Waikato RiverCare

RIPARIAN RESTORATION BEST PRACTICE

Guidelines for a successful Lower Waikato River planting project

Wai-Ora, Wai-Māori, Waikato

Hoki ake nei au ki tōku awa koiora me ōna pikonga, He kura tangihia o te mātāmuri

- The river of life, each curve more beautiful than the last.

Waikato RiverCare's vision

Kia whakapakari te mauri o to taatou Awa

- To make a positive difference to the wellbeing of our River.

Waikato RiverCare's focus

Hei whakarite i teetehi huarahi e taea ai ngaa haapori e noho tata ana ki te puaha te tupu i ngaa tupu Maaori ki ngaa tahataha o te awa o Waikato

- To implement an enduring programme to establish self-sustaining native plant-based communities on the lower Waikato River banks.

Tena koe e te rangatira,

E mihi ana ki nga ahuatanga katoa o te wa, ki nga mate tuatini kua huri ki tua o te arai, ratou kia ratou tatou te hunga ora kia tatou.

Kati ra nga mihi

Ko Waikato Te Awa
Waikato is the River

Te Awa He Tapu
The River is Sacred

Te Tapu Te Wehi
From Sacredness is Fear

Te Wehi Te Ihi
From Fear is Awe

Te Ihi Te Mana
From Awe is Power

Te Mana Te Kaha
From Power is Strength

The Waikato River represents our identity; who we are, where we are from and why we are from there. This whakatauki describes the Waikato river as embodying tapu, (sacredness), from tapu comes wehi (fear), from wehi comes ihi (awe) from ihi comes mana (power), and from mana comes kaha (strength). Combined in that order this encompasses the exercise of rangatiratanga, the responsibility of kaitiakitanga, the ability or mana of rangatira to weave these integral aspects of Māori life together and in so doing enhance their social, cultural, economic and political development.

Statement

Ngati Te Ata acknowledges the positive work that the Waikato RiverCare group has currently been undertaking, primarily to make a positive difference to the wellbeing of our River ***Kia whakapakari te mauri o to taatou Awa*** and to implement an enduring program to establish self-sustaining native plant-based communities on the lower Waikato River banks.

Heoi, Na

Karl Whare Tipeti Flavell
Heritage Manager
Ngati Te Ata

BACKGROUND

Introducing Waikato RiverCare

Waikato RiverCare has been actively working with supporters to improve habitat and biodiversity on the banks of the lower Waikato River since 1999.

In 2013 Waikato RiverCare engaged the services of Wildland Consultants Ltd to review our projects and produce a report specific to restoration of the lower Waikato River.

Waikato RiverCare is pleased to present this how-to guide on riparian restoration best practice, based on Wildlands report 3143 Nov 2013 Volume 1 and 2 and report 3143a Oct 2013.

Waikato RiverCare encourages individuals, communities, iwi, landowners and government agencies to work together to maximise your project's success! Waikato RiverCare is here to help and welcomes the opportunity to provide assistance on your riparian project.

The benefits of riparian zones

Improving the health of the riparian zone is more than just planting trees; it's about protecting and improving the freshwater environment New Zealander's enjoy every day. Working on a riparian project will increase your awareness of the interaction between insects, fish, birds and the trees that line the riverbank. Undertaking a riparian project will open the door to a closer relationship with the natural world, providing the opportunity to experience seasonal change, like witnessing the enormous power of a river in flood to the devastation of a summer drought. A riparian project done correctly will reward your hard work, providing years of enjoyment.

There are many other benefits that your restoration project will bring, including increased biodiversity of both flora and fauna; habitat enhancement for birds, insects and fish; the creation of buffer zones to protect water quality; erosion control, reduction of weed spread and occupation within the riparian zone, aesthetic improvement of the river bank, and nesting cover for birds.

The riparian zone of the lower Waikato River is a challenging environment in which to re-establish native plants. It has both very high and very low water levels for long periods of the year, which can cause erosion and sediment movement due to powerful currents. Introduced plants are dominant, including many highly invasive plants and weeds.

A successful restoration project must consider a number of key factors before planting any native trees:

site assessment, project planning, site preparation, species selection, plant stock and planting, matching of species to habitats, monitoring, and maintenance.

This set of guidelines will help you to plan and implement your project to get the best outcome possible.

BEFORE YOU BEGIN

Photo: Ben Wolf, Waikato District Council.

1. Identify interested parties

Before starting any restoration project, the land manager should be identified. Approval may also be required from an adjoining landowner for access to the project area.

You'll need to talk with the relevant District council, and the Waikato Regional Council.

2. Undertake a detailed site survey for a prospective restoration project

So that you can plan the project you'll need a detailed site survey. This should include a description and map of the existing features e.g: vegetation types and landforms. Where practical, these should be mapped at a scale appropriate to the size and diversity of the site. The following information should be collected:

- **Important points of interest**, e.g. vegetation, landform or flood zone boundaries, or other potential management units that are not evident on aerial photographs, should have their boundaries recorded using a hand-held GPS unit with the tracking function activated.
- **Evidence of erosion, the presence and location of structures for flood control or drainage**, such as stop banks, drains, pumps, culverts, and the presence, location, and condition of fences should be noted, along with potential Health and Safety issues. Observations should be recorded in a notebook, or using a field PC, and some features can be drawn directly onto a printout(s) of a large scale aerial photograph.
- **A plant species list needs to be compiled,** all invasive pest plants noted, evidence or presence of birds and mammals recorded, and the boundary between the upper and lower flood zones delineated, along with any other hydrological feature that could potentially affect vegetation and habitats.
- **Digital photographs** should be taken of all features within the project area and immediately beyond it, to provide context.
- All notes, photographs, and GPS files should be labelled, catalogued, and **backed up** electronically.
- **Vegetation cover** at potential riparian restoration sites along the Waikato River downstream of Ngaruawahia mostly comprises of one, but up to three, vegetation and habitat types:
    - Exotic tree and/forest (e.g: willow, alder, and privet)
    - Herbaceous wetland (which largely comprises introduced plant species, many of them invasive)
    - Rough or improved grazed pastureland.

3. Develop a restoration plan

A restoration plan needs to be developed and should be a one-stop shop that provides direction to a project in terms of tasks, timelines and methods.

- **Introduction** - provides the background to the project, including who instigated it, why it was initiated, the key participants, and who is going to be managing it
- **Ecological and/or cultural context** - an overview of the immediate landscape in which the site is located, including a description of other nearby natural areas, and historical and cultural relevance
- **Goals and objectives** - the over-riding purpose of the project, and the specific outcomes being sought
- **Location and land tenure**
- **Site description** - existing features: landform(s), hydrology, water control structures, vegetation and habitats, flora, pest plants, and fauna

- **Issues and constraints** - particular issues that need to be taken into account when putting together a restoration programme e.g. in relation to access, exclusion of stock, pest plant control, other parties' interests such as drainage and flood control, planting, the need for resource consents
- **Restoration/enhancement approach** - an overview of what is going to be done and how it fits in with other restoration initiatives
- **Project area boundaries** - a figure showing management units (if applicable), and/or areas in which pest plants are to be controlled, planting is to be undertaken, and fencing is to be erected
- **Site preparation** - what needs to be done prior to planting e.g. pest plant control, erosion prevention, exclusion of stock, and pest animal control (e.g: rabbits, possums)
- **Plants and planting** - where, what, and when, including plant schedules for initial, infill, and enrichment planting, plant sourcing, plant sizes, plant spacings, and timing

- **Maintenance** - releasing, pest plant control, infill planting, and pest animal control
- **Monitoring** - reasons for monitoring, methods and timing of monitoring, data storage, and project review and progress reporting
- **Work plan/implementation schedule** - tasks, timing, costs, training and who is responsible

Determining the planting boundary

Identifying the planting zone correctly is key to ensuring the long-term success of the project and significantly reducing the on-going cost of weed control. Planting within the flood zone significantly increases the cost of weed control, damage to plants in a flood event and the possibility that your planting zone could become infested by a pest plant. In the event of a pest plant establishing within your planting zone contractors working to control the pest may inadvertently cause negative effects on your planting through spray drift or the use of residual agrichemicals.

Waikato RiverCare recommends your planting zone should start at 'mean high water'.This doesn't mean big flood events will not affect your planting, the aim is simply to get above average river flows.

Along the river there are likely to be plant species that indicate or provide an insight and a practical means of determining the location of 'mean high water' or upper flood zone. Alder, yellow flag iris, willow weeds *(Persicaria spp.* and/or *Polygonum spp.)* and beggars' tick *(Bidens frondosa)* are the best indicators for identifying the lower boundary of the upper flood zone.

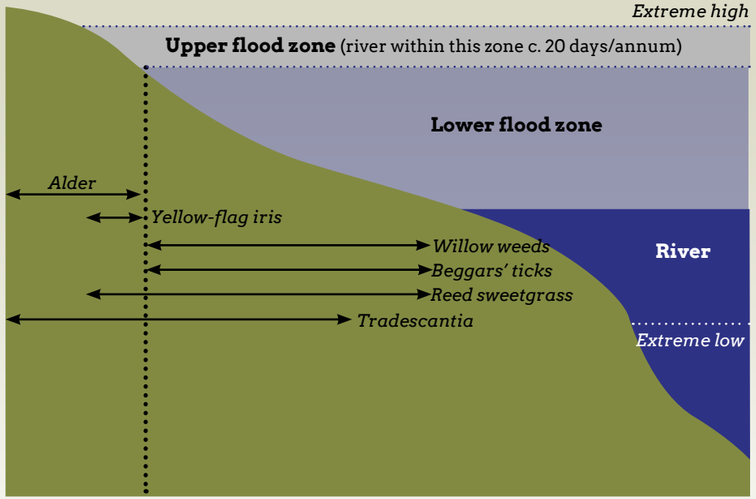
The next best option is to work downwards from the approximate location of the upper boundary. Identify the upper boundary by again using species indicators. This zone often comprises grazed pasture and the demarcation line is generally quite obvious. From this, estimate the position of the lower boundary by measuring a vertical distance downslope of approximately:

- 1 m if the site is in the vicinity of Ngaruawahia
- 1.5 m if the site is located between Huntly and Mercer
- 1-1.25 m near Tuakau
- 0.5 m in the vicinity of Hoods Landing.

When determining planting boundaries take note of the Waikato Regional Council rules relating to how close planting can be undertaken within the vicinity of stopbanks, pump station outlets and floodgate structures. No planting can be undertaken within 10 m of the toe of stopbanks, or within a 10 m radius of outlets and structures. No plant roots are permitted within 5 m of the toe of a stopbank or any other flood control structure. This means that when planting trees you should allow for a 20 m gap between identified structures.

Between the Tuakau Bridge and the river mouth, river levels fluctuate daily as a consequence of tides, and seasonal flooding therefore plays a lesser role in this section of the river. For this reason the flood zone can be termed the tidal zone.

Potential plant indicators for identification of the boundary between the upper and lower flood zones



Based on observations made by Wildland Consultants (2013).

Target weeds and control methods

The greatest barrier to creating self-sustaining native planting is the ongoing establishment and spread of weeds. Correctly preparing a site by significantly reducing or removing identified weed species and then establishing an ongoing maintenance programme is key to increasing a project's long-term success. It is strongly recommended that between 6 to 12 months of weed control be completed before planting begins. At particularly weedy projects additional time may be required to achieve weed suppression.

The most common weeds you'll encounter are: tradescantia; pampas; yellow flag iris, common alder, inkweed, Chinese privet, reed sweetgrass, bindweed, creeping jenny and black nightshade. Locally significant weeds include ginger, Himalayan honeysuckle, Japanese honeysuckle, German ivy, *Rubus sp.*, woolly nightshade, onion weed, nasturtium and *Persicaria spp.*

To help you identify weeds, this table outlines the common and species names.

Species	***Common Name***
Acer negundo	Box elder maple
Alnus glutinosa	Common alder
Alocasia brisbanensis	Elephants ear
Alternanthera philoxeroides	Alligator weed (notify Waikato Regional Council if detected)
Calystegia sepium	Hedge bindweed
Calystegia silvatica	Greater bindweed
Cortaderia jubata	Purple pampas
Cortaderia selloana	Pampas
Crataegus monogyna	Hawthorn
Glyceria maxima	Reed sweet grass
Hedychium gardnerianum	Kahili ginger
Ipomoea indica	Blue morning glory
Iris pseudacorus	Yellow flag iris
Jasminum polyanthum	Jasmine
Juglans ailantifolia	Japanese walnut
Ligustrum lucidum	Tree privet
Ligustrum sinense	Chinese privet
Lonicera japonica	Japanese honeysuckle
Muehlenbeckia australis	Puka (indigenous species - can be problematic during establishment)
Pennisetum clandestinum	Kikuyu
Phytolacca octandra	Inkweed
Rubus fruticosus agg.	Blackberry
Salix cinerea	Grey willow
Salix fragilis	Crack willow
Senecio mikanioides	German ivy
Solanum mauritianum	Woolly nightshade
Solanum pseudocapsicum	Jerusalem cherry
Tradescantia fluminensis	Tradescantia

Herbicide treatment is the most cost effective and successful method to control unwanted vegetation within your planting zone; however herbicide use is restricted to people that have completed "grow safe" training or are under the direct supervision of a qualified person. When using herbicide ensure you follow all manufacturer's recommendations on the label including wearing required PPE, mixing the correct concentration of the herbicide and ensuring its application in calm weather conditions. If your project is located on public land you may be subject to additional controls or measures when using herbicide. Useful advice and 'how to' guides are available online at sites such as:

www.waikatoregion.govt.nz
www.weedbusters.co.nz

You can also ask professional weed control operators working in this environment for advice.

Some weeds may need to be treated two to three times before planting. In particular yellow flag iris, tradescantia, and gorse need to be guaranteed as completely excluded from the site before planting.

Erosion control needs to be considered during site preparation. A significant erosion event can have immediate, serious impacts on a restoration project, but insidious ongoing erosion of river banks at a smaller scale can result in the same effects over a longer time period. Consultation with Waikato Regional Council river engineers prior to, or during the course of, site preparation will help to avoid such effects.

If machinery is being used to remove vegetation, care should be taken to minimise the cultivation of and disturbance to soil, as this can lead to erosion and sediment loss. Use of machinery for this purpose generally requires a resource consent.

Generally, all grey willow *(Salix cinerea)*, alder *(Alnus glutinosa)*, and privet *(Ligustrum spp.)* should be killed in situ, unless there are very good reasons for not doing so. These species seed prolifically and are an ongoing threat to restoration initiatives. However, crack willow *(Salix fragilis)*, weeping willow *(Salix babylonica)*, and/or sterile willow varieties such as Moutere and Booth, or other large, non-invasive tree species which are growing on, or close to the river margin, should not be poisoned or physically removed unless specialist advice from river engineers sanctions this. These trees may be preventing or retarding erosion of the river bank.

Plants to use

A staggered approach to the planting project is recommended by Waikato RiverCare. Planting early colonising species first reduces weed encroachment, soil and water loss (erosion), whilst creating a micro environment that supports and encourages slower growing successional species.

Many of New Zealand's native plants require established vegetation cover to be successful; exposure to excessive wind, frosts and sunlight can all be damaging to a new planting.

Initial planting

In Year 1 the initial planting should comprise of PB2/3-sized plant grades at relatively close spacings using identified 'colonising' species found in the area.

While some faster-growing canopy species should be included in the Year 1 planting schedules, most slower-growing successional species should be planted once there is primary canopy closure. Planting of these species, along with understorey trees and shrubs and ground cover species should be undertaken in around Years 3-5, or later depending on circumstances.

Ecosourced Waikato has developed indigenous plant lists and planting guides for the lower Waikato River, and Waipa River, with support from the Waikato District Council and the Department of Conservation.

The planting guides provide useful information on species' niches and roles, environmental tolerances and preferences, food values for birds, indicative planting densities, and microsites for planting. The guides can be accessed at ***www.doc.govt.nz*** .

Recommended plant selection for initial (Year 1) planting of river bank sites between Hamilton City and Ngaruawahia

Colonising species
(from wettest to driest sites)
Plagianthus regius
Cordyline australis
Hoheria sexstylosa
Carpodetus serratus
Coprosma robusta
Leptospermum scoparium
Aristotelia serrata
Hebe stricta
Sophora microphylla
Kunzea ericoides

Canopy trees
(from most to least common)
Dacrycarpus dacrydioides
Podocarpus totara
Alectryon excelsus
Knightia excelsa

Colonising species
Hebe stricta
Austroderia fulvida
Coprosma robusta
Phormium cookianum
Kunzea ericoides

Canopy trees
(from most common to least common)
Weinmannia racemosa
Sophora microphylla
Cordyline banksii

Recommended plant selection for initial (Year 1) planting of river bank sites between Ngaruawahia and Tuakau

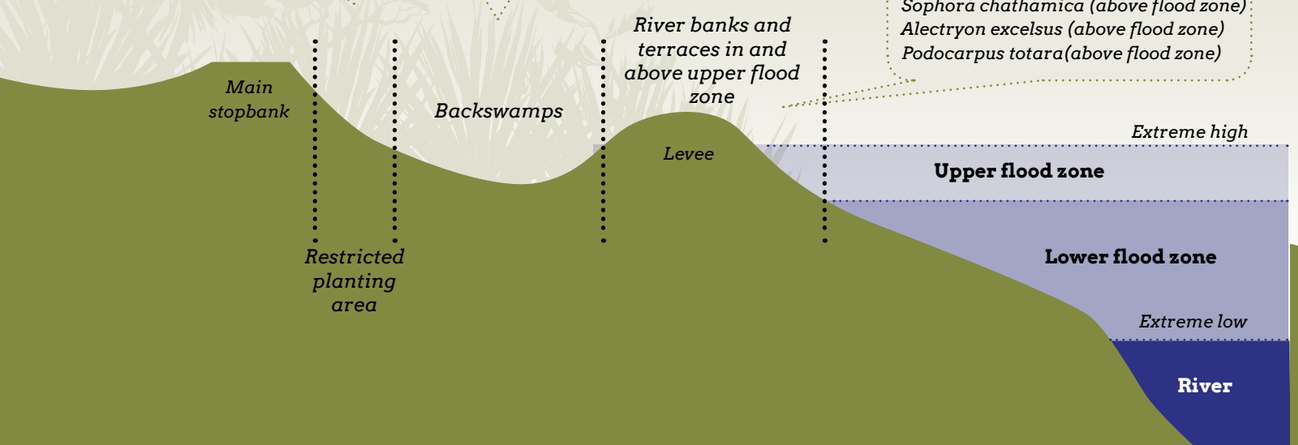
No planting within 10m of the toe of the stopbank. No planting of tall trees within 20m of the top of the stopbank.

Colonising species
(from wettest to driest sites)
Typha orientalis
Phormium tenax
Carex geminata
Bolboschoenus fluviatilis
Cyperus ustulatus
Leptospermum scoparium
Cordyline australis
Coprosma robusta

Canopy trees
(from most to least common)
Dacrycarpus dacrydioides
Laurelia novae-zelandiae
Syzygium maire
Sophora microphylla (dry margins)
Sophora chathamica (dry margins)

Colonising species
(from wettest to driest sites)
Phormium tenax
Cordyline australis
Coprosma robusta
Plagianthus regius
Kunzea ericoides (above flood zone)
Hebe stricta (above flood zone)
Aristotelia serrata (above flood zone)

Canopy trees
(from most to least common)
Dacrycarpus dacrydioides
Sophora microphylla(above flood zone)
Sophora chathamica (above flood zone)
Alectryon excelsus (above flood zone)
Podocarpus totara(above flood zone)



Recommended plant selection for initial (Year 1) planting of river bank sites between Tuakau and the Waikato river mouth

BACKSWAMPS
Colonising species
(from wettest to driest sites)
Typha orientalis
Machaerina articulata
Machaerina rubiginosa
Carex secta
Carex virgata
Cyperus ustulatus
Phormium tenax
Austroderia splendens
Cordyline australis
Coprosma robusta

Canopy trees
(from most to least common)
Dacrycarpus dacrydioides
Laurelia novae-zelandiae
Sophora microphylla (dry margins)
Syzygium maire

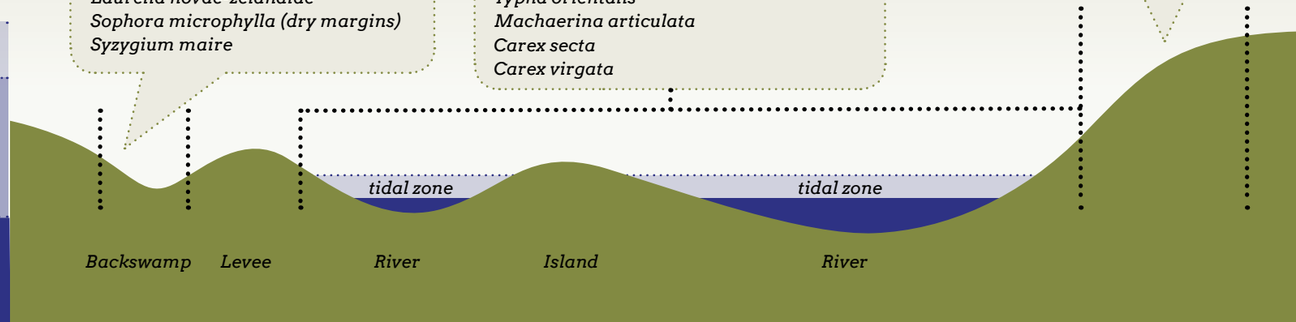
LOW ISLANDS AND RIVER MARGINS
Colonising species
(from wettest to driest sites)
Phormium tenax
Cyperus ustulatus
Austrodena splendens
Cordyline australis
Coprosma robusta

Canopy trees
(from most to least common)
Dacrycarpus dacrydioides
Sophora microphylla (above flood zone)
Sophora chathamica (above flood zone)

Grasses and sedges
(from wettest to driest sites)
Typha orientalis
Machaerina articulata
Carex secta
Carex virgata

STEEP RIVER BANKS AND TERRACES ABOVE FLOOD ZONE
Colonising species
Hebe stricta
Coprosma robusta
Cordyline autralis
Kunzea ericoides

Canopy trees
(from most to least common)
Dacrycarpus dacrydioides
Sophora microphylla
Sophora chathamica
Alectryon excelsus



Infilling, enrichment, and successional planting

Plants that die within one year of planting should be replaced with fast-growing, colonising species used in the initial planting. It is not unreasonable to expect losses of up to 10% due to uncontrollable environmental variables.

When the primary planting has formed a complete canopy within the planting zone it is recommended to plant slower-growing successional species. The canopy suppresses weeds and pest plants allowing the establishment of understorey and ground cover species. Other enrichment planting may need to be deferred for some years until vegetation cover and structure is more advanced. Plant selections for these undertakings can be generated from Ecosourced Waikato's planting guides.

Plant sourcing, plant sizes, and plant spacings

It is recommended that plants used in the restoration project are eco-sourced (i.e. seeds are sourced from mature native plants found in close proximity to the planting site). By using eco-sourced native plants the area's unique local plant characteristics are preserved and the plants are more likely to survive.

Using eco-sourced plants reduces the risk of planting species which are not native to the local area and which could become invasive.

Larger plants are typically supplied in soft plastic bags or hard plastic pots. A PB2/3 sized bag container or its pot equivalent (1.2 litres - 1.5 litres) is recommended as being a robust yet cost-effective plant grade to use in this environment.

Open ground should be planted at a density of no less than 70 plants per 100 m2, which is a plant spacing of 1.2 m. In practical terms it can be challenging to do this, but it is important to ensure spacings do not materially exceed this, as rapid canopy closure is what is required to facilitate the ongoing suppression of pest plants.

On particularly weedy or problematic sites it may be desirable to go to spacings closer to 1 m, but the downside to this spacing is that it is equivalent to 100 plants per 100 m2 or 10,000 plants per hectare, which is significantly more costly.

- *When selecting plants the vegetation should be 500-600mm high for the best chance of survival*
- *Some nurseries supply plants in pots not plastic bags. Conversion for PB's to pots: PB2 and PB3 equal pot sizes of 1.2 – 1.5 litres*
- *Plants that have been pruned to reduce vegetation while building root mass look of poor quality but respond well to planting*
- *Remember to remove PB's or pots from the planting site*

While the overall spacing of open ground plantings should generally be no greater than 1.2 m, canopy trees, particularly tall-growing species, should be planted at least 3.0 m from another canopy specimen, which is a density of approximately 10 plants per 100 m2.

As a general rule of thumb, understorey plants should be planted at a density of approximately 25 plants per 100 m2, which is equivalent to a spacing of 2 m. Grasses and sedges are often best planted in clumps, but spacings between individual plants, depending on species, may be reduced to 0.5- 0.7 m.

Germination and natural regeneration of at least two non-bird dispersed species - ribbonwood and houhere – is greatest where these species have been planted in clusters rather than singly and widely-spaced. This may be the case for other species also, and it may be useful to apply this approach more widely and plant other species in groups of 3-5, rather than placing individuals more randomly.

'Edge' effects are less at sites where the interior is sheltered by the presence of 'bushy' plants established along margins. Indigenous canopy closure and plant height advance better at sites where kawakawa, koromiko, and harakeke form a relatively dense edge to the area planted. This effect can also be achieved by planting margins at closer spacings, e.g. 1 m.

Low-growing and/or light-demanding species - such as koromiko and kowhai - will, ultimately, be competitively overtopped if closely surrounded by taller growing species. If an objective is to retain species such as this, they will also need to be established on margins and in open areas.

Photo: S. Frimmel

Timing of planting

Most sites above the flood zone or tidal zone that are unaffected by rising river levels can be planted during the winter months, from May onwards, although discretion should be used if a late summer drought has extended through autumn and into early winter.

Planting into the upper flood zone should generally be deferred until September, and/or when river levels are receding after sustained winter highs, which in some years may not be until mid to late October.

Maintenance

The ongoing success of a riparian project is extremely dependant on comprehensive weed management and plant releasing. With the absence of a canopy, nutrient abundance and a high light environment, grasses and weed seeds within the planting zone will require control, particularly over the key growing months from October to January. As the planting matures the time and costs of plant releasing decrease as the canopy forms, reducing light and space for weeds to occupy.

Some weeds will remain a threat to a planting even after the formation of a canopy; examples include bindweed *(Calystegia spp.)* or other climbing vines including the indigenous puka *(Muehlenbeckia australis)* which remains a threat even when plantings are 2 m or more in height.

Other project maintenance typical of a lower Waikato River planting includes infill planting, periodic pest animal control and fence maintenance after flooding.

A pest plant control plan should be prepared which identifies the species to be targeted, when, and how, so that an integrated work programme can be prepared and scheduled. Control of many weeds can only be achieved with persistent, systematic and ongoing effort and, in this environment, it is very likely that weeds will need to be treated up to four times a year.

Animal damage to plantings is not always confined to rabbits, hares, possums, or domestic stock. Issues can also arise with wetland birds such as pukeko, canada geese, and black swan.

More than minor erosion of the river bank may require attention, and consultation with Waikato Regional Council should be undertaken at an early stage.

Projects need to be reviewed (at least informally) after every site inspection, and debriefings undertaken after key tasks have been implemented on-the-ground, e.g. pest plant control, final site preparation prior to planting, planting, and releasing.

Brief notes should be compiled after each debriefing, recording the date, who was involved, key issues, actions and observations. These can be bullet-pointed notes, stored in a project folder.

Monitoring and measurement

Monitoring of key aspects of a project - from beginning to end - is important to measure progress against objectives and identify issues requiring management intervention. Monitoring also provides information that can be used to profile a project, or obtain additional funding for it or another initiative.

Aspects to be monitored should be identified during the project planning phase, and baseline observations obtained prior to commencement of physical works.

Once site preparation has started, initial site inspections should be undertaken at least monthly, to monitor progress in relation to pest plant control, or as and when required to monitor or audit the effects of particular undertakings.

Site inspections should be undertaken weekly immediately following planting, with particular emphasis on monitoring of plant survival and identifying whether other issues have arisen, such as pest animals.

After a month or so, if there are no major issues to deal with, plantings should be inspected on a fortnightly to monthly basis, depending on seasonal conditions and provisional timing of upcoming management undertakings such as releasing and weed control.

In addition to site inspections, simple monitoring using permanent photopoints should be established at appropriate locations, to record changes in vegetation and habitats over time. These need to be installed prior to works commencing, and should be re-photographed as and when needed to capture significant change as it becomes apparent, and/or annually for at least the first five years of the project. A photographic record should also be maintained of issues, activities, and events as they occur.

Depending on project objectives, quantitative monitoring programmes could be established to augment qualitative observations, e.g. permanent vegetation plots, bird counts, and invertebrate monitoring.

Measurement

There are a wide range of goals and outcomes from undertaking a riparian restoration programme. The following table summarises riparian restoration indicators, measurement methods, and monitoring time scales for riparian restoration projects along the lower Waikato River.

Goal codes:

EF = Ecosystem Functioning
NH = Natural Habitat
TB = Terrestrial Biodiversity
A = Aesthetics
C = Cultural and Spiritual

For detailed information on these measurement methods you can refer to the Department of Conservation's vegetation inventory and monitoring toolbox.

Visit ***www.doc.govt.nz*** for more information.

Indicator	*Goals*	*Measurement Method*	*Suggested Minimum Monitoring Time*
Survival of plantings	NH, TB, A, C	Photopoints, quick plots, transects, marked plants.	Photopoints annually first five years then at five-yearly intervals. Quick plots, transects at project start and then at 2-3 yearly intervals.
Canopy height	EF, A	Recce plots	At project start and then at 3-5 yearly intervals.
Canopy closure	EF, A	Canopy cover assessments, Recce plots	At project start and then at 3-5 yearly intervals.
Relative dominance of different planted species (structural diversity)	EF, NH, TB	Recce plots	At project start and then at 3-5 yearly intervals.
Total indigenous/exotic species cover	EF, A, C	Recce plots, assessment of overall cover	At project start and then at 3-5 yearly intervals.
Indigenous plant species diversity	EF, NH, TB, C	Recce plots	At project start and then at 3-5 yearly intervals.
Litter abundance	EF, NH,	Recce plots	At project start and then at 3-5 yearly intervals.
Indigenous vs. exotic weed regeneration/recruitment	EF, TB	Recce plots	At project start and then at 3-5 yearly intervals.
Microclimate	EF, NH	Air temperature and relative humidity data loggers	
Bird species abundance	EF, NH, TB, A	Slow walk transects	Annually first five years then at five-yearly intervals.
Invertebrate species abundance	EF, NH, TB	Pit fall traps	Annually first five years then at five-yearly intervals.

Improved Approaches and Techniques

To improve plant survival and the resilience of restoration sites, the following approaches and techniques are suggested:

- Avoid planting below average winter river levels until planting trials have determined what will establish and grow successfully in this particularly challenging environment
- Ensure that restoration sites are at least 10 m in width, or where this isn't an option plant the margins with 'bushy' indigenous plants that will provide shelter for the interior
- Select sites where invasion by weeds is likely to be slower, e.g. sites upstream of weed control programmes, sites without dense weed populations within 1 km, or sites that are currently weed-free
- Proper site preparation is extremely important
- Plant selection is crucial. Carefully match plant species and their tolerances and preferences to the habitats present at each site
- Provide timely and comprehensive ongoing monitoring for each site
- Weed control is critical, especially as plantings are becoming established
- Provide high quality maintenance (3 years post planting) of a restoration site; including weed control, infill planting and discourage the dumping of garden waste
- Ensure that all grazing and browsing domestic stock are excluded permanently by good fencing and that fences are located at least 1.5-2 m from the nearest plantings. Consider the necessity of gates within fencelines. Encourage the use of permanent wire strainers on new fences to provide access in and out of a planting project.
- Consider the use of fencing for new urban sites and erection of signage to reduce human disturbance during the establishment phase
- Consider trimming or the creation of canopy gaps on the landward sides of crack willow stands where planting is undertaken, to reduce shading, which will improve the survival of normal winter flood zone planting and allow better development of a 'closed edge'

Limitations and risks

There are some project limitations and risks to keep in mind when planning and undertaking riparian restoration along the lower Waikato River.

Limitation or Risk	*Potentially Unachievable Goals*	*Achievable Goals*	*Possible Means to Improve Chances of Success*
Restoration provides minimal intercept of runoff and shading of river habitat to improve water quality or in-stream habitat.	Iwi cultural objectives related to: aquatic biodiversity, water, quality, river health and fisheries.	Natural habitat. Terrestrial biodiversity. Some ecosystem functioning. Aesthetic value.	Trials for river edge species (see below) may help.
Highly modified river and floodplain and hydrology.	Natural habitat and terrestrial diversity (below the flood zone).	Some ecosystem functions, terrestrial plant diversity (above the flood zone), Aesthetic value. Habitat for tolerant species.	Investigate use of evergreen exotic and indigenous species that might replace willows to enable better establishment of typical indigenous species.
Excess sediment and flood debris in the flood zone and long flood durations damage plants.	Natural habitat. Aquatic biodiversity. Ecosystem functioning. Iwi cultural objectives related to the above.	Some terrestrial biodiversity short term.	Limit planting zone to above flood level; trial species and size of stock for this zone.
River erosion makes retention/planting of willows unavoidable.	Natural habitat and terrestrial diversity (along the river margin).	Some ecosystem functions, terrestrial plant diversity (above the river edge). Aesthetic value. Habitat for tolerant species.	Trial shade tolerant species and indigenous species for bank stability; trial trimming of willow canopy on landward side.

Limitation or Risk	*Potentially Unachievable Goals*	*Achievable Goals*	*Possible Means to Improve Chances of Success*
Extensive unrestored stream length upstream of restoration site, with extensive weed presence.	Natural habitat. Terrestrial biodiversity. Ecosystem functioning. Iwi cultural objectives related to the above.	Some terrestrial biodiversity short term.	Work with Regional Council weed control programmes or carry out buffer weed control upstream of restoration site.
Indigenous habitat (natural source of seed) is often not within a reasonable distance of prospective sites.	Natural habitat. Terrestrial ecosystem functioning may be limited. Iwi cultural objectives related to the above.	Some terrestrial biodiversity short term.	Enrich planting after establishment period with successional species for long term seed supply.
Stopbanks and roads sometimes limit the width available for planting.	Terrestrial ecosystem functioning may be limited.	Aesthetic value. Habitat for tolerant species.	Establish good edge planting with dense shrub species.
Limited resources to maintain sites beyond five years.	Natural habitat. Terrestrial ecosystem functioning may be limited.	Terrestrial biodiversity short term.	Investigate/revise funding distribution over the project life to enable periodic monitoring and release maintenance.
Possible stock access.	Natural habitat. Terrestrial biodiversity. Terrestrial ecosystem functioning may be limited.	If stock excluded: Natural habitat; Terrestrial biodiversity; Terrestrial ecosystem functioning may be limited.	Insist on stock-proof fences.
Possible direct human impacts.	Natural habitat. Terrestrial biodiversity. Terrestrial ecosystem functioning may be limited.	If human disturbance is controlled: Natural habitat; Terrestrial ecosystem; Terrestrial biodiversity.	Possibly fence sites to discourage access or rubbish dumping.

Restoration targets

A key component of being able to judge whether the ecological success has been achieved is having an "endpoint" that determines when the restoration project is complete.

Natural systems are dynamic and subject to gradual or abrupt changes depending on a range of conditions created by environmental conditions and events. This "dynamic equilibrium" also relates to the functioning of natural riparian ecosystems. The endpoint for a riparian restoration project would normally be the ecological state and condition of a nearby reference site that has a similar size, geology, soils, topography and range of habitats. A site which is relatively unmodified, with its ecological processes intact.

Restoring the riparian environment is a highly satisfying and ecologically important task. By undertaking a restoration project you are enhancing a valuable New Zealand resource.

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Waikato RiverCare

Private Bag 4115
Hamilton East
Hamilton 3216
info@waikatorivercare.co.nz
www.waikatorivercare.co.nz