

CLARENCE/WAIAU TOA CATCHMENT

RIVERBED WEED CONTROL STRATEGY



A report prepared for
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SUMMARY

This report presents the results of a survey of riverbed weeds in the Clarence/Waiau Toa catchment, and proposes a strategy to control weeds that threaten the ecology and functioning of the braided riverbed.

The report lists the most invasive weed species and describes their distribution in the catchment. It identifies types of sensitive indigenous vegetation and habitat that should be protected from disturbance. The report then proposes a weed control strategy, and discusses issues associated with weed control operations.

The survey was undertaken on foot, and by four-wheel-drive vehicle and helicopter between January and May 2018, and between December 2018 and February 2019. Consultation with landowners, Environment Canterbury staff, Department of Conservation staff, and weed control operators occurred during the survey period. All weed infestations were recorded and mapped as points or polygons, as presented on maps that accompany this report. Small isolated weed infestations at the upper extent of the species' distribution were controlled during the survey.

A considerable number of naturalized plant species were recorded, of which a relatively small number pose a significant threat to the functioning of the braided river. The most significant riverbed weed species present in the upper catchment are broom, gorse and crack willow. Other important riverbed weed species are alder, poplar, Russell lupin and Spanish heath. Other significant weed species in the lower catchment are buddleia, false tamarisk, stonecrop and tree lupin. Sweet brier and wilding trees are also important weeds in the catchment, but do not pose a significant threat to riverbed habitats.

This strategy proposes eradication of Russell lupin, tree lupin, alder, poplar, columbine and spearmint from the upper Clarence/Waiau Toa catchment. It also proposes eradication of broom, gorse and crack willow from upper tributaries. Below St James Homestead, where broom and to a lesser extent gorse and willow form extensive dense infestations, this strategy proposes containment of those weed species to protect areas of important riverbed habitat. This strategy proposes eradication of false tamarisk from the lower catchment, and eradication of tree lupin and buddleia from the mid-catchment tributaries. Key weed control priorities are summarised on the next page.

This strategy proposes a change in emphasis from helicopter-based control to ground-based control, and a concentration of effort in upper tributaries instead of downriver control. It prioritises control of riverbed weed species at the up-valley extents of their distributions. It proposes control of additional weed species, including eradication of species where feasible. The strategy does not address other priorities for weed control, such as for farm management, or for protection of indigenous biodiversity at sites away from the riverbed.

The strategy discourages control of dense infestations of broom, unless there is a plan to rehabilitate or restore native vegetation at the site following weed control. It encourages further introduction of biological control agents for broom, and investigation of techniques to restore native vegetation at weed control sites such as through seeding or strategic planting. A number of monitoring, surveillance and advocacy actions are proposed, to help ensure new weed species do not become established in the catchment, and to ensure that weed control is effective and sustainable.

SUMMARY OF THE WEED CONTROL STRATEGY

(Listed in order of priority under each heading)

Priorities for Eradication

1. Russell lupin at and adjacent to the upper Acheron trial planting site.
2. False tamarisk from all parts of the catchment.
3. Tree lupin from all sites above Clarence Bend.
4. Buddleia from all sites above Clarence Bend.
5. Alder, at Fowlers Hut and downriver to St James Homestead.
6. Poplar at Saxton River road-bridge.
7. Broom and gorse from Clarence River catchment above St James Homestead.
8. Broom and gorse from Acheron River catchment.
9. All willow species from Acheron River catchment, above Severn confluence.
10. All willow species from upper Clarence River catchment, above St James Homestead.
11. Columbine from one site at Lake Tennyson.
12. Spanish heath from lower Timms Stream.
13. All willow species from remaining parts of Acheron River catchment.
14. Spearmint, from Alma River, lower Leader Dale, and Bunkers Stream/Bush Gully.

Priorities for Containment

1. Broom, gorse and willow at important areas of open riverbed (including a riparian buffer), to protect breeding habitat of black-fronted tern.
2. Spanish heath along Clarence River between Leader Dale and Styx River (east of Tophouse Road).
3. Broom and gorse north of road, between St James Homestead and Acheron River.
4. Alder at Quail Flat.
5. Maintain wild animal populations at low densities.

Priorities for Surveillance and Monitoring

1. Monitor all broom, gorse, Russell lupin and tree lupin control sites annually.
2. Monitor all other control sites regularly.
3. Monitor the spread and vigour of birdsfoot trefoil along Acheron River.
4. Monitor the spread of stonecrop and white stonecrop.
5. Survey weed-free parts of the upper catchment regularly (especially vehicle tracks) to detect new infestations of existing and new weed species.

Priorities for Advocacy and Investigation

1. Encourage continued cooperation between agencies and land owners/occupiers.
2. Investigate release of additional bio-control agents for the control of broom and gorse.
3. Investigate issues associated with eradication of willow from the upper catchment.
4. Restrict spread of weeds by vehicles by erecting barriers to prevent vehicle access to smaller valleys, and by better signage/advocacy.
5. Liaise with Transpower to ensure weed seeds are not introduced during servicing of electricity pylons, and to ensure effective weed control occurs at pylon sites.
6. Investigate options for seeding or planting of native vegetation at broom control sites.

General Recommendations for Control of Riverbed Weeds

1. All riverbed weed control should be undertaken by experienced operators who are well briefed on the nature and likely locations of sensitive native species and habitats.

2. Small isolated infestations of all shrubby weed species (broom, gorse, tree lupin, Spanish heath, buddleia, alder) and Russell lupin should be controlled by ground-based methods, or helicopter-based wand spraying provided native species are not affected.
3. Control of large dense infestations of broom or gorse (for riverbed weed control) should only occur where required for the urgent protection of riverbed habitats, or where post-control site rehabilitation is proposed. Helicopter-based control may be appropriate, provided native species are not affected.
4. Helicopter-based control of tall weed species such as crack willow and poplar, provided native species are not affected.



Dense broom in the upper Clarence valley.

1.0 INTRODUCTION

This report presents the results of a survey of weedy naturalized plants on and adjacent to the bed of the Clarence/Waiau Toa River and its tributaries in North Canterbury/South Marlborough. It proposes a strategy to address the threat posed by these weeds to the ecology and functioning of the riverbed habitat.

The survey and strategy are presented to help meet the objectives of the Canterbury Water Management Strategy (CWMS). The CWMS recognises the value of braided rivers and has a goal of maintaining the upper catchments as largely natural ecosystems and landscapes. Weed encroachment was identified as one of the greatest threats to the braided river ecosystem in the Clarence/Waiau Toa. Weed control is listed as a priority action in the Clarence/Waiau Toa Biodiversity Action Plan.

This Clarence/Waiau Toa Riverbed Weed Control Strategy has two main objectives:

1. Survey and map braided riverbed weeds; and,
2. Present recommendations to ensure a targeted, strategic approach to control operations.

Tasks associated with meeting these objectives include: identifying weed species for eradication, containment or surveillance; identifying types of indigenous vegetation that are sensitive to weed control operations; providing observations on past control work; and undertaking control of remote/isolated weed infestations.

The Clarence/Waiau Toa Riverbed Weed Control Strategy was prepared in two stages. Stage 1, covering all parts of the catchment above the confluence of Spray Stream (Area 3 and Area 4), was completed during the 2017/2018 summer season. Stage 2, covering lower parts of the catchment (Area 1 and Area 2) was completed during the 2018/2019 season. The strategy includes areas adjacent to the river that may have weeds that could reasonably be expected to spread to the riverbed habitat. All weed species that have the potential to modify the functioning of the braided river system are included.

This report is presented in three sections, reflecting the objectives of the project. The first section (3) lists the most invasive weed species and describes their distribution. It also describes areas of sensitive indigenous vegetation and habitat, and the control undertaken during this survey. The second section (4) proposes a weed control strategy, including priorities for eradication, containment, monitoring/surveillance and advocacy. This strategy is summarised at the start of the document. The third section (5) discusses weed control operations and issues, and provides recommendations to address those issues.

2.0 SURVEY METHOD

This project commenced with a helicopter reconnaissance flight in January 2018. The ground-based field survey was undertaken over several separate trips between January and May 2018, and during December 2018 and January 2019. These surveys were undertaken on foot and, where practical, by four-wheel-drive vehicle. Further helicopter flights were undertaken in May 2018 and February 2019, to confirm the mapped weed distribution and check areas not readily

accessible on foot. Consultation with landowners, Environment Canterbury (Ecan) staff, Department of Conservation (DOC) staff, and weed control operators occurred throughout the survey period.

The survey area was searched by scanning the riverbed and river banks through binoculars and traversing areas of open riverbed on foot. A key objective of the field survey was to determine the up-valley extent of each invasive weed species. Therefore, the upper valley tributaries were searched more thoroughly. Particular effort was made to survey recently disturbed sites, especially those associated with vehicle tracks, buildings, and electricity pylons.

Survey effort was less thorough in the main stem of the Clarence/Waiau Toa River below the confluence of Dillon River, where the river is more confined. Weed distribution here was determined from existing data, and field-checked by helicopter survey. Survey data throughout were supplemented by weed distribution records held by weed-control contractors (notably Amuri Helicopters and Ian Cuff-Molesworth Station), landowners, DOC and Environment Canterbury.

The upper reaches of some tributaries were not covered by the field survey, including the headwaters of the Saxton, Severn, Acheron (above Carters Yards), and Alma. These tributaries are, by all accounts, weed-free.

Each weed infestation observed was recorded as a point or polygon on hard-copy aerial images or maps, map-referenced by GPS (Garmin Etrex), and described in a field notebook. A separate point or polygon was recorded for each infestation. These data were transferred to computer-based maps (QGIS) following each field survey. Weed distributions distant from riverbeds are mapped less precisely. Polygons depicting this peripheral spread provide an indication of the known distribution and density of the species, to the extent required to guide control priorities.

Small isolated weed infestations at the upper extent of the species' distribution were controlled by hand-pulling, herbicide granules (Tordon™ 2G) or by cutting with a hand saw and treating with herbicide gel (Vigilant®). Larger infestations were not treated.



Removal of broom bush (within tree lupin infestation) lower Clarence River

3.0 SURVEY RESULTS

A large number of naturalized plant species were recorded on or adjacent to the bed of the Clarence/Waiau Toa River and its tributaries. Of these, a relatively small number pose a significant threat to the functioning of the braided river. Many others are ubiquitous species that do not achieve structural dominance on the braided riverbed, or localized species that are unlikely to colonize the open riverbed. Weed species that pose a significant threat are discussed below in Section 3.1. Other species are listed in Section 3.2.

3.1 Invasive Weed Species

Key weed species are those that have the potential to modify the ecology or functioning of the braided river system. Such species that are present on or adjacent to the tributaries and braided bed of the Clarence/Waiau Toa River are (in alphabetical order):

alder.....	<i>Alnus glutinosa</i>
broom	<i>Cytisus scoparius</i>
buddleia	<i>Buddleja davidii</i>
crack willow	<i>Salix fragilis</i>
false tamarisk	<i>Myricaria germanica</i>
gorse.....	<i>Ulex europaeus</i>
grey willow	<i>Salix cinerea</i>
lotus.....	<i>Lotus corniculatus</i> and <i>Lotus pedunculatus</i>
Montpellier broom.....	<i>Genista monspessulana</i>
poplar.....	<i>Populus nigra</i>
Russell lupin.....	<i>Lupinus polyphyllus</i>
silver poplar	<i>Populus alba</i>
Spanish heath.....	<i>Erica lusitanica</i>
spearmint.....	<i>Mentha spicata</i> subsp. <i>spicata</i>
stonecrop.....	<i>Sedum acre</i>
sweet brier	<i>Rosa rubiginosa</i>
tree lupin.....	<i>Lupinus arboreus</i>
white stonecrop.....	<i>Sedum album</i>
wilding trees.....	mostly <i>Pinus</i> species

The distribution of each species, as recorded during this survey, is described below and mapped (except lotus, sweet brier and wilding trees). Single plants or small isolated infestations are depicted as points (dots) on the maps; larger infestations are mapped as polygons. The characteristics and ecology of the main weed species are described in Appendix 1.

Alder

Alder (*Alnus glutinosa*) is present along the upper main stem of the Clarence River between Fowlers Hut and St James Homestead. The source of the infestation is at small streams and wetlands adjacent to Fowlers Hut, where it was presumably planted. It has spread from that source to scattered locations along the Clarence River down to St James Homestead, forming a low-density (<1% cover) infestation. If not controlled, alder is likely to continue spreading downriver, and increase in density along the river. It also poses a threat to streams and wetlands adjacent to the river. Two large patches of alder are present at Quail Flat, though these do not appear to be spreading to the riverbed at that location.

Broom

Broom (*Cytisus scoparius*) is the most important and problematic riverbed weed in the Clarence River catchment. It is present from the headwaters of the Clarence River near Lake Tennyson to the bottom of the catchment at the Clarence River mouth. It is present along the full length of Acheron River downriver from Wards Pass. It forms extensive dense infestations from near St James Homestead to the confluence of Dillon River, and dense but less extensive infestations downriver to near Quail Flat. Broom is present at scattered sites over a wide area encompassing the Leader Dale, Bush Gully, Five Mile Stream, Blinkers Stream and Dillon River. Isolated broom infestations in the Acheron and upper Clarence valleys are associated with the road and electricity pylons.



Broom on pylon track, upper Clarence valley.

There has been extensive control of dense infestations on and adjacent to the main Clarence River to protect bird-nesting habitat. Systematic control of the infestations on Molesworth Station is undertaken annually as part of farm management. There is an ongoing broom-control programme on Hossack Station. The broom gall mite (*Aceria genistae*) was released at numerous locations along the Clarence River in 2015 and is having a noticeable effect on broom at some sites. Broom poses a significant threat to riverbed habitats, and to ecological values and farm productivity away from the river.

Buddleia

Buddleia is common in the lower catchment below Clarence Bend. Here it forms dense stands on the unstable beds of the tributary streams and larger scattered infestations on the bed of the lower Clarence River. Smaller infestations of buddleia were observed in Mead Stream and Dee Stream. A single bush was observed (and controlled) in lower Muzzle Stream. Buddleia has been

recorded from the main Clarence River below the Ouse Stream confluence (Frances Schmechel, *pers.comm.*) and in Jam Stream (DOC, *pers.comm.*) and may be present at other locations along the lower Clarence River.



Buddleia infestation, Mead Stream.

Crack willow

Crack willow (*Salix fragilis*) is present from the headwaters of the Clarence River below Island Pass to the bottom of the catchment at the Clarence River mouth. It is present along the full length of Acheron River downriver from Wards Pass, and along the Alma River between Tarndale and its confluence with Acheron River. Other smaller tributaries with sizeable crack willow infestations are Bush Gully, Five Mile Stream, Yarra River, Half Moon Stream/upper Dillon River, Tweed River (including Lake McRae), and Elliott Stream. Its spread is confined to river margins and adjacent wetlands and ponds/lakes, usually as scattered trees but occasionally as denser stands. There has been some crack willow control along the Clarence River between St James Homestead and Dillon River, and in the upper Acheron (S. Satterthwaite, *pers.comm.*).

Trees similar in appearance to grey willow (*Salix cinerea*) were recorded at two locations, near the Leader Dale-Clarence River confluence, and near the Severn River-Acheron River confluence. These trees were not positively identified, though should be controlled as part of crack willow control. Isolated trees of grey willow were also observed in the lower catchment, at Wharf, Swale and Mead streams. Grey willow is usually a smaller tree than crack willow and less invasive on open riverbeds. However, it sets viable seed, so poses a considerable threat to areas away from the main rivers, especially streams and wetlands.



Crack willow, Clarence River between Dee and Muzzle streams.

False tamarisk

A small infestation of false tamarisk is present in lower Limestone Stream. This has been controlled previously, and most living plants at this location were controlled during this survey. A single false tamarisk plant was observed (from the helicopter) on the Clarence River bed below Limestone Stream. False tamarisk has been recorded in lower Seymour Stream (DOC, *pers.comm.*), but was not observed at that location during this survey. Plants were observed at three locations on the riverbed below Clarence Bend. False tamarisk has become well established on other braided riverbeds, notably the Rakaia, and poses a serious threat.



False tamarisk at Clarence River-Limestone Stream confluence.

Gorse

Gorse (*Ulex europaeus*) is present from the upper Clarence River at Lake Tennyson to the bottom of the catchment at the Clarence River mouth, though its distribution is patchy and much less extensive than that of broom. It is present but uncommon along the Acheron River below the confluence of Yarra River, and present at low densities along Bush Gully. Denser patches are present on river terraces and lower slopes between St James Homestead and the Acheron River confluence, and at riverside locations further down the Clarence River. Denser patches of gorse have been controlled on and adjacent to the main Clarence River to protect bird-nesting habitat. Systematic control of infestations on Molesworth Station is undertaken annually as part of farm management.

Lotus/Birdsfoot trefoil

Two similar species of lotus are present on riverbeds in the Clarence River catchment: lotus (*Lotus pedunculatus*) and birdsfoot trefoil (*Lotus corniculatus*). Lotus is widely distributed, whereas birdsfoot trefoil appears to be restricted to the Acheron catchment, where it has been sown and subsequently dispersed by cattle (S. Satterthwaite, *pers.comm.*). At most locations lotus is present at such low densities that it does not affect the ecological functioning of the riverbed. However, in the upper Acheron River birdsfoot trefoil forms dense stands on recently-deposited river gravels, and appears to be spreading downstream. Its potential to affect riverbed habitats and the ecological functioning of the river are uncertain.



Birdsfoot trefoil on bed of upper Acheron River.

Montpellier broom

Montpellier broom is present, and relatively widespread, away from the riverbed in the Wharf Stream area (Bluff/Coverham Station). It was observed (and controlled) at one location in the lower catchment, below Clarence Bend. This species appears unlikely to pose a significant threat to the open riverbed, though its presence and any spread should be monitored.

Poplar

Poplar, mostly Lombardy poplar (*Populus nigra*) is present at scattered locations adjacent to the upper Clarence River, Acheron River, and at Tarndale. The only significant area of spread is of what appears to be a poplar cultivar along the lower Saxton River, just above its confluence with the Acheron. Here, poplar is spreading downstream and upstream along edges of the riverbed by suckering. Poplar is more widespread in the lower catchment, especially Area 2 (Clarence Reserve/Muzzle Station), both in and adjacent to the riverbed.



Poplar on Clarence River near Muzzle Station homestead.

Russell lupin

Russell lupin (*Lupinus polyphyllus*) was observed at two locations. One is an old trial planting site in the upper Acheron River valley, where Russell lupin is present in rough pasture on a gentle toe slope some distance from the open riverbed. Control work has been undertaken at this site (DOC, *pers.comm.*), though scattered plants are still present. Russell lupin plants were also observed approximately 300m distant, outside the planting site. The other location is in Duncans Stream, a small tributary of the upper Clarence River, where a single young plant was observed (and removed) from beside the vehicle track in the lower valley during this survey. The map reference (NZTM) for this location is 1580623E-5318787N.



Single plant of Russell lupin (subsequently controlled) beside vehicle track in lower Duncans Stream.

A third recorded location for Russell lupin is in the upper Acheron River near Carters Yards. Plants have been previously recorded and controlled (DOC, *pers.comm.*), though no plants were observed at that location during this survey. Russell lupin is a highly invasive species that poses a significant threat to braided riverbeds elsewhere in the country.

Silver poplar

Silver poplar forms dense localized stands and large scattered infestations in the lower catchment, below Waiautoa Station. It is also present in the mid Clarence, notably as planted trees at roadside culverts and streams. It does not presently pose a significant threat to the open bed of the Clarence River, though its presence and spread should be monitored.



Silver poplar at roadside, Seaward Kaikoura Range.

Clarence/Waian Toa Riverbed Weed Strategy.

Spanish heath

Spanish heath (*Erica lusitanica*) is present on the hills and valleys west of St James Homestead. There are substantial infestations on Peters Hill, Peters Valley, Williams Valley and the lower Styx River valley. Small scattered infestations are present on the open bed of the Clarence River between Leader Dale and Styx River. An outlying infestation, comprising small scattered patches, is present on lower hill slopes in Timms Stream, an upper tributary of the upper Clarence River. It is also present near Jacks Pass. Spanish heath is not known as a riverbed weed. However, its successful establishment on the stable bed of the Clarence River adjacent to Peters Hill, indicates that it may pose a threat.



Spanish heath on Clarence riverbed near Edwards Stream.

Spearmint

Spearmint (*Mentha spicata* subsp. *spicata*) was recorded at several locations along the Alma River, at the lower Leader Dale, and lower Bunkers Stream (Bush Gully) where it has presumably spread from plantings at Tarndale and Bush Gully. It is present as occasional well-established plants on open river gravels. It is also present in lower Seymour Stream and lower Miller Stream. This common garden escape is not known as a riverbed weed. However, the vigour of the plants observed, and its ability to spread by broken stems washing downstream, suggests that it may pose a threat.

Stonecrop

Stonecrop is present and in places dominant on the riverbed below Clarence Bend. It was also observed in Mead Stream and lower Seymour Stream. Stonecrop is present on the Chalk Range (DOC, *pers.comm.*). This low-growing succulent species can form a complete ground cover at

favoured locations and readily spreads by broken plant fragments or its light wind-blown seed. There also appears to be a relationship between the presence of stonecrop and southern black-backed gulls (*Larus dominicanus*). Dense stonecrop infestations are present at gull nesting sites in the Rakaia catchment and at a gull-nesting site on the lower Clarence River just below Clarence Bend. Effective control of this species is very difficult.



Stonecrop (yellow flowers) on the stable bed of Mead Stream.

White stonecrop is also present on the riverbed in the lower catchment, below Shag Bend (Waiautoa Station). It grows taller than stonecrop and also forms dense patches. White stonecrop appears to favour more stable sites. Its threat to riverbed ecology is unclear.



White stonecrop, lower Clarence valley (below Clarence Bend).

Clarence/Waian Toa Riverbed Weed Strategy.

Sweet brier

Sweet brier (*Rosa rubiginosa*) is the most widespread woody weed in the Clarence River catchment. It is present as scattered to dense shrubland over extensive areas on lower hill slopes and valley floors, especially in the drier eastern part of the catchment. It is also present on older stable riverbeds and terraces, but does not pose a significant threat to the recently-deposited open gravel riverbed surfaces. Its distribution was not mapped during this survey.

Tree lupin

Tree lupin (*Lupinus arboreus*) is present in lower Seymour Stream and lower Limestone Stream, and at scattered locations on the adjacent Clarence River bed. It is present and widespread in the lower catchment below Clarence Bend. It is also present on the nearby upper Wairau River. Tree lupin is a serious riverbed weed, forming dense stands on braided rivers such as the Rakaia.



Tree lupin, lower Clarence valley (below Clarence Bend).

Wilding trees

Wilding trees (mostly *Pinus* species) are present over large parts of the upper Clarence River catchment, notably in the vicinities of Tarndale and St James Homestead. Small wilding pine trees are occasionally present on riverbeds, though usually on older stable terraces. They are not considered a significant riverbed weed species, though denser infestations may affect river hydrology by causing a decline in water yield. Wilding trees are subject to an extensive control programme in the upper Clarence River catchment. The distribution of wilding trees was not mapped during this survey.

3.2 Other Weed Species

Many naturalized plant species additional to those listed above were recorded during this survey of the Clarence/Waiau Toa catchment and its tributaries. These are listed in Table 1 below.

Table 1: Other naturalized plant species

Scientific Name	Common Name
<i>Acaena agnipila</i>	Australian sheep's bur
<i>Achillea millefolium</i>	yarrow
<i>Agrostis capillaris</i>	browntop
<i>Anagallis arvensis</i>	scarlet pimpernel
<i>Anthoxanthum odoratum</i>	sweet vernal
<i>Arenaria serpyllifolia</i>	silvery hair grass
<i>Bromus</i> sp.	bromus
<i>Carex ovalis</i>	oval sedge
<i>Cerastium arvense</i>	field chickweed
<i>Cerastium fontanum</i>	mouse-ear chickweed
<i>Chenopodium album</i>	fathen
<i>Cirsium arvense</i>	Californian thistle
<i>Cirsium vulgare</i>	Scotch thistle
<i>Conyza sumatrensis</i>	broad-leaved fleabane
<i>Crepis capillaris</i>	hawksbeard
<i>Dactylus glomerata</i>	cocksfoot
<i>Dianthus armeria</i>	Deptford pink
<i>Digitalis purpurea</i>	foxglove
<i>Dryopteris filix-mas</i>	male fern
<i>Echium vulgare</i>	viper's bugloss
<i>Erodium cicutarium</i>	storksbill
<i>Festuca rubra</i>	Chewings fescue
<i>Holcus lanatus</i>	Yorkshire fog
<i>Hypericum perforatum</i>	St John's wort
<i>Hypochaeris radicata</i>	catsear
<i>Juncus articulatus</i>	jointed rush
<i>Juncus effusus</i>	soft rush
<i>Leucanthemum vulgare</i>	oxeye daisy
<i>Linum catharticum</i>	purging flax
<i>Marrubium vulgare</i>	horehound
<i>Melilotus albus</i>	sweet clover
<i>Navarretia squarrosa</i>	Californian stinkweed
<i>Orobanche minor</i>	broomrape
<i>Phleum pratense</i>	timothy
<i>Pilosella officinarum</i>	mouse-ear hawkweed
<i>Pilosella piloselloides</i> subsp. <i>pratense</i>	king devil hawkweed
<i>Plantago lanceolata</i>	narrow-leaved plantain
<i>Polygonum aviculare</i>	wireweed
<i>Prunella vulgaris</i>	selfheal
<i>Ranunculus ficaria</i>	a buttercup
<i>Rumex acetosella</i>	sheep's sorrel
<i>Rumex crispus</i>	curled dock
<i>Sagina procumbens</i>	procumbent pearlwort

<i>Senecio jacobaea</i>	ragwort
<i>Schedonorus phoenix</i>	tall fescue
<i>Trifolium arvense</i>	haresfoot trefoil
<i>Trifolium dubium</i>	suckling clover
<i>Trifolium pratense</i>	red clover
<i>Trifolium repens</i>	white clover
<i>Verbascum thapsus</i>	woolly mullein
<i>Verbascum virgatum</i>	moth mullein
<i>Veronica verna</i>	spring speedwell
<i>Vittadinia cuneata</i>	purple fuzzweed

Other notable naturalized plant species recorded in or adjacent to tributary streams, and that pose a threat to other habitats, are hawthorn, rowan, apple, gooseberry, silver birch, wattle, cherry and columbine. Rowan (*Sorbus aucuparia*) is present in the upper Clarence River, lower Acheron River, and at Coverham. Hawthorn (*Crataegus monogyna*) is present in and around Spray Stream, at the lower end of the survey area, and has been controlled at that location. An isolated hawthorn bush near Whisky Stream (Branch Stream catchment) was controlled. Apple (*Malus X domestica*) and gooseberry (*Ribes uva-crispa*) are widespread but not common.

Silver birch (*Betula pendula*) was recorded near Jacks Pass and near Fowlers Hut (where it was controlled during this survey). The map reference (NZTM) for the Fowlers Hut location is 1580420E-5315495N. Columbine (*Aquilegia vulgaris*) is present adjacent to the shore of Lake Tennyson. The map reference (NZTM) for this location is 1577077E-5327628N.

Rowan, hawthorn, gooseberry and cherry have attractive fleshy fruits that are readily dispersed by birds. Silver birch is uncommon, apple appears to be confined to roadside locations, and columbine recorded at just one site. These species do not appear to pose a significant threat to open riverbed habitats. Rowan and hawthorn are subject to separate control programmes. Eradication of silver birch, cherry and columbine would be prudent.

Blackcurrant (*Ribes nigrum*) is present at Lake Tennyson, at map reference (NZTM) 1577077E-5327628N. Cherry (*Prunus* sp.), red currant (*Ribes rubrum*) and white currant (*Ribes rubrum*) are present at St James Homestead. However, these species do not appear to be spreading, and do not pose a significant threat to open riverbeds.



Fleabane forms dense stands at some locations in the mid Clarence valley.

3.3 Sensitive Indigenous Vegetation and Habitats

The Clarence/Waiau Toa River catchment is a vast area with a range of plant community and habitat types. It supports a distinctive flora, including a number of plant species which are endemic to South Marlborough, and a large number of nationally ‘threatened’ or ‘at risk’ species¹. Many of these plant communities and species are sensitive to weed control activities, especially the indiscriminate use of herbicides.

The main sensitive indigenous plant communities that support plant pest infestations and are therefore potentially affected by herbicide use are: sedgeland-rushland-tussockland in wetlands; herbfield-grassland-shrubland on undeveloped terraces; sparsely vegetated rockland on bluffs and rocky slopes; kanuka shrubland-low forest; and herbfield-gravelfield-stonefield on open riverbeds. These are discussed in turn below.

There are extensive valley-floor wetlands, especially in the Clarence valley above St James Homestead, and along the Clarence River between the confluences of Acheron and Dillon rivers. Seepage wetlands are also present on lower slopes and in tributary valleys. These plant communities were not surveyed, but some support extensive areas of red tussock (*Chionochloa rubra*). They may also support notable indigenous plant species, such as marsh arrow-grass (*Triglochin palustris*), and the willowherb (*Epilobium birtigerum*). Woody plant pests present in wetland plant communities are alder and crack willow.



Extensive wetlands are present in the upper Clarence valley.

Undeveloped river terraces support a distinct herbfield-grassland-shrubland community characteristic of montane eastern South Island valleys and basins. Although often dominated by naturalized grasses or herbs, such as mouse-ear hawkweed (*Pilosella officinarum*), these communities support a number of ‘threatened’ or ‘at risk’ plant species, including *Aciphylla subflabellata*, *Carmichaelia corrugata*, *Carmichaelia monroi*, *Carmichaelia nana*, *Coprosma intertexta*, *Raoulia monroi*, and *Rytidosperma merum*. Terraces along the Clarence River are seriously affected by broom, and to a lesser extent gorse, between St James Homestead and Dillon River, and threatened by spread of these weed species elsewhere. They are affected by scattered to dense infestations of sweet brier throughout, and by wilding trees at some locations.

Steeper rocky slopes and bluffs are present in the lower part of the survey area, below the confluence of Dillon River, where the Clarence River is confined within a gorge. This steep dry country supports extensive rockland (bluff) plant communities with a number of ‘threatened’ or ‘at risk’ plant species, including kanuka (*Kunzea ericoides*), leafless pohuehue (*Muehlenbeckia ephedroides*), and sun hebe (*Veronica scruposa*). Broom is present in these plant communities, especially on slopes close to the Clarence River.

Kanuka (*Kunzea ericoides*) shrubland and low forest is relatively extensive on lower slopes and river terraces below the confluence of Dillon River. Kanuka has been recently classified as a ‘threatened’ (nationally vulnerable) species². Kanuka is sensitive to herbicide and is slow to recover from disturbance in this extremely dry part of the catchment. Notable ‘threatened’ or ‘at risk’ plant species present within this plant community are *Carex inopinata*, *Leptinella filiformis*, and *Myosurus minimus* subsp. *novae-zelandiae*. Infestations of broom are present within and adjacent to stands of kanuka.

Areas of riverbed support open (sparsely-vegetated) gravelfield or stonefield at recently-disturbed sites, and herbfield or grassland at more stable sites. Within the riverbed are sandy channels with ponds and occasionally wetlands. Older riverbed surfaces tend to be dominated by naturalised species. However, these habitats support ‘threatened’ or ‘at risk’ plant species, including *Dysphania pusilla* and *Luzula celata*.

Open riverbeds in the Acheron River and upper Clarence River valleys provide important habitat for black-fronted tern (*Chlidonias albostratus*), a species listed as ‘threatened’ (nationally endangered)³. There are approximately 720 breeding pairs of black-fronted tern in the upper Clarence and Acheron rivers, comprising approximately 7% of the total population of this species⁴. The upper catchment riverbed provides habitat for other notable bird species, including banded dotterel (*Charadrius bicinctus*) and black shag (*Phalacrocorax carbo*). The open riverbed habitat is vulnerable to invasion by a number of woody weed species, most importantly broom, gorse, and crack willow.

Plant pest control operations in all these sensitive plant communities and habitats should be by ground-based control methods, using experienced and well-briefed operators. If aerial control is necessary, it should be restricted to wand (rather than boom) spraying from a helicopter.

3.4 Weed Control

A secondary purpose of this survey was to control isolated infestations of plant pests. Such control was limited to infestations at or near the up-valley distribution of the plant pest. Much of this control was at disturbance sites, notably electricity pylons, pylon-servicing tracks, and beside roads. The locations of these control sites are illustrated (as red dots) on the weed distribution maps appended to this report.

The main species controlled in the upper catchment was broom: 145 broom plants were pulled, prilled, or cut (and treated) at 31 separate infestation sites. Other species controlled at fewer sites were gorse, crack willow, apple, silver birch, Russell lupin, and wilding pines.

In the lower catchment, individual plants controlled were: broom 50; false tamarisk 19; tree lupin 12; buddleia 5; gorse 1; grey willow 1; crack willow 1; hawthorn 1; and one patch of stonecrop (Seymour Stream).

4.0 RIVERBED WEED CONTROL STRATEGY

The Canterbury Water Management Strategy (CWMS) priority management action for the Immediate Steps restoration initiative for braided rivers is to “*maintain and restore the natural character of braided rivers as iconic natural landscapes/features and for their associated habitats and species*”. The management action for pest control proposed by the strategy is to “*control weeds and pests to enhance habitat values for threatened river bed birds*”.

The Clarence/Waiau Toa Biodiversity Action Plan identifies weed encroachment as one of the greatest threats to the braided river ecosystem, habitat and species. It identifies the aim of weed control as: “*to contain and where possible eradicate weeds that affect freshwater biodiversity values, while not impacting on the native species present*”.

It identifies this weed distribution survey as a Next Step to ensure a targeted, strategic approach to weed control operations. Other Next Steps that are within the brief of this strategy are:

- identify key weed species to be eradicated from the catchment
- determine containment weed species for the catchment (to prevent further spread)
- establish a surveillance list of high threat weed species to keep out of the catchment
- note highly sensitive areas within the catchment (key native species)
- ensure weed control operations do not negatively impact on the native vegetation present

The weed control priorities proposed in this Strategy are for the protection of riverbed habitats. There may be different priorities for the control of weeds for the protection of other values.

4.1 Eradication

The following riverbed weed species are present as only isolated or geographically confined infestations. Eradication of these infestations is feasible and prudent. These eradication actions are listed below, in order of priority.

1. Russell lupin

Russell lupin has been recorded from three locations in the upper catchment. One location is an old trial planting site, where plants are still present. The other two sites are where plants have been previously recorded and apparently eradicated. This weed species poses a serious threat to braided riverbeds and is very difficult to eradicate once established.

- Monitor the Duncans Stream and upper Acheron (Carters Yards) sites annually and remove any new plants.
- Eradicate all plants at the upper Acheron trial planting site (and adjacent infestations) annually.

2. False tamarisk

A small infestation of false tamarisk is present in lower Limestone Stream. Only single plants were observed elsewhere, on the Clarence riverbed below Limestone Stream (one plant) and below Clarence Bend (three plants). It may still be possible to eradicate this species from the catchment.

- Eradicate plants at Limestone Stream and on the adjacent Clarence River bed.
- Eradicate plants in lower catchment (below Clarence Bend).
- Monitor control sites and surrounding areas annually, and eradicate any regrowth/new plants.
- Monitor the former control site in lower Seymour Stream.

3. Alder (upper catchment)

Alder is present as small scattered infestations along the upper main stem of the Clarence River between Fowlers Hut and St James Homestead. These infestations appear to arise from one source, at Fowlers Hut. Alder does not pose a serious threat to braided riverbeds, but does pose a significant threat to riparian areas and wetlands. It would be prudent to eradicate this weed species from the upper catchment.

- Eradicate all plants at the Fowlers Hut infestation sites.
- Eradicate infestations along the Clarence River, working downstream from Fowlers Hut.
- Monitor control sites annually, and eradicate any regrowth/new plants.
- Monitor alder at Quail Flat and prevent spread onto the riverbed.

4. Poplar (upper catchment)

Planted poplar is present throughout the catchment, though it appears that different clones or cultivars are present, some of which pose a greater spread threat. In the upper catchment, poplar is spreading at one location, at flood-protection plantings at the Saxton River road bridge in the upper Acheron valley. Poplar is relatively common, and spreading, in the lower catchment.

- Remove planted poplar trees from the Saxton River bridge site.
- Eradicate infestations adjacent to these plantings.
- Monitor this control site annually, and eradicate any regrowth/new plants.
- Monitor poplar spread in the lower catchment.

5. Spearmint

Spearmint is not recognised as a significant threat to braided riverbeds. It is present as small isolated infestations along the Alma River, lower Leader Dale, Bunkers Stream, and lower Seymour Stream. It is well established at these locations and may pose a future threat. It would be prudent to eradicate this species while it is feasible.

- Remove or contain any source plantings at Tarndale and Bush Gully.
- Eradicate all infestations of spearmint.
- Monitor control sites regularly, and eradicate any regrowth/new plants.

Spearmint.



6. Columbine

Columbine was recorded at only one location, at a camp site (along with crack willow, apple, gooseberry and blackcurrant) on the south-west shore of Lake Tennyson. It does not pose a significant threat to open riverbeds, but will readily colonise damp shaded habitats. It would be prudent to remove this single infestation.

- Eradicate this single infestation of columbine.
- Monitor this control site regularly, and eradicate any regrowth/new plants.

4.2 Containment

7. Buddleia

Buddleia is common in the lower catchment below Clarence Bend, but uncommon (and newly colonising) elsewhere. At present it poses a new threat to the open beds of tributary streams, notably Jam, Mead, Dee and Muzzle streams. It may be possible to eradicate buddleia from areas upstream of Clarence Bend.

- Contain buddleia to the lower catchment (below Clarence Bend).
- Eradicate infestations in Jam, Mead and Dee streams.
- Monitor the controlled infestation site in Muzzle Stream.
- Monitor all control sites regularly, and eradicate any regrowth/new plants.

8. Tree lupin

Tree lupin is common in the lower catchment below Clarence Bend. Elsewhere, it is present in lower Seymour Stream and lower Limestone Stream, and at scattered locations on the adjacent Clarence River bed. These mid-valley infestations could be eradicated.

- Contain tree lupin to the lower catchment (below Clarence Bend).
- Eradicate infestations in lower Seymour Stream, lower Limestone Stream, and on the adjacent Clarence River bed.
- Monitor these infestation sites, and areas immediately downriver, annually.

9. Broom

Infestations of broom in the Clarence/Waiau Toa catchment are too extensive and too well established for eradication to be a practical option. Furthermore, attempts to eradicate dense infestations of broom will probably create favourable conditions for vigorous regrowth of broom, unless control sites are actively managed. There is also a high risk of by-kill of native species within or adjacent to the infestations. Resources would be better spent containing the spread of broom, and undertaking targeted control at important locations of riverbed habitat.

The most important broom control priorities for the long-term protection of riverbed habitats are eradication of isolated and scattered infestations in the upper reaches of the Clarence and Acheron rivers and their tributaries. The most important short-term control priorities are control of infestations at important riverbed habitats (such as black-fronted tern colonies), and containment of infestations adjacent to those riverbed habitats. Broom control should address both priorities.

Control of broom at other locations, such as to eradicate or contain infestations on grazing land or to protect important indigenous vegetation or plant species away from riverbeds, should be determined by priorities for farming or conservation of indigenous biodiversity respectively. In the long term, more sustainable methods to control or reduce the dominance or vigour of broom should be pursued, such as the release of further bio-control agents, and the encouragement of native species succession.

This strategy proposes progressive control of broom, starting with eradication of broom from the upper reaches of the Clarence River valley (above St James Homestead), followed by eradication from the Acheron River catchment. Meanwhile, broom should be controlled at locations where spread threatens riverbed bird breeding habitat. If resources permit, the next priority is containment of broom in the Clarence Valley between St James Homestead and Acheron River. A suitable containment boundary is the road on the south (true right) side of the Clarence River.

Recommended actions for protection of riverbed habitats are:

- Eradicate broom from the upper Clarence River catchment above St James Homestead.
- Eradicate broom from the Acheron River catchment.
- Monitor control sites in the Acheron and upper Clarence annually, and control any regrowth/new infestations.
- Control infestations on open braided riverbeds below St James Homestead, to protect habitats of braided river birds (notably black-fronted tern).
- Contain infestations adjacent to riverbed control sites, to reduce the risk of re-infestation.
- Release additional bio-control agents to reduce the vigour of broom.
- Investigate seeding or planting of native woody species at broom infestation sites, to encourage restoration/succession of indigenous vegetation.
- Contain broom to the south side of the road, between St James Homestead and Acheron River.
- Control isolated infestations in the lower catchment.



Effects of gall mite on broom.

10. Gorse

Infestations of gorse in the Clarence/Waiau Toa catchment are less extensive than broom, but occupy similar habitats. Eradication of gorse is made more difficult by its presence within infestations of broom. The most practical option for control is to eradicate or contain gorse along with the control of infestations of broom, as described above.

Control of gorse at other locations, such as to eradicate or contain infestations on grazing land or to protect important indigenous vegetation or plant species away from riverbeds, should be determined by priorities for farming or conservation of indigenous biodiversity respectively.

Recommended actions for protection of riverbed habitats are:

- Eradicate gorse from the upper Clarence River catchment above St James Homestead.
- Eradicate gorse from the Acheron River catchment.
- Monitor control sites in the Acheron and upper Clarence annually, and control any regrowth/new infestations.
- Control infestations on open braided riverbeds below St James Homestead, to protect habitats of braided river birds (notably black-fronted tern).
- Contain infestations adjacent to riverbed control sites, to reduce the risk of re-infestation.

11. Crack willow

Crack willow is the most widespread riverbed weed in the Clarence/Waiau Toa catchment. However, it is confined to river margins and is relatively easy to control. Eradication is feasible, though other factors should be considered before this option is pursued. Willow trees may provide habitat for native birds, such as nesting habitat for southern crested grebe (*Podiceps cristatus*) at Lake McRae, and roosting habitat for black shag. Willow trees have been planted for flood-protection, and may also provide shelter and shade for cattle.

While these factors are considered, it would be appropriate to contain the spread of willow by eradicating scattered infestations (and planted trees) in tributary valleys above important areas of riverbed habitat. The following willow control is recommended, in order of priority:

- Eradicate willow from the Acheron River and its tributaries above the confluence of Severn River.
- Eradicate willow from the upper Clarence River and its tributaries above the confluence of Acheron River.
- Monitor control sites in the upper Clarence and upper Acheron regularly, and control any regrowth/new infestations.
- Eradicate willow from remaining parts of the Acheron River and its tributaries (including Alma River, Severn River, Yarra River and Five Mile Stream).
- Control infestations on open braided riverbeds below the confluence of Acheron River, to protect habitats of braided river birds (notably black-fronted tern).

12. Spanish heath

It is uncertain whether Spanish heath will pose a significant threat to riverbed habitats. However, it is spreading downriver, on stable riverbed surfaces, from the main infestation at Peters Hill (near St James Homestead). Eradication of all infestations would be a major undertaking. However, it would be prudent to eradicate valley-floor infestations, and contain spread of the

main infestation. The following Spanish heath control is recommended for protection of riverbeds, in order of priority:

- Eradicate the scattered patches of Spanish heath in lower Timms Stream (St James Conservation Area).
- Eradicate Spanish heath from the valley floor, between Tophouse Road and the Clarence River (between Leader Dale and Styx River).
- Monitor control sites in Timms Stream and the Clarence valley annually, and control any regrowth/new infestations.

13. Birdsfoot trefoil

Birdsfoot trefoil (*Lotus corniculatus*) is well established on the bed of Acheron River at Muller Station, and appears to be spreading downriver. It is not clear whether lotus infestations will attain sufficient density or stature on the open riverbed to have adverse effects on habitat quality or river functioning.

- Monitor the spread and effects of lotus.



Birdsfoot trefoil is actively colonising new riverbed surfaces.

4.3 Surveillance

Other invasive naturalized plant species that are present on other braided riverbeds or similar habitats and have the potential to invade the open riverbeds of the Clarence River and its tributaries are listed in Table 2.

Table 2: Potential Riverbed Weeds

Scientific Name	Common Name
<i>Eschscholzia californica</i>	Californian poppy
<i>Salix cinerea</i>	grey willow
<i>Thymus vulgaris</i>	wild thyme

It is unclear if grey willow is present in the upper catchment. Specimens similar to grey willow, though not positively identified, were recorded at two locations within crack willow stands. It is present at scattered locations in the lower catchment.

Other potential weed species that do not pose significant threat to braided riverbeds, but should be included in any surveillance are listed in Table 3.

Table 3: Other Potential Weeds

Scientific Name	Common Name
<i>Acacia</i> sp.	wattle
<i>Acer pseudoplatanus</i>	sycamore
<i>Berberis darwinii</i>	Darwin's barberry
<i>Cotoneaster simonsii</i>	Khasia berry
<i>Crataegus monogyna</i>	hawthorn
<i>Iris pseudacorus</i>	yellow flag
<i>Nassella trichotoma</i>	nassella tussock
<i>Prunus avium</i>	sweet cherry
<i>Prunus cerasifera</i>	cherry plum
<i>Prunus cerasus</i>	sour cherry
<i>Rubus fruticosus</i> agg.	blackberry
<i>Sambucus nigra</i>	elderberry
<i>Sorbus aucuparia</i>	rowan

Wattle is present (and controlled) at Quail Flat, and blackberry present (and controlled) between Willows Hut and Palmer yards (DOC, *pers.comm.*). Barberry is present in the head of Puhi Puhi Stream, and yellow flag in Miller Stream, on the east side of the Seaward Kaikoura Range (DOC, *pers.comm.*).

Continued surveillance is important to ensure that newly colonising weed species, and new infestations of existing weed species, are detected early while eradication is still feasible. The discovery of Russell lupin in Duncans Stream, and buddleia in Muzzle Stream, during this survey is an example of the importance of surveillance.

- Survey the upper weed-free parts of the catchment regularly to detect new weed infestations.

4.4 Advocacy

A number of the invasive riverbed weed species present in the Clarence/Waiau Toa catchment have almost certainly been deliberately introduced to the area. Notable examples are crack willow and poplar at flood-protection structures, Russell lupin at the trial planting site, spearmint at huts, *Lotus corniculatus* on Muller Station, and probably Spanish heath at St James Homestead. Other notable invasive species deliberately introduced to the catchment are wilding conifers and gooseberry.

Other species have become unintentionally established, most likely through the transport of weed seeds on vehicles and machinery (broom and gorse), or by deliberate disposal of plant material (apple).

Information about plant species which pose a threat to the braided river habitat, especially species that are not yet established, should be provided to agencies, landowners, contractors and visitors to the area. Prevention of new weed infestations through this type of advocacy is probably the most cost-effective weed control.

5.0 WEED CONTROL OPERATIONS AND ISSUES

5.1 Weed Control Operations

Past Control Operations

Existing control of riverbed weeds in the catchment comprises four main components: helicopter-based control; ground-based control of pasture weeds on Molesworth Station; ground-based control to protect high-value conservation sites; and biological control of broom (broom gall mite).

Helicopter-based control of riverbed weeds over the past three years has targeted broom and gorse throughout the upper catchment. This includes control on Hossack Station and adjacent public conservation land. Some large dense infestations of broom have been controlled (by helicopter spraying) in the main Clarence valley mostly just above the confluence of Acheron River. There has also been helicopter-based control of hawthorn at the lower part of Area 2, and of willow above the Acheron River confluence.

Ground-based control of broom and gorse occurs annually on Molesworth Station, targeting outlying infestations and re-growth at earlier control sites. Additional ground-based control of important weeds (such as Russell lupin) and at key sites is undertaken by the Department of Conservation.

It is difficult to judge the effectiveness of weed control without robust monitoring. However, discussions with Ian Cuff (Molesworth Station), Phil (Amuri Helicopters) and DOC staff, indicate that control of isolated patches and plants of broom and gorse in the upper catchment has contained and in places reduced infestations of these weed species. Control efforts have also been effective in maintaining important areas of open riverbed habitat free of woody weeds.

Foot-based survey of the upper valleys revealed numerous isolated infestations of woody weeds, mainly broom and often single bushes, at or associated with electricity pylons, pylon tracks, or the main Clarence and Acheron valley roads. These infestations most likely originate from vehicles or machinery used for construction or servicing of the electricity lines, or subsequent use of the pylon tracks by vehicles.

Helicopter-based survey of the mid-Clarence valley (below Acheron confluence) revealed patches of broom that have been controlled along this part of the river, but also many remaining infestations. There has also been by-kill of kanuka and possibly other native species. The spraying of kanuka, and other native species such as weeping broom, has also been recorded lower down the river (Area 2) in 2016 (Ecan, *pers.comm.*).

The presence of many small infestations of broom in the upper valleys, notably along pylon lines and roads, and widespread infestations along the Clarence River below Dillon River, indicates that recent control efforts have not been particularly effective at controlling broom at those locations.

Three main issues arise from analysis of past control efforts: the effectiveness of control of dense infestations, the adequacy of control of isolated upper-valley infestations, and the effects of control on non-target species.

Recommended Control Operations

It is not possible to eradicate all riverbed weed infestations from the Clarence/Waiau Toa catchment with the existing (and likely future) resources available for weed control. It is therefore important that funds are used in a way that provides the most effective and sustainable weed control. Control of target weed species (weed-led control) should be based on the following principles:

- New localized plant pest infestations should be eradicated before they spread.
- The up-valley extent of infestations of weed species whose seeds are transported by water, should be controlled first.
- Control sites should be checked for re-growth annually, especially sites of fast-maturing weed species and/or species with long-lived seeds (notably broom and gorse).
- Control should be restricted to methods that avoid damage to native species or destruction of potential native species habitat.
- Control of large dense infestations of species that aggressively re-establish (such as broom) should not be undertaken unless there are resources to establish other vegetation at the site.
- Greater effort should be expended to establish sustainable methods of weed control, such as biological control agents and succession of native vegetation.

Protection of key habitats and species (site-led control) should be based on the following principles:

- Weed control operations should not have adverse effects on the habitat or species for which protection is sought.
- The weed species should also be controlled over a buffer area, to reduce the risk of re-infestation.
- Control sites should be checked for re-growth regularly (annually for species such as broom and gorse).

A recent five-yearly review of riverbed weed control work in the upper Rakaia River catchment⁵ illustrates the effectiveness of weed control undertaken by experienced operators using a combination of ground-based control and helicopter-based surveillance and control. Importantly, all helicopter-based control of small infestations of broom and gorse is by wand (not boom) spraying. The review also emphasises the importance of consistency, whereby the weed control operator is familiar with the country and the infestation sites.

Helicopter-based boom spraying is appropriate for infestations of tall species such as crack willow and poplar, or denser infestations of other species where there is no risk of killing non-target species.

General recommendations for control of weed species that threaten riverbed habitats are:

- All riverbed weed control should be undertaken by experienced operators who are well briefed on the nature and likely locations of sensitive native species and habitats.
- Small isolated infestations of all shrubby weed species (broom, gorse, tree lupin, Spanish heath, alder) and Russell lupin should be controlled by ground-based methods, except at inaccessible sites where helicopter-based wand spraying may be necessary.
- Control of large dense infestations of broom or gorse (for riverbed weed control) should only occur where required for the urgent protection of riverbed habitats, or where post-control site rehabilitation is proposed. Helicopter-based control may be appropriate, provided native species are not affected.
- Control of tall weed species such as crack willow and poplar can be by helicopter-based control, provided native species are not affected.

5.2 Weed Control Issues

Implementation of the proposed goals will be determined by the resources available and the practicalities of weed control. Some of the important issues that affect implementation are discussed below.

Cooperation and Liaison

Several agencies (Environment Canterbury, Marlborough District Council, DOC, LINZ, Transpower) and land owners and occupiers have obligations for and benefit from weed control in the upper Clarence/Waiau Toa catchment. Cooperation between agencies and individuals is critical to achieve cost-effective and sustainable weed control. Groups, such as the Zone Committee, provide a critical role.

- Encourage continued cooperation between agencies and land owners/occupiers.

Vehicle Access

Vehicles, and the people who travel in them, are important transporters of weed seeds. There are good examples of vehicle-assisted weed spread in the upper Clarence/Waiau Toa catchment, notably broom along vehicle tracks, and Russell lupin at Timms Stream. The extent to which vehicle use contributes to weed spread, compared with birds and mammals, is unclear. Nevertheless, vehicles are important agents of weed spread.

It would be difficult and probably impractical to restrict vehicle access to the main formed roads. However, some actions or restrictions may be helpful:

- Erect barriers to prevent vehicle access to smaller valleys.
- Provide signs (similar to the didymo signs) that remind drivers to ensure their vehicles are clean before driving into the upper valleys.
- Monitor main vehicle tracks regularly for new weed infestations.

Mammals and Birds

It is well established that mammals and birds are important dispersers of weed seeds. Weed seeds are ingested and later deposited by feral pig⁶, goat, deer⁷, possum⁸, ship rat⁹ and domestic stock¹⁰. Seeds are also carried on the coats or hooves of mammals. Weed seeds are also readily dispersed by birds, especially seeds within attractive fleshy fruits¹¹.

Regardless of the extent to which mammals or birds are responsible for weed seed dispersal, the implication for weed control is that new infestations can occur a long distance from existing infestation sources and at locations not usually visited by people. Actions that may help prevent long distance seed dispersal by mammals are:

- Avoid grazing of cattle at weed infested areas before stock are moved up-valley.
- Maintain wild animal populations at low densities.
- Control southern black-backed gull populations if gulls are implicated in the spread of stonecrop.

Biological Control

A number of biological control agents are available for the control of gorse, broom and buddleia. Seven organisms have been released for the control of gorse, four of which are widely established¹². Six organisms have been released for the control of broom, one of which was released in the upper Clarence/Waiau Toa valley in 2015. Biological control is an important control method though it won't, by itself, eliminate important weed species from the Clarence/Waiau Toa River catchment.

- Investigate the release of additional biological control agents for the control of broom and gorse.

APPENDIX 1 Weed Species Descriptions

Broom

Cytisus scoparius

Broom is a fast-growing leguminous shrub that reaches a height of up to three metres. It can flower at two years of age¹³, producing thousands of seeds per plant¹⁴. Seeds are dispersed explosively from its pods and can remain viable in soil for more than 30 years¹⁵, though seed viability declines over time. Seeds are robust and can survive transport in water¹⁶ and ingestion by mammals¹⁷ and birds¹⁸. Seeds are also transported by vehicles, people and on the coats or hooves of animals¹⁹. One study showed that broom seeds deposited onto sheep (as would occur if sheep grazed within mature broom) remained in the fleece for at least five weeks, with gradual loss of seed over that time²⁰.

Broom tolerates most well-drained soil types²¹. Its altitudinal limit in New Zealand appears to be determined by winter cold or winter drought affecting the previous season's growth²², though it tolerates cold very well²³. Broom growth is most vigorous at low-altitude sites. It is usually more dominant than gorse on the youngest surfaces of riverbeds, whereas gorse tends to be more dominant further back from the water's edge²⁴.

Broom typically lives for 10 to 12 years, though 15 year-old bushes have been recorded²⁵. Other vegetation, including native species, can establish within and regenerate through stands of broom, though replacement of broom is slower on thin stony soils subject to summer drought²⁶.

Broom is palatable to mammals and is favoured by goats and hares. When confined, goats can have a major effect on broom when it is present at low densities (4% cover), whereas sheep have minimal impact. Neither goats nor sheep have significant effect on broom when it is present at greater than 10% cover. Goats browse broom to a height of 120cm; sheep browse to 90cm. Both remove stem and flowering points, preventing seed production within browse height²⁷.

Gorse

Ulex europaeus

Gorse is a fast-growing leguminous shrub that usually reaches a height of approximately two metres, though can grow as high as seven metres. It can flower at two years of age and produce more than one thousand seeds per plant²⁸. Seeds can remain viable in soil for more than 30 years²⁹, though seed viability declines over time. Seeds are dispersed explosively from its pods and are readily transported by vehicles, people³⁰, animals³¹, birds and water.

Gorse is tolerant of a wide range of soils and habitats, including coastal dunes, pakihi (wetland), pasture and subalpine tussockland. It readily establishes at open sites, though gorse seeding densities are highest at burnt or cleared sites where gorse has formerly grown³². Gorse tends to be more dominant than broom on older surfaces, probably due to its longevity, resistance to grazing and better response after fire³³.

Gorse plants generally reach maturity at 15 years before senescing and dying, though can grow to 30 years and possibly as old as 50 years. If left undisturbed, gorse acts as a nurse crop for regeneration of woody species, including natives³⁴. Establishment of a native canopy through gorse on an undisturbed site would usually take no more than 50-60 years³⁵, though this may

depend on availability of seed of colonizing species. Gorse is palatable to mammals and is readily browsed by goats and sheep.

Willow

Salix species

Crack willow grows to a large tree, reaching up to 25 metres tall. All crack willow trees in New Zealand are male, probably all belonging to a single clone³⁶. Dispersal of crack willow is through broken shoots and branches, transported by water and then sprouting and growing. Crack willow forms dense tall stands alongside rivers and lakes, frequently extending out into standing water at lake margins. Dislodged trees or branches readily take root on open riverbeds, altering the river flow and creating stable islands.

Grey willow grows as a shrub or small tree up to seven metres tall. Trees are male or female, with the female producing thousands of tiny short-lived seeds that are widely dispersed by wind³⁷. Its wide environmental tolerance and high seed production mean that grey willow has the widest geographic distribution of any woody weed in Canterbury³⁸. Grey willow favours and often forms the dominant vegetation around lakes, streams and wetlands.

Golden willow (*Salix alba* var. *vitellina*) and hybrids between golden willow and crack willow are common on Canterbury riverbeds³⁹. Golden willow and possibly hybrid species appear to have been used alongside crack willow in flood protection plantings.

Russell lupin

Lupinus polyphyllus

Russell lupin is an herbaceous leguminous perennial, growing to less than one metre tall. It produces hundreds of seeds per plant, in pods which split explosively to disperse the seeds. It has a weak rootstock that is able to re-sprout and a persistent seed bank with seeds remaining viable for many years⁴⁰.

Russell lupin is an early colonizer, favouring stony ground and especially freshly-deposited gravels. It poses a major threat to open braided riverbeds as it can form dense stands that displace indigenous vegetation and completely alter vegetation structure and ecological processes⁴¹. Russell lupin is palatable to stock and has been trialled as a fodder crop in the Mackenzie Basin.

Seeds of Russell lupin are dispersed by propulsion from the pod and transported by water. Seeds are also likely to be dispersed by mammals and birds. An important agent of dispersal is humans carrying the attractive flowers to, or deliberately sowing seed at, new locations.

Russell lupin is present at scattered locations throughout the South Island and lower North Island, though is most obvious on roadsides and riverbeds in the Canterbury high country. Here, it has been deliberately planted for its attractive flowers, which feature in tourism promotions. It is especially problematic on riverbeds where years of control at Arthur's Pass, Forbes River (Rangitata catchment), Mount Cook and Ahuriri River have failed to eradicate infestations.

Sweet brier

Rosa rubiginosa

Sweet brier is a prickly perennial shrub which grows up to three metres tall. It produces attractive red to orange-red many-seeded fruits (rose-hips) up to two centimetres long⁴². Fruits are attractive to birds and readily dispersed by blackbirds⁴³ and feral pigs⁴⁴. Sweet brier tolerates drought, heat, cold, low fertility and well drained soils⁴⁵. It is therefore considered to pose a threat to native vegetation of braided riverbeds⁴⁶.

Sweet brier is present throughout the country, but most widespread and dominant in the eastern South Island. Seedlings are often slow to establish but adult plants are very competitive and resilient⁴⁷. Stems and roots will readily re-sprout.

Tree lupin

Lupinus arboreus

Tree lupin is a soft-wooded, short-lived leguminous shrub, growing to three metres but usually shorter. It produces hundreds of seeds per plant, in pods which split explosively to disperse the seeds⁴⁸. It has a weak rootstock that is able to re-sprout and a persistent seed bank with seeds remaining viable for many years⁴⁹.

Tree lupin is common throughout the country on coastal dunes, riverbeds and waste places. Although often affected by fungal disease and not as common as it once was⁵⁰, it is extending its distribution in some areas. It poses a serious threat to indigenous vegetation on braided riverbeds, where it can completely alter vegetation structure and ecological processes⁵¹. It is frequently the first naturalized woody plant to colonize fresh riverbed surfaces.

False tamarisk

Myricaria germanica

False tamarisk is a deciduous shrub growing to one to two metres tall. It produces large numbers of small seeds which are wind dispersed and have short viability. The plant is usually confined to active riverbed zones and is under threat in its natural range in Eurasia due to loss of braided river habitat⁵². False tamarisk can form dense stands that help stabilize riverbeds and affect river flows.

False tamarisk appears to have naturalized in New Zealand relatively recently. The earliest herbarium record is a specimen collected from the lower Rakaia River in 1986. Two other herbarium records from the Rakaia River, both below the gorge, are from collections in 1993 and 2003⁵³. It is present in Canterbury primarily on braided riverbeds, including the Rangitata and Waimakariri, though has been recorded in the upper Waihi River and coast of South Canterbury⁵⁴.

It has been suggested that false tamarisk is dispersed mainly by vehicles transporting its seed⁵⁵. However, it appears more likely that its small light seeds are dispersed primarily by wind. The fact that many recorded infestation sites are near vehicle tracks is probably an artefact of the survey method, where access to valleys is by vehicle. It was clear during recent survey of the Rakaia River that false tamarisk has quite specific habitat requirements: it prefers damp sandy sites alongside channels.

Buddleia

Buddleia davidii

Buddleia is a fast-growing woody deciduous perennial, growing up to three metres tall. It produces thousands of short-lived (less than five years) seeds per plant. Seeds are readily dispersed by wind and water⁵⁶. Buddleia dominates early succession on fresh alluvium and initially shades out all other plants, including native pioneering species⁵⁷. In North Canterbury, buddleia is later dominated by the native tree tutu (*Coriaria arborea*)⁵⁸ and elsewhere by native broadleaved woody species⁵⁹. Buddleia is widely naturalized in New Zealand, though not widespread in Canterbury. It is regarded as having potential to become a significant threat to braided riverbeds⁶⁰.



Buddleia on stable riverbed, Lower Clarence valley.

APPENDIX 2 Acknowledgements

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