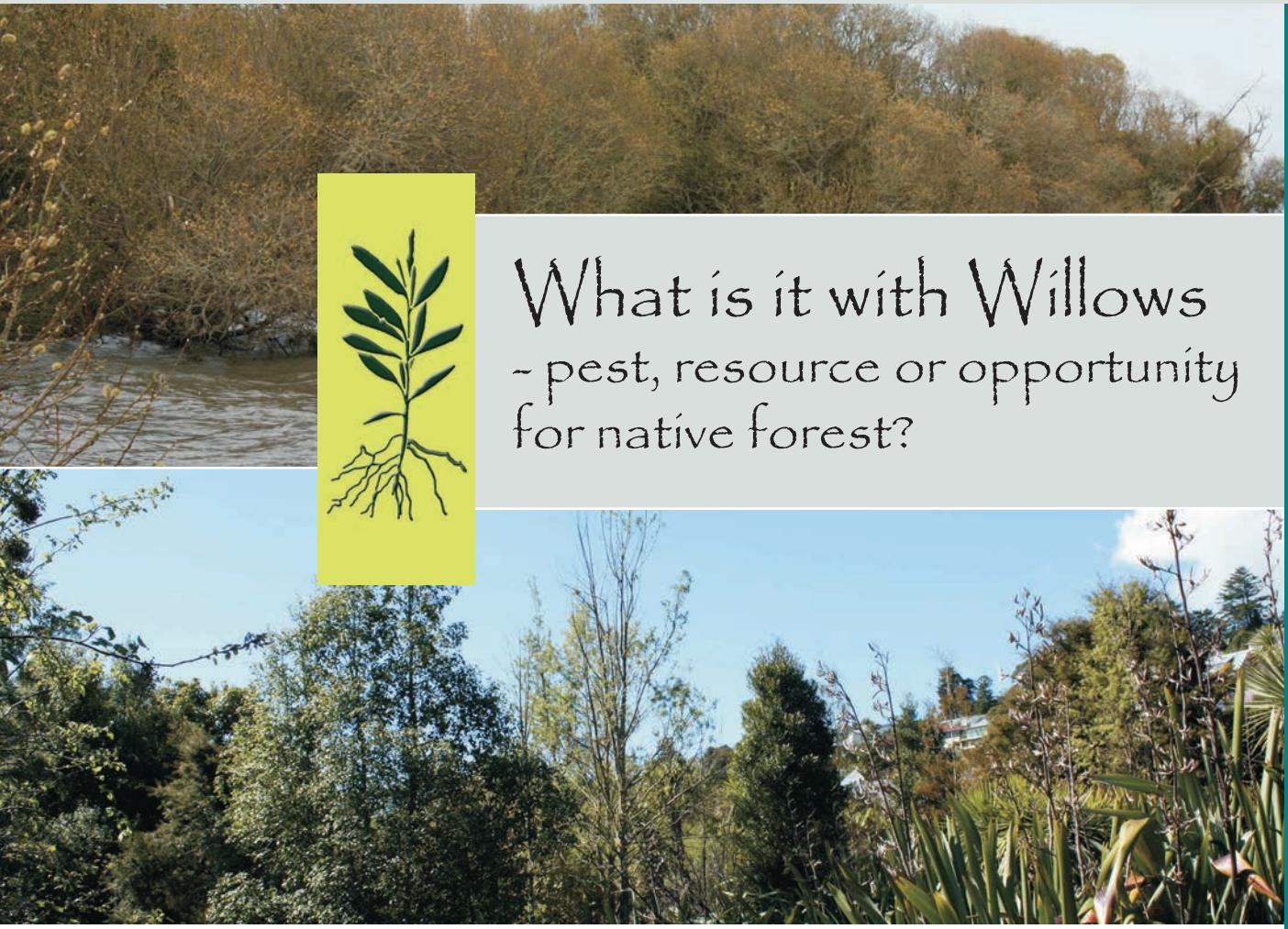

What is it with Willows
- pest, resource or opportunity for native forest?

BACKGROUND

One of the many time bombs in the New Zealand landscape is the introduced willow. There are 11 species and 5 hybrids reported in New Zealand (Webb et al. 1988) out of around 400 willow species worldwide, mainly in wet or cool environments of the northern hemisphere. They range in stature from lofty and graceful trees to tiny dwarfed mats. They are famous for containing the valuable pharmaceutical salicin – which is the natural active ingredient of aspirin. They have been traditionally used for basket weaving, 'wattle and daub', furniture, medicinal and cultural purposes – including for cricket bats.

Relative of poplar

Willows are related to poplars which have many similar characteristics of very rapid stem and root growth, soft light wood, deciduousness, separate male and female plants, and production of massive amounts of light wind-blown seed. The fine feathery seed-containing capsules may be produced in such abundance as to resemble snow (especially with some of the poplars). The similar, but unrelated, prolific wind-blown seed of the fireweed genus *Epilobium*, has led to their alternative name – willow herb. Seedlings then establish downwind of a seeding tree in vast numbers on moist bare soil. Amazingly willows and poplars can be established with bare poles stuck in the most inhospitable ground and while they prefer moist soils they can tolerate extremes of temperature and drought.

Miracle plant for riverbanks

The regenerative powers are exceptional. They are highly valued in some quarters because of their prodigious growth and ability to colonise and stabilise eroding river banks and cuttings. The roots of willows rapidly form a dense meshwork in the substrate. They seem like miracle plants – the best thing since

sliced bread! Huge numbers were planted as vegetative clones by Catchment Boards during the post WWII era. And they are now ubiquitous in the New Zealand cultural landscape and many people would imagine they have always been here.

New Zealand has, since its colonial beginnings, had a preoccupation with introducing every foreign species of plant and animal into this country that would grow or live here – to plug the perceived gaps in the natural environment and provide resources the settlers were familiar with, were useful and easy to propagate. The attitude was that the native biota was inferior (compared to familiar northern hemisphere species), doomed to extinction and therefore needed to be 'improved' on or bolstered with imports. This phase of introductions was extremely successful, and the rest, as they say, is history. In many cases, such as willows, they were just too successful. In fact, local authorities have been actively removing them from clogged streams and rivers to reduce flooding.

Willow sawfly

But there are supporters and detractors. As an example of current ambivalent attitudes to willows it is noted that the willow sawfly was accidentally introduced to New Zealand over 10 years ago. It has been observed defoliating crack, matsudana, weeping and golden willows and their hybrids – in other words most of the tree willows occurring in New Zealand, but not the sallows or osiers (Charles et al. 1999). This might have been seen as a rare happy occurrence of a natural biological control of a pest arriving unassisted. But the response from some researchers was to seek science money to investigate a possible biological control for the sawfly – despite concerns being expressed several years ago that more caution was required (Harman 2004).

The willow sawfly accidentally introduced to New Zealand a decade ago illustrated the ambivalent attitude to willows - supporters and detractors!

WILLOW SPECIES AND THEIR CHARACTERISTICS

We have about a dozen willow species growing wild or maintaining themselves in the wild. The good news is that mercifully only two of these, and none of the poplars, have been introduced or established as widespread breeding populations. Most are single sex clones and can only reproduce vegetatively – that is by twigs falling on the ground and taking root. Some mixed gender stands have been experimentally established along the Waimakariri River, north of Christchurch, and near Aokautere by the former National Plant Materials Centre over 20 years ago. Many of these trial sites have residual breeding populations.

A time bomb!

The typical trajectory of pest species in this country is for arrival to be followed by a long lag period, while the species becomes genetically acclimatised or builds up a critical mass of individuals or the environment becomes more suitable, then sudden rapid expansion. In the case of willows, most of the species in this country are hybridising even if they exist as 'pure' species only as single sex clones. So the potential is there for an explosion of these aggressive plants, perhaps assisted by hybrid vigour, following the trend set by the highly invasive grey willow.

The most common species

The most common willow species in New Zealand are male crack willow (*Salix fragilis*), fertile grey willow (*Salix cinerea*), female weeping willow (*Salix babylonica*) and predominantly male pussy willow (*Salix* X*reichardtii*) – a hybrid, where the male catkins are especially soft, golden and fluffy, grown primarily for amenity. Female golden willow (female *Salix alba* var. *vitellina*) and tortured willow (*Salix matsudana*) are more localised, as is the osier (*Salix viminalis*) which is popular for basket weaving. This last species, and grey willow, share the sinister property in New Zealand of being fertile and threaten many open habitats with plagues of seed.

Even in Europe willows are often managed with cattle or traditionally by regular cutting for wattles or weaving materials. Otherwise wetland reeds and other herbaceous species become shaded out. Crack willow is essentially a species of river banks with mineral soil substrate as is weeping willow. Grey willow or sallow and osier are in contrast preferentially associated with peat or fen soils (moderately low fertility).

In willow-dominated riparian areas there can be a wide range of native and exotic species provided there is a local seed source.

Regenerating mahoe, five-finger, coprosma, totara and kahikatea under grey willow near Ahuriri Lagoon, Canterbury, approximately 3 km from the nearest natural seed sources.

Regenerating five-finger, tree ferns, mahoe, kiokio, and various weeds such as ivy and blackberry, under crack and grey willow beside the outlet of Lake Rotorua.

VALUE OF WILLOWS

Habitat for fauna

Apart from the utilitarian values of willows they also provide habitat for birds, fish, and insects. The fresh young spring shoots are enjoyed by kereru (wood pigeon). Willows can provide a nursery for regenerating native (and exotic) forest species, especially those dispersed by kereru or other fruit eating bush birds that may also be attracted by and glean insects from willow forests. However, the observation of matai (*Prumnopitys taxifolia*), with its large fruits only known to be dispersed by kereru in New Zealand, under a grey willow stand near Motukarara, near Banks Peninsula, along with totara and many other native berry-fruited trees and shrubs, indicates that it is these birds with their large gapes that are indeed visiting these places to feed on the spring foliage, and are incidentally spreading the seed . Similarly, a recently visited Lake Rotoiti (North Island) riparian willow woodland supports a wide range of native plants, but fewer podocarps, probably a factor of proximity to seed sources.

Willows as a nurse for natives

The willow is in some respects the ideal pioneering, nursery plant for native regeneration. It has sufficiently dense canopy foliage in summer to shade out exotic competing grasses, while in autumn through early spring the deciduous habit permits the evergreen native species to 'make hay while the sun shines'. In fact many native trees and shrubs have a double flush of growth at the margins of summer. The willow branches and twigs in their winter state, additionally provide some shelter from frost; an ideal arrangement.

Landscape scale native forest dynamics, within the context of willows as receptive establishment sites, has been described by Meurk and Hall (2006). The nearest nursery equivalents in the native flora, capable of growing to small tree size in similar fen soils, are manuka (*Leptospermum scoparium*), cabbage trees (*Cordyline australis*), karamu (*Coprosma robusta*), mikimiki (*Coprosma propinqua*) and swamp maire (*Syzygium maire*). Willows occupy thousands of hectares of floodplain and riparian land in New Zealand and as such are potentially rich kahikatea-pukatea/pokaka forests.

SEX PROBLEMS

Crack willow does alter the hydrology of waterways, which is at least limited to the downstream spread of twigs along riverbeds and banks. But the real concern is with the few fertile species and the potential of others to form fertile populations. All the tree and shrub species of willow hybridise amongst their own group and there are male and female clones in the wild for each group. Once a breeding population of any of the willows (or poplars for that matter) is established, transformation of the New Zealand landscape would be total. It would be faster, and less controllable, than the present nightmare of wilding conifers in the high country. Grey willow is already showing this potential with major and increasing infestations of wetlands around New Zealand.

Typical riparian area dominated by crack and grey willow coming into leaf in early spring, Lake Rotorua.

WHAT CAN WE DO ABOUT IT?

Urgent action on policy

Like many weed problems, the longer they are left the harder and more expensive it will be to eradicate let alone control them -

'one year's seeding, seven years' weeding'.

Eventually, it will be beyond the physical and economic capabilities of governments and communities to deal with it. The case of the sawfly referred to above highlights the need for dialogue amongst the various stakeholders so that benefits, threats and appropriate courses of action are agreed on by all parties. The currently conflicting agendas are both a waste of money and potentially damaging to the environment and biodiversity. So there are policy and management issues to be addressed to ensure everyone is pulling in the same direction.

From a policy perspective, the urgent need is to firstly restrict and perhaps ultimately eradicate fertile species and those represented by female clones. The complementary need is to look at indigenous or non-invasive species that can perform the same useful functions that willows do. It needs to be accepted that flashy, fast growth is a two-edged sword when it comes to exotic species.

Apart from biological control, such as by the willow sawfly or rusts, there are various other interventions possible to control willows (see www.weedbuster.co.nz).

Ground-based control

Cut, paint and extract

Where there are relatively small infestations of willow it is feasible to use a work gang to go through and physically remove plants. Care must be taken to remove all twigs, branches and logs. The operation is likely to have to be repeated on an annual basis for many years. In any event, cut stumps will need to be painted with herbicide to prevent resprouting. The formula used at Lake Kaituna, Waikato was 4 parts diesel and 1 part glusomate (Bodmin 2010). It is best to apply this to fresh cuts in mid-summer, after the active Spring rise of sap has subsided, as new photosynthate is beginning to be translocated back to the roots, but before foliage has started to colour. For spraying stumps add a few drops of vegetable dye to avoid missing stems that will resprout. This or other eco-dyes are safer than some of the older varieties. It can be applied using a 'pump pot'."

A practical method for removal of willows to allow planting of natives is cutting trees down and painting stumps with a concentrated solution of glyphosate and diesel.

Restoration of a wetland site underway where native shrub hardwoods are being planted after willows have been cut down and stumps swabbed with herbicide.

Drill and inject

This is probably the best method for moderate infestations - to drill every 10 cm around the tree trunk (with a 1 cm bit down to 10 cm), 30 cm above ground level, and then dribbling or injecting the herbicide (same mix as above) to fill the holes. When drilling large trees, use quite shallow, downwardly-angled holes - enough to hold the herbicide mixture - since it only needs to penetrate into the outer tissues that translocate foods from the shoot to root. The beauty of this approach is that one can be selective and progressive and one is not bothered by disposing of cut trunks and zillions of little twigs that will all sprout. Leave the tree standing and it will gradually disintegrate and rot away. It gets lighter as it dries out so little damage is done to anything caught under falling limbs. This is fine if the public are not going to be walking around underneath these disintegrating trees. If they are on public paths then cutting the heavy wood out and painting the stumps will be necessary; although trees could be cut down a year after they have been drilled and poisoned.

Further herbicide trials

Trials are continuing to evaluate different herbicide formulations for killing willows as well as developing more efficient and cost-effective methods of application. For example, current trials are indicating that using diesel as a penetrant seems to give good results almost any time of year - winter, spring or summer. Another approach is to use a 1:1 mix of diesel and glyphosate sprayed directly onto the bark of the lower trunk. This is being successfully trialled in Canterbury where the diesel appears to be assisting the herbicide penetrate through the bark carrying the herbicide to the phloem.

A sexist solution

A variation on the above theme is to select for sex. Sudden exposure of the ground layer to light by total removal of willows or other shrub weeds can be counter-productive if the willows are replaced by an even denser layer of exotic shrubs, blackberry, grasses or ferns. In the case of the sexually fertile willow populations, a good solution is to identify and mark the female trees in early spring – they have green chunky catkins rather than fuzzy yellow male catkins (see photos page 6). Try the drilling and injecting method to selectively remove the females. One of the problems here is that when the sap is rising – through spring and early summer – it can force the herbicide away rather than 'sucking' it in and down to the roots. Hence, mid-to late summer is often regarded as optimum time for this treatment. This means that those female trees will have shed another year's seed all over the countryside – what did we say about one year's seeding?

By progressively eliminating the seeding trees you are left with a canopy of benign, even beneficial, male willows that will shelter an array of regenerating native ferns, sedges, shrubs and even tall forest species. There may still be an ongoing need for ground-based control of understorey weeds such as the blackberry (*Rubus fruiticosus* agg.), royal fern (*Osmunda regalis*), and willow seedlings.

Female trees of grey willow have been identified in spring when flowering and progressively removed from this wetland to allow natural regeneration and planting of natives.

In the case of Travis Wetland Nature Heritage Park, Christchurch, this technique of removing female trees has been applied for a decade on several hectares of grey willow growing on fen peat. Female willows continue to pop up but the source is drying up and there are relatively few new seedlings establishing out in the open sedgelands. For years sprayers had to work line-abreast across about 50 ha of open wetland at least once a year to pick up the new young willow plants (together with a handful of other weeds).

On peat, it is important to remember that there are no equivalents in the New Zealand indigenous flora to grey willow. The only native trees that will work their way up to maybe just below the willow canopy are cabbage tree, karamu, and in the open, manuka and perhaps in the north swamp maire. Our other taller swamp forest species such as kahikatea, matai, pokaka, and pukatea require firmer, gleyed mineral soil which periodically has some aeration or at least eutrophic water movement. These podocarp and other noble native trees are therefore more likely to establish and grow beneath crack rather than grey willow stands. They do not thrive on peat. Other native hardwoods such as mahoe, five-finger and lancewood, can grow up on the root plates of willows, but once the willows are gone then these colonisers also lose their dry footing.

Male and female (inset) catkins of willow.

Scattered willows (foreground) cut and removed from a dense cover of native wetland rushes, sedges, manuka and miki miki species, Travis Wetland, Christchurch.

Aerial Spraying

On a large industrial, big-budget scale that seeks dramatic results, helicopter spraying with glyphosate may be the ticket. At Lake Kaituna in the Waikato, on sites too wet for ground-based operations, this was carried out using 9L Roundup™, 500 ml Pulse penetrant and 1L Delfoam anti-drift agent in 200L water (Bodmin 2010). Results from the Whangamarino Wetlands in the Waikato have been only partially successful in that resprouting and seeding has occurred and some native understorey species were affected by spray drift penetrating the canopy. Effectiveness depends on the density of the canopy at time of spraying.

Follow-up ground-based operations are always necessary. As mentioned, total removal of canopy can have unforeseen effects – such as explosions of hitherto suppressed weeds in the sudden influx of light down to ground level. The most prevalent are blackberry, exotic grasses such as Yorkshire fog (*Holcus lanatus*) and tall fescue (*Schedonorus phoenix*), exotic rushes and sedges, lotus (*Lotus pedunculatus*), beggars tick (*Bidens frondosa*), gorse (*Ulex europaeus*) and royal fern.

Aerial techniques should only be used after careful survey of potential by-kill and exotic weeds that may be lurking in the wings waiting for the opportunity to pounce. If the canopy is continuous, and there are only exotic species in both the canopy and subcanopy, then it is perhaps a good option. However, there must be a succession plan – what will follow; are there seed sources of desirable species within dispersal range; are their weed sources similarly placed; is there an ambitious, ecologically-informed and well-resourced planting plan? Don't bite off more than you can chew; on the other hand don't let small problems escalate. In most cases, years of careful monitoring and follow-up, including eliminating sources in the wider landscape, will be required to achieve full eradication.

WARNING / DISCLAIMER

Note: Use of chemical sprays is hazardous and only suitably qualified operators with appropriate protective clothing and masks should handle or apply herbicide.

The information on selection, rates and use of herbicides in this article, is based on information reviewed from a range of sources, but must be assessed on a case by case basis and/or specific technical advice sought. It is recommended that users of herbicides follow manufacturers instructions at all times.

Accordingly, Tane's Tree Trust will not be liable on any ground for any loss, claim, liability or expense arising from or due to any errors, omissions or advice provided within this article or from the use of herbicides or consequences arising from the use of herbicides.

A restored riparian area once dominated by exotic trees including willows 20 years after planting a range of native trees and shrubs including kahikatea, matai, pokaka, harakeke, ribbonwood and ti kouka (cabbage tree).

Succession – Going with the Flow

Vegetation is changing and regeneration of native species within willow stands can occur, provided there is a seed source within about 3 km (the common flight distance of kereru and other fruit-eating native birds) and browsing mammals have been removed. If there are no seed sources then succession can be accelerated by planting appropriate native species and provenances under the willow canopies. Periodic thinning of the willow canopy as compatible with strengthening of the plantings and keeping weeds suppressed. One has to take account of the points made above regarding the kinds of species suitable for planting on different (peat or mineral) soil types.

One of the main ecosystem services provided by willows is stabilisation of bank and hill erosion. Another is wetland wastewater treatment. These valid attributes are used to argue for retention and efforts to breed better and potentially even more aggressive and invasive willows, and for biocontrol agents to attack the biocontrol agent that arrived here apparently unannounced – the willow sawfly. Pragmatically, we need to look at (ideally) indigenous (or at least benign exotic) systems that will perform some of the same services. We cannot pretend there is any indigenous system that will out-perform or match willows. They are truly remarkable plants – but then that is to be expected – they are the pick of the most vigorous trees from the entire temperate world.

Main plant selection

There are some options:

- **For riparian erosion** use mixes of harakeke/NZ flax (*Phormium tenax*), toetoe (*Cortaderia*), umbrella sedge (*Cyperus ustulatus*), tall rushes (*Juncus edgariae, J. sarophorus*), purei (*Carex geminata*), raupo and the woody plants of mikimiki (*Coprosma propinqua*), manuka (*Leptospermum scoparium*), ti kouka/cabbage tree, manatu/lowland ribbonwood (*Plagianthus regius*), kohuhu (*Pittosporum tenuifolium*), and lacebark (*Hoheria* spp.). These have complementary roots systems – surface, fibrous or tap roots; and they all grow relatively fast (Marden et al. 2005);
- **For wetland treatments** use *Eleocharis sphacelata* (Bamboo spike-sedge), *Schoenoplectus tabernaemontani* (lake clubrush), raupo (all three are aquatic), pukio (*Carex secta*), tall rushes, umbrella sedge and harakeke (suitable in saturated ground); and
- **For seepy, eroding hill slopes and floodplains**, toetoe, harakeke, cabbage tree, lacebark, manuka, ribbonwood, and kohuhu (together with sterile clones of willow and poplar) will provide some initial stability, with kahikatea, matai, pokaka or pukatea inter-planted once the nursery species are established.

The range of associated species will vary across the country - there are numerous regional guides published by local government, Crown Research Institutes and the Department of Conservation. A demonstration trial, evaluating progressive control of willow and other weeds with under-planting of presently absent podocarps, is being conducted by the Pukahukiwi Kaokaoroa 3B6 Trust, Scion and Manaaki Whenua Landcare Research in a willow-infested floodplain adjacent to the Ohau Channel along the northern edge of Lake Rotoiti. This will be reported on in the future.

SUMMARY RECOMMENDATIONS

- Eradicate all breeding/fertile populations of willow from former trial sites.
- Re-evaluate all the merits and demerits of willows in terms of their ecosystem services (with a wider cross-section of stakeholders and expertise) – and explore alternative, safer, more biodiverse and biosecure ways of achieving the same ends – even if a little slower! It may be that there are safe willows, poplars and alders that can be mixed with the faster-growing native species for initial erosion control with a view to thinning them out at a later date.
- Apply the appropriate approach for eliminating willow according to local conditions, substrates, native and weed species, scale, goals and resources.
- Survey existing values and threats (by a suitably qualified person) before embarking on a control programme. This may affect the techniques that are employed – to avoid loss of important native species or stimulating the performance of undesirable, invasive pest plants.
- Try to avoid clear-felling techniques as this is often very disruptive or induces new rounds of weed invasion. Weeds love disturbance and light!
- Before rushing into trying to get rid of willow sawfly and breeding poplars and willows for resistance to this insect and rusts, consider how lucky we are that these agents are here and that they are quite host-specific to exotic, expendable or noxious species. Really, there shouldn't be any work carried out on making more vigorous and resistant cultivars of willow and poplar until all fertile populations and species are eliminated. The danger to our natural environments and landscapes from the development of super willows or poplars is too great to risk.
- Rethink willow as a transition to floodplain/riparian native habitat that will be dominated by erosion - controlling edge species (reeds, raupo, harakeke, ti kouka) and tall forests of podocarps, and other hardwoods.

References:

Bodmin, K.; 2010: Weeds. *In* Peters, M.; & Clarkson, B. (eds). *Wetland restoration – A handbook for New Zealand freshwater systems,* Manaaki Whenua Press, Lincoln, New Zealand. 122-153.

Charles, J.G.; Allan, D.J.; Froud, K.J.; Fung, L.E. 1999: A Guide to Willow Sawfly (*Nematus oligospilus*) in New Zealand. HortResearch, Palmerston North.

Harman, H.M.; 2004: Feasibility of biological control of grey willow *Salix cinerea*. *Department of Conservation Science Internal Series 183*. Wellington. 28p.

Marden, M.; Rowan, D.; Phillips, C. 2005: Stabilising characteristics of New Zealand indigenous riparian colonising plants. *Plant and Soil 278*: 95-105.

Meurk, C.D.; Hall, G.M.J. 2006: Options for enhancing forest biodiversity across New Zealand's managed landscapes based on ecosystem modelling and spatial design. *New Zealand Journal of Ecology 30*: 131-146.

Webb, C.J.; Sykes, W.R.; Garnock-Jones. P.J. 1988: Flora of New Zealand, *Volume IV Naturalised pteridophytes, gymnosperms, dicotyledons*. Botany Division, DSIR, Christchurch, New Zealand.

Acknowledgements:

Thanks to Bill Sykes for checking over the information on willows and poplars and Stephen Brailsford for comments on herbicide use. David Bergin made useful comments on the text. Michael Bergin provided the photographs other than those indicated.

Author: Colin D Meurk,
Landcare Research - Manaaki Whenua
Lincoln, New Zealand

Contact: Tane's Tree Trust
Website: www.tanestrees.org.nz

Tāne's Tree Trust
Native Trees for the Future

Tāne's Tree Trust promotes the successful planting and sustainable management of New Zealand native trees and shrubs for multiple uses.

www.tanestrees.org.nz

ISSN 2230-3014 April 2011. Revised May 2012.

Printed by Scion Digital Print Centre, Rotorua