiting plants at a site are likely to attract birds, particularly silvereyes. Blackberry (*Rubus s*pp.) provides a common starting point for muehlenbeckia for this reason, and because it provides such an ideal climbing frame.

These three vines also have very different effects on the future seed rain where they have established. Because neither bindweeds nor old man's beard are attractive to birds, the seed rain of taller woody species is low beneath their canopies. In contrast, the same birds that bring muehlenbeckia subsequently bring a potentially wide range of other fleshy fruited woody plants to the muehlenbeckia stands. The actual species will mostly reflect what is available within a radius of less than a kilometre. Both native species such as coprosma (*Coprosma* spp.) and weeds such as barberry (*Berberis* spp.) are likely candidates.

As with all weed control, consideration should be given as to what will replace the weed once it is killed by sprays or physical removal. Achieving good cover of tall vegetation as quickly as possible is the only defense against vine invasion. Although it may seem perverse, a dense canopy of bindweed can act as a foil to other weed species, some of which may have more longer term consequences than bindweed, e.g. blackberry.

Table 1 A comparison of some features of weedy vines

	Calystegia sepium/silvatica	*Muehlenbeckia australis*	*Clematis vitalba*
Form	Herbaceous rhizomatous geophyte	Woody	Woody
Growth rate	Fast	Medium	Fast
Seasonality	Deciduous	Partially deciduous	Deciduous
Mean/max height	2–3/5	4–6/10	4–6/20
Site persistence	Low	Moderate	High
Light requirement	High	Moderate	Moderate - low
Importance of vegetative dispersal	High	Low	Medium
Recovery from damage	Very common	Common	Very common
Seed production	Moderate	High	Very high
Seed dispersal	Gravity	Birds	Wind
Biological success rating (max 21)	14	12	18
Esler's index of weediness (max 24)	8	8	15

4.3 Species summaries

Pink bindweed (*Calystegia sepium*)

(as a surrogate in this review for *C. silvatica*).

Family

Convolvulaceae

Origin

Cosmopolitan

Weed

Considered a weed throughout most of its native and introduced range, through Europe, North America, Australia. In New Zealand it is considered a crop weed, or garden weed, and does not occur on DOC land. *C. silvatica* is considered a 'DOC weed'.

Uses

Used as a herb. Considered by some to have ornamental value.

Form

Very vigorous herbaceous vine with many interlocking fine stems arising from underground rhizomes commonly climbing to 3 m, covering the supporting vegetation. *C. sepium* has two types of stem: aerial stems that bear leaves and flowers and underground stems, called runners, which are technically rhizomes, which bear scales. A histological study showed that the meristems are structurally and functionally identical in the two types of stem and that differentiation occurs during subsequent growth and development. Rhizomes can reach 5 mm in diameter and are packed with starch. Fibrous roots are produced at the nodes and these can penetrate to several metres in deep alluvial soil. Plants are semi-deciduous over winter, and during floods pieces of rhizomes are swept away. Both aerial shoots and further rhizomes can arise from these pieces.

Ecology

Grows in a wide range of marginal habitats with relatively light cover of other species, such as forest margins, plantation edges, ditches, banks, and gardens. Grows best on moist fertile soils, especially alluvial soils. *C. sepium* is an important weed of maize crops in the USA.

Ratings

Biological Success and Environmental Impact (0–3)

2 Versatility: Wide climatic range throughout the temperate zones, but requires open conditions and high light levels, fertile soil, and a good supply of nutrients. *C. sepium* has the capacity to adjust the allocation of resources to above or below ground, depending on nutrient availably: a higher proportion is allocated to runners than to aerial shoots in nutrient-poor conditions (Klimes & Klimesova 1994). In the case of *C. arvense*, seedlings given full light produced more leaves than those in the shade (Armellina & Zimdahl 1988).

2 Maturation rate: The first runners are produced from seed when plants are only 20 cm tall. New runners are produced from the base of the adult runners. *C. sepium* runners can grow up to 15 cm per day and several metres over the length of a growing season (Klimes & Klimesova 1994). Resprouts very rapidly from rhizomes and can cover bare areas of ground in a few months, for example those exposed after winter floods, or open areas created by disturbance such as windthrow.

2 **Seeding ability:** Flowers are self-compatible, but pollinator services of a range of insects (bumblebees, small bees, and syrphid flies) are needed for self-pollination (Ushimaru & Kizuzawa 1999). Seed set in Japan ranged from 19 to 66% under natural conditions. (These figures were higher than for *C. soldanella,* in the same trial, a species native to New Zealand.) *C. sepium* produces abundant seed in late summer and autumn, but only in high-light situations (Klimes & Klimesova 1994). Documented evidence for *C. sepium* shows that abundant seeds can survive for at least 10 years in the soil. Dormancy is broken by storage in wet cold conditions. However, seedlings were rare in the wild in Japan, and most biomass was produced from a single clone (Ushimaru & Kizuzawa 1999).

2 **Dispersal and establishment:** Seeds are dispersed only by gravity or water and are otherwise unspecialised. Rhizomes are commonly dispersed by rubbish dumping and by flooding, when banks of rivers, for example, fall in.

2 **Cloning:** New plants are produced from pieces of rhizome (minimal length required is unknown).

2 **Recovery:** Grows from any rhizome fragment, or stem fragments if these are held in contact with the soil. In large disturbed areas, will regenerate from seed. Apparently, *C. sepium* has a long-term persistent seed bank whereas *C. silvatica* does not.

2 **Competitive ability:** Competitive with associated short vegetation but it requires a support structure, which reduces its competitive ability once the accompanying vegetation becomes dense and greater than 3 m. For these reasons, it is constrained to marginal habitats.

14 Biological Success and Environmental Impact Rating

Weed Status Assessment (0–3)

1 **Obstruction:** Forms only minor obstructions.

2 **Suppression:** A minor factor only in some localised revegetation plantings.

0 **Health impairment:**

0 **Quality impairment:**

1 **Damage to natural areas:** Occasionally reported for *C. silvatica*.

0 **Other:** None

Opportunity

2 **Extent of suitable habitat:** Much marginal habitat is available, but competition from other weeds is often severe in these habitats, which limits its growth.

2 **Resistance to management practices:** Grubbing is not effective unless all stems are pulled. Spraying is effective if the plants can be accessed outside of the period when it

is ‘hiding’ in the crop. Biocontrol agents, especially mycoherbicides, are being widely investigated in Europe.

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http://www.ecoflora.co.uk/ (note: there are 32 entries for ecological characteristics of C. *silvatica* and 102 for *C. sepium*).

Pohuehue (*Muehlenbeckia australis*)

Family

Polygonaceae

Origin

New Zealand

Weed

One of the few native species considered a weed in some situations in New Zealand because it covers conservation plantings and similar.

Uses

Unknown outside the gardening context or conservation context. Recognised as a very important host for native invertebrates.

Form

A very stout, much branched from base, tangled, interlocking, perennial vine that can reach 10 m. The branches are quite fine and interlaced, so that the whole plant forms a mat over the object it is climbing. The outer branches bear a mass of small leaves about 5 cm long with pointed tips. The mass of the crown is increased by bearing many small leaves and often masses of flowerheads and fruit.

Ecology

Grows in a wide range of marginal habitats with relatively light cover of other species, such as forest margins, plantation edges, ditches, banks, regenerating scrub. Grows best on moist fertile soils, especially alluvial soils and in gullies, but it is quite tolerant of drought.

Ratings

Biological Success and Environmental Impact (0–3)

2 **Versatility:** Grows on a wide range of soil substrates in the lowlands. *M. australis* has a high light compensation point (1.8% RI) compared with some other vines, so the potential for rapid growth will be realised only in high-light environments. It cannot invade mature scrub, but has to establish on the margins and grow up along with its support plant.

2 **Maturation rate:** No data are available on the growth rate of in the wild of *M. australis*, but unpublished observations suggest it can reach the canopy of tall shrubs in 2–3 years from germination.

2 **Seeding ability:** Abundant seed is produced. Published information on the germination of *M. australis* is conflicting. Burrows (1996) reported 75% germination in the dark and 97% germination in the light, whereas Mackay et al. (2002) reported zero germination in the dark and from 58 to 72% germination in the light. Udy (2004) noted seeds of *M. astonii* were eaten by ship rats and no doubt seeds of *M. australis* are similarly eaten.

2 **Dispersal and establishment:** Seeds are eaten and dispersed by several birds, including bellbirds, blackbirds, tui, and silvereyes.

0 **Cloning:** Not known to reproduce by any form of fragments. New plants are produced from pieces of rhizome (minimal length required is unknown).

2 **Recovery:** Regrows to some extent from persistent underground roots if not pulled out completely. Tops can withstand a great deal of cutting. In all probability, there is only a short-term seed bank.

2 **Competitive ability:** Competitive with associated short vegetation but it requires a support structure, which reduces its competitive ability once the accompanying vegetation becomes dense and greater than about 3 m. For these reasons, it is constrained to marginal habitats.

12 **Biological Success and Environmental Impact rating**

Weed status assessment (0–3)

1 **Obstruction:** Forms only minor obstructions to human activities, such as blocking pathways if left long enough.

1 **Suppression:** A minor factor only in some localised revegetation plantings.

0 **Health impairment:**

0 **Quality impairment:**

1 **Damage to natural areas:** Could be claimed to be damaging where it is covering particular items of interest such as revegetation plantings or rare plants. However, first impressions may not give a proper understanding of its role in the vegetation at the site. In inland South Island the smothering effects can be exacerbated in winter by the massed crown accumulating snow and adding to the impact of crushing the underlying plants.

0 **Other:** None

Opportunity

3 **Extent of suitable habitat:** Extremely widespread plant.

2 **Resistance to management practices:** Difficult to pull out because of the strong woody root system. Can be killed by spraying.

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Old man's beard (*Clematis vitalba*)

Family

Ranunculaceae

Origin

Eurasia

Weed

Weed mainly in Australia and New Zealand.

Uses

Once grown as an ornamental.

Form

Very vigorous woody vine with stems commonly to 10 cm in diameter that climbs to over 20 m, covering the supporting vegetation. Deciduous, with masses of persistent seed heads over winter.

Ecology

Grows in a wide range of marginal habitats, regenerating scrub, forest margins, plantation edges, and banks. Grows best on fertile soils, especially alluvial soils.

Ratings

Biological Success and Environmental Impact (0–3)

2 **Versatility:** Seedlings are stress tolerant (grows in footpaths) and relatively shade tolerant (light compensation point is 1%) compared with some other vines. Needs light levels above 5%. Can withstand severe frosts. Tolerates a range of soil conditions and not particularly sensitive to soil acidity.

2 **Maturation rate:** Seeds can germinate throughout the year if sufficient moisture. Flowers in mid- to late summer and seeds produced the same autumn (March–December). Growth is rapid and in high light will be multi-stemmed from the base. Can grow up to 5 m in a season. Flowers in 4–5 years. Can probably live for at least 20 years.

3 **Seeding ability:** Abundant seeds produced, >10 000 per square metre. These can be dispersed immediately or overwinter on the vines. High germination rates in the order of 80% but increases with chilling, nitrates, and low light. Seeds are hygroscopic, which buries them in the soil by twisting the awn.

3 **Dispersal and establishment:** Long-distance dispersal by wind and water (plants often on river margins**).** Also a contaminant on river gravel and as attachments.

2 **Cloning:** New plants are produced at the nodes every 15 cm from stems in contact with the ground.

3 **Recovery:** Grows from any stem fragments in contact with the ground. Fragments can live for months if left hanging and later come in contact with moist ground. In large disturbed areas will regenerate from seed.

3 Competitive ability: Highly competitive with all associated vegetation. Climbs and shades out its supporting canopy so it becomes extremely dark underneath and prevents germination of other species (and its own seedlings).

18 Biological Success and Environmental Impact rating

Weed Status Assessment (0–3)

3 Obstruction: Forms dense thickets that are almost impossible for humans and stock to get through, especially when in vegetation 2–5 m tall.

3 Suppression: A single plant can cover 180 square metres.

0 Health impairment:

0 Quality impairment:

3 Damage to natural areas: Covers secondary vegetation and damaged forest. Prevents regeneration of native species. Smothers existing understorey shrubs, including threatened species. Particularly bad because it occupies already threatened ecosystems on flood plains.

0 Other: None

Opportunity

3 Extent of suitable habitat: Widespread over much of New Zealand but much habitat still remains vulnerable. Chilling requirement may limit germination in Northland, but this needs testing.

2 Resistance to management practices: Grubbing is not effective unless stems kept off the ground. Cutting and spraying stumps is effective. Can also be controlled by helicopter spraying. Greatest difficulty is finding isolated stems before they emerge above the canopy and seed. Old man's beard leaf miner (*Phytomyza vitalba*) is widely established in New Zealand but unable to provide effective control. Other biocontrol agents are being sought.

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5. Acknowledgements

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