Removing willows can generate big water savings

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for ENSIS

Willows have infested waterways throughout south-east Australia and become a major environmental problem — taking over from native plant species, altering the course of many waterways and reducing water flows and water quality.

A research project involving CSIRO scientists has quantified the amount of water used by willows compared with normal evaporation — and the results are significant.

Photos: Ensis

Problem plant: *Willows were introduced into Australia to help control stream bank erosion but have become a major environmental problem.*

At a glance

- Willows were introduced to Australia mainly to help control stream bank erosion but they have become a major weed problem.
- Willow infestations can destroy native plant communities and wildlife habitats, alter stream flows, cause flooding by blocking the natural water course, reduce water quality and increase water use in the affected stream.
- Removing willow infestations from within creek beds can save water, improve water quality and indirectly boost agricultural production.
- The amount of potential water savings that can be achieved by removing willow infestations will vary between properties depending on local conditions.

Farmers can achieve substantial water savings by removing willow infestations that are growing in permanently flowing creeks on their properties.

This is the key finding of a study involving scientists from Ensis, a forestry-focused research joint venture between CSIRO and New Zealand's Scion.

The precise volume of the water saving will vary between individual properties but researchers have identified annual savings of 3–4 megalitres per hectare of willows removed for a property at Jerilderie, New South Wales.

As well as producing water savings, removing willow infestations from within creek beds will generate associated benefits for landholders such as improvements to water quality, reduced flooding during storms and potential production gains from having more water available for agricultural enterprises.

Background to the research

Willows were introduced into Australia during the 1800s for a range of purposes including stream bank stabilisation, the production of raw materials to make baskets and cricket bats and as a shelter and forage resource for livestock.

But willow trees propagate easily and spread rapidly.

Many waterways have become infested as willows have effectively taken over the banks and creek beds. They now occupy an estimated five per cent of all the available suitable habitat throughout Tasmania, NSW, Victoria and the Australian Capital Territory.

Thousands of willows were planted along stream banks as part of erosion control programmes throughout south-east Australia until as recently as the 1980s.

A problem plant

Infestations of willows can have considerable adverse impacts on stream and wetland hydrology and biodiversity. Invading willow trees form dense stands with extensive, thick root mats. They can destroy native plant communities and wildlife habitats, alter stream flows, cause flooding, reduce water quality and increase water use from the stream.

Willows grow quickly and reach reproductive maturity within 2–3 years, producing a large number of seeds, which can be spread by wind or water and germinate within two days.

The trees also can spread through vegetative reproduction — where plant fragments break off, float downstream, take root and grow mid-stream.

Scientists become involved

Water for Rivers, an organisation formed to identify, investigate and implement water-saving projects, commissioned scientists from Ensis to assess the potential water saving from removing willow infestations from streams in south-central NSW. In particular, they focused on a section of the Yanco Creek system, which includes part of the Billabong Creek near Jerilderie.

Yanco Creek starts as an offshoot of the Murrumbidgee River near Narrandera in the NSW Riverina and flows 800 kilometres south-west before joining the Murray River at Moulamein on the NSW–Victoria border.

It is a complex water system, supplying water to eight towns and hundreds of private irrigators. A natural resource management plan for Yanco Creek aims to identify current water losses from the system and potential rehabilitation works to save 36 gigalitres of water a year.

Infestations of willows can have a considerable impact on stream and wetland hydrology and biodiversity.

Weeping willows *(Salix babylonica)*, which were originally planted for stream bank stabilisation and shade, are particularly prevalent along Yanco Creek — in some areas they have spread from the stream edge to the natural floodplain of the creek and into the stream-bed.

Two aspects to the study

Researchers used computer modelling to estimate the potential water savings from reduced evapotranspiration in response to the removal of willows from Yanco Creek (evapotranspiration is the process by which water is transferred from the land to the atmosphere via evaporation from the soil and other surfaces and by transpiration — the loss of water vapour from the surface of plants).

These estimates were then compared with the results of a field study, which directly measured water use of willows and natural riparian vegetation (mainly river red gums) along Yanco Creek.

The analysis

Evapotranspiration from the creek bed and banks with and without willows was modelled but a lack of available data on willow stomatal behaviour meant willow water use was only simulated within broad limits. (Stomata are minute pores in the leaves or stem of a plant through which gases enter and leave the plant and water vapour moves out into the atmosphere: the process of transpiration). As a result, researchers modelled willow water use for a wide range of stomatal behaviour.

The model used climate data including daily air temperature, relative humidity, sunshine hours and 24-hour wind measurements. These were obtained using 12 years (1986–1997) of daily weather records from nearby Deniliquin.

Daily water use was predicted and rainfall interception by the tree canopy and soil and surface water evaporation also were modelled.

Results from the simulations

The computer simulations predicted mean annual evapotranspiration per hectare of willow canopy of 1250–1900 millimetres per year, which equates to 12.5–19 megalitres (ML)/ha/year.

This compares with expected evaporation from an unshaded water surface of 1720–1820mm/year and 240mm/year from non-saturated bare soil.

The simulated net water saving from willow removal varied, depending on the rate of evapotranspiration and the proportion of willow canopy shading water compared with a dry creek bank.

If the willows are shading water and saturated soil but not dry soil, modelling showed that even at the highest likely rate of willow evapotranspiration willow removal would only deliver net water

Field work: *Mark Tunningley helped with some of the field work near Jerilderie, New South Wales. More field work is being planned for other areas.*

Creek cloggers: *Willows can sprout up mid-stream when plant fragments break-off, float downstream, become lodged and then start growing.*

Tangled trees: *Although they are very efficient at stabilising stream banks, willows also spread and grow very quickly. They can easily clog waterways and reduce water flow and water quality.*

savings of 1ML/year for each hectare of willow canopy removed.

But if the willows are shading equal areas of water or saturated soil and dry soil, even at the lowest rate of willow evapotranspiration the net water saving delivered by willow removal would be 2ML/ha/year. The water saving for the mid range of predicted willow water use was 4–6ML/ha/year.

The simulated net water saving from willow removal depended on the rate of evapotranspiration and the proportion of willow canopy shading water compared with dry creek bank.

For an intermediate scenario in which willow water use is moderate and willows shade twice as much water–saturated soil as for dry soil, willow removal would generate net water savings of 2–4ML/year.

Gathering data from the creek site

Researchers monitored evapotranspiration from willows and nearby river red gums *(Eucalyptus camaldulensis)* during the August 2005–May 2006 growing season.

Two creek measurement plots were established. One plot was at times partially or completely inundated during spring but was mainly dry for most of summer and autumn.

The second plot, representing a non-infested length of creek, was solely occupied by river red gums. As the red gums were slightly higher up the bank, this plot was never completely inundated and was entirely above the creek water level for most of the time.

A weather station was established at the site to collect measurements of temperature, wind speed, wind direction, relative humidity, solar radiation (hourly means) and rainfall (hourly totals). Evapotranspiration measurements (tree water use, canopy interception of rainfall and evaporation from bare soil) were collected.

Some unexpected results

Some results gathered on-site were unexpected — willows in the creek bed had transpiration rates about six times more, on average, than those on the creek bank, reaching a peak of 15.2mm/day during December compared with a 2.3mm/day peak in the bank willows and 1.6mm for the red gums on the bank.

Annual evapotranspiration from open water, based on measurements taken at Deniliquin, totalled 1642mm (or 16.4ML/ha).

Total evapotranspiration of the red gums and bank willows was 553mm and 563mm respectively (5.5ML/ha and 5.6ML/ha respectively) but for the 'wet' creek willows it was considerably higher at 1989mm (19.9ML/ha) due to their large transpiration rates. Total evapotranspiration of the 'wet' willows would have been even higher had there not been substantial leaf shed during extremely hot conditions during January.

Despite this, total evapotranspiration from the 'wet' willows was 347mm/year (about 3.5ML/ha) more than the total maximum amount of evaporation expected from an unshaded water surface in this environment.

That is, the results indicate a potential net annual saving of 3.5ML/ha of willow canopy is possible by removing willows from the permanently wet part of the creek based on the difference in total evapotranspiration between willows in the creek and open water.

Other benefits

Removing willows might also improve flow rates and reduce the width of the creek for a given flow rate, resulting in lower evaporation rates from the stream surface up-stream of the willow infestations.

The similarity of annual evapotranspiration from natural red gums and willows on the creek bank indicate that removal of willows from the bank followed by replanting with natural riparian eucalypt vegetation would provide bank stability without changing evapotranspiration.

Willows in the creek bed had transpiration rates about six times higher than those on the bank of the creek.

Future research goals

There is still considerable uncertainty about the potential water saving achievable by willow removal due to the wide statistical confidence interval for 'wet' willow transpiration at the site and uncertainty about evaporation rates from the shaded water surface under the willow canopy compared with unshaded water without willows.

Predictions of the net water saving achievable by willow eradication could be improved by measurement of transpiration rates in a larger number of 'wet' willows at the site during a longer period. This would provide a full season of measurements and narrow the statistical limits.

Researchers will carry out similar measurements in other areas and climatic zones to refine parameters for modelling and verify how broadly the results of this study can be applied to other river systems, climates, soils and willow species.

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