Plant & Food Research
Rangahau Ahumāra Kai

RESEARCH BRIEF 11

Willows at work in the catchment

Willows as Bioengineering Tools

Natural water catchments extend from mountains to sea, collecting water on the way. The erosive power of flowing water increases during periods of high water runoff, e.g. rainstorms. The heavier the rainfall the greater the water volumes and velocity the greater the erosive forces.

Willows are bioengineering tools to reduce gully erosion on slopes, bank erosion in streams and rivers, and have been for millennia. The natural habitat of many willows is the unstable streambank and riverbank environment. Their extensive root system gives them great stability in floods and the mass of fine roots will bind soil in all its forms and create an effective barrier between the flowing water and the soil, preventing gullying and protecting stream and river banks. Willows are adapted to cope with parts of their root system submerged in flowing water, a feature not shared by many other tree species. They have thick bark which develops early and protects the living tissue beneath during floods when abrasive forces from water, stones and debris would strip the bark from other trees.

They are the right tree in the right place for gully and waterways protection.

Willows can establish where few other trees can. They are first colonisers of new shingle and sand banks formed along rivers following flooding or a change of course. Seeds germinate and grow quickly on low nutrient sandbanks, stabilised by a rapidly expanding root system. Broken twigs that get fully or partially buried in sediment can develop shoots and roots and become a new plant. Willows require a high light environment so tend not to establish underneath other willows or in established vegetation, but are opportunists exploiting newly formed environments liked sandbanks.

New Zealand waterways typically 'operate' within a managed landscape. Rivers run across plains through farmland and alongside urban settlements and pose risk of floods to human livelihoods. The rivers themselves need to be controlled and floodwaters confined between protected stopbanks, and sediment (stones, sand, soil, other debris types) transfer reduced. National and local solutions employ a mix of hard engineering (gabions, rock walls, concrete structures) and soft or bioengineering (tree willows, shrub willows, native grasses). Hard engineering is expensive and its strength declines over time. Bioengineeering is cheap and its strength increases over time. Both approaches require maintenance so have ongoing costs. Willows, as the premier bioengineering tool, can be relocated along rivers as whole trees with minimal impact to the tree. They can be pruned and large branches cropped and physically shifted to create protection at another site.

Tree willows provide protection in highly mobile energetic systems and shrubby willows are more suitable for smaller scale, lower energy systems such as streams. Why? Root systems of shrubby willows, while substantial, are not as extensive or as deep as tree willows roots. Right tree, right place.

Why then do willows get a bad press from some critics?

They are so good at what they do that we do not notice how good they are. We see a stream bank held together with willow roots and think 'any tree can do that'. Planting slow growing trees with a poorly adapted root system in an environment with highly mobile sediments and subject to brief and severe erosive and abrasive forces is not wise engineering. The best candidates are trees which are adapted to the environment; fast growing to deal with competing vegetation, an extensive root system adapted to low nutrient soils, and resistant to erosive forces both above and below ground. Willows are such trees. Their roots bind both fine sediments (silt, sand) and coarse gravels.

So we find fault with other aspects of willow's character; they shade out other plants, they drop leaves and twigs into the waterways, their offspring are unruly, they don't have fruit, they grow too fast, they use too much water.

So let's replace them with hard engineering solutions that consume mineral resources, are costly to ratepayers and add to climate problems (CO_2). Alternatively, let's replace them with other bioengineering options, but where are the other bioengineering options? Are they as adaptable? Will they stabilise the banks? Are their root systems extensive? Can they compete with weedy plants by themselves? do they require protection for many years? Right tree, right place.

Maybe as we consider these questions we will be more forgiving of their 'faults'. However, it is important to consider 'faults'.

Answering the criticisms

Water use – willows are big water users like most trees, including native trees being planted along waterways. A study in catchments near Waipara, North Canterbury showed willows do extract water from the water-course, but not as much as they source it from surrounding land and ground water, where the greater root growth occurs to source nutrients and create stability. The same study showed tree willows do reduce summer flow rates in streams, but have little effect in other seasons. There is sparse information on their effect on water flow in rivers.

Shading - shading conserves water on land and reduces evaporation from streams. Shading cools the environment and is important both on land and in water. Oxygen levels, important to aquatic animals, are higher in cooler water. Their relatively wide canopy makes tree willows important shade trees. Birds and insects need shade as much as sheep and cattle.

Stream ecosystems – willow leaf litter is a non-toxic food source for aquatic animals. There have been several studies on the contribution of willow leaves to stream ecosystems, notably one in Australia. Summer shading can suppress growth of algal films on stones which can reduce the numbers of grazers (e.g. snails), and their predators. Willow leaves are thin and soft and they break down quickly so are a short-lived food and nutrient source compared with thicker, more waxy leaves. This is most significant at leaf fall when stream flows are increasing. In parts of the stream shaded by willows, one Australian study indicated a shift in trophic pathways from autotrophic light – algal-grazer pathway to a heterotrophic detrital-fungal-collector-gatherer pathway.

Unruly offspring – this can be a problem, but do we incriminate the parents for the unruly children? Well, yes, we do. Crack willow and grey willow are two parents of unruly children. Neither are produced in regional council nurseries or distributed. Crack willow is used 'under close supervision' in some river systems where unruly children can be tracked and removed. For almost all other willow species unruly children are rare. Male willows are selected for stream and river engineeering where possible, and most willow removal is due to ill health, transfer to other locations or because individual trees are too big and no longer fit for purpose because of their size. This is fine. Catchments are managed systems and this is what management means. Remove and replace goes hand in hand with right tree - right place.

Fast growth – this is so important for effective bioengineering solutions. Once willows get established and are doing their job, they can be managed for size, they can contribute further material for other projects (as is done across the country), and when they age they can be coppiced. pollarded, or removed and replaced.

No fruit – true, so not much for the birds except as a roosting and nesting site. However, bees love their spring pollen and nectar, as do other insects. Willows contribute to the wider ecology of the areas where they are planted and pollinator health is part of this contribution.

Using the Tools

Willows are the most useful tools in our bioengineering toolbox to protect river and stream banks and combat gully erosion during periods of high water flow. In doing this they bind soil and gravel, protect banks, reduce sediment transfer and provide some protection to aquatic habitats. The New Zealand public has benefitted from the knowledge contributed by international and national research and bioengineering practice in cultivar breeding, selection and wise use of willows. The contribution of willows to the protection of valuable land, urban communities and infrastructure is immense.

For more information

This is one in a series of research briefs about Poplars and Willows that can be found at poplarandwillow.org.nz

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CBO-1108

Te Uru Rākau With funding support from New Zealand Forest Service

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