FACT SHEET 7

Managing woody debris in rivers

7

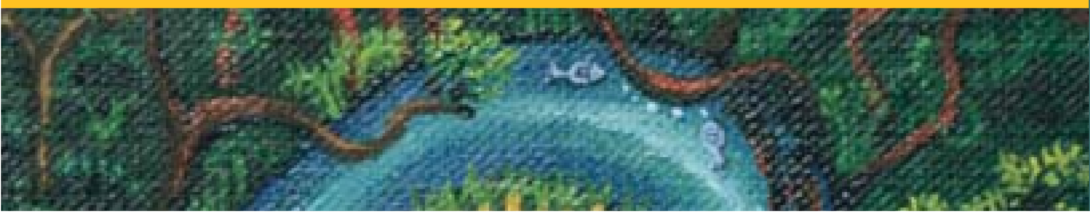
RiverLandscapes

This Fact Sheet is the seventh in a series dealing with the management of riparian land.

Woody debris is a natural component of rivers

As the trees growing alongside a stream or river age, die and decay, large branches and sometimes even the whole trunk, can fall or topple onto the streambank or into the channel itself. There is increasing evidence that before European settlement, most rivers in Australia had a large amount of this woody material, usually known as large woody debris (LWD) along their banks and within their channels. Natural events such as major floods, bushfires and severe frost are likely to have contributed to the amount of LWD found within rivers.

To the early settlers, LWD was often a nuisance. It made access to streams by stock difficult, and large snags within rivers were a major hazard to transport and navigation at a time when waterways were a major route for moving goods and people. It was generally thought (often incorrectly, as we now know) that LWD blocked the channel and caused additional flooding at times of peak flow. As a result, particularly in southern Australia, millions of snags were removed from streams and usually piled on the bank and burnt.



In undisturbed rivers there is often a large amount of large woody debris present on streambanks and in the channel of the lower Campaspe River, northern Victoria. Photo Ian Rutherfurd.

LWD is now viewed in a very different light. Research over the past 20 years has shown that woody debris is a vital component for the healthy functioning of rivers. LWD also helps to protect the beds and banks of streams from erosion and in many situations it does not contribute significantly to flooding. As a result, much more thought is given before LWD is removed from rivers, and several projects are even reintroducing LWD into streams as a means of returning critical habitat and complexity for improved river health. This Fact Sheet describes why LWD is important to rivers, and provides some principles about managing woody debris and snags.

Why is LWD important?

LWD can be an important control of bank and bed erosion in active river channels. Large debris, particularly whole tree trunks within the channel, provide an important grade control structure. For example, a large trunk which extends across all, or most of the channel, will cause an upstream pool to develop and provide a control point slowing or preventing further erosion or incision of the channel during major flow events. The large quantities of LWD present in many river channels in their natural state would have been quite sufficient to armour and protect the bed against erosion and incision. There are several examples of high-energy streams that, when extensively de-snagged, suffered major erosion events with incision of the bed, subsequent collapse of banks and loss of habitat and fishery values.

Although LWD can act to reduce the *rate* of bed and bank erosion, this does not mean that there is no erosion at all in its presence. In fact, woody debris is an important factor adding complexity within river channels. An upstream pool is usually associated with a downstream scour hole, and these deeper pools are very important to fish and other aquatic animals in periods of low flow. Water flowing over large branches and trunks becomes aerated, and the range of flow rates produced around debris (slow in deep pools, fast around obstructing wood) is important for the diversity of plant and animal life required for healthy rivers.

In addition to the physical effects on the shape, depth and flow of water in the river, LWD also has many important ecological benefits. Large items of debris provide a secure, hard surface upon which microscopic plants (algae) can grow, and provides habitat for aquatic invertebrates such as insect larvae and snails. LWD helps to trap leaf litter and other organic matter moving down the stream to form 'debris dams', which become hot-spots of biological activity and a major source of food for animals. Animals feeding on algae or involved in shredding and consuming leaves and fine litter are key components of aquatic ecosystems because they, in turn, become food for larger river animals such as crustaceans, fish and platypus. In this way, LWD plays an important role in providing a base for the processing of energy and nutrients to support the aquatic food web.

Woody debris buried by sand in the Wannon River, SW Victoria. Photo Ian Rutherfurd.

LWD is particularly important in sandy rivers, where the constantly-moving bed material provides little habitat for aquatic animals. In this situation, having large debris in the channel is essential for most aquatic life, and research shows that the presence of LWD is the most important factor predicting the occurrence and diversity of invertebrate and fish populations.

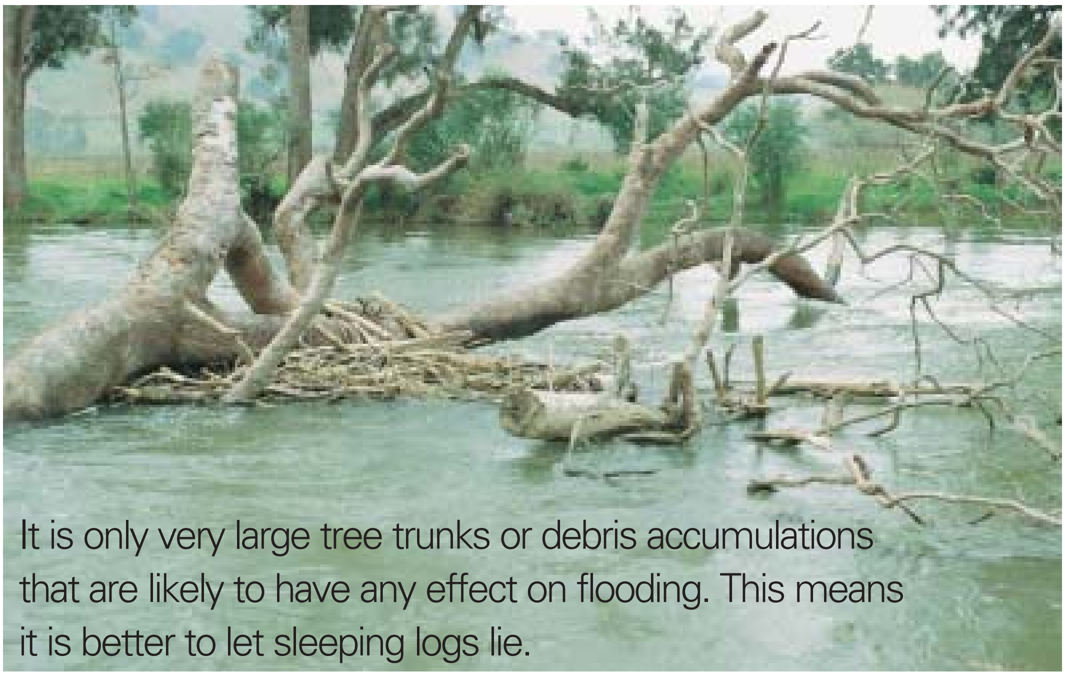
Large debris is also vital for the survival and growth of many important fish species. It provides habitat and shelter from predators, while hollow logs are an essential spawning habitat for several native fish species; for example the Mary River Cod of south-east Queensland, and the River Blackfish of Victoria and Tasmania require submerged hollow logs in which to lay and nurse their eggs. Many other fish species that are important for commercial production or because they are endangered (e.g. Murray River Cod, Barramundi) also need the presence of LWD for successful breeding and growth.

Effects of LWD on flooding

The initial reason for removing LWD from the larger river systems in southern Australia was that large snags represented a hazard to river transport. This was undoubtedly correct, however, even when river transport was no longer important, de-snagging continued. This was in the belief that LWD, particularly large tree trunks within the channel, impeded water flow and resulted in additional flooding. We now know that a channel needs to be substantially blocked by LWD before there is any measurable effect on water height. For example, at a particular spot in the channel, the cross-sectional area of LWD needs to be at least 10% of the whole channel before there is likely to be a significant effect on water levels. It is unusual to find anything like this amount of LWD in river channels today.

In general terms, LWD has an insignificant effect on the frequency or duration of large floods, although it can increase the duration (length of time) of smaller floods. Even here, the effect is usually minimal and may mean that a small, over-bank flood (for example, the peak flow that occurs once in every 1–2 years) may be extended by a few hours or, lower in the catchment, by a day or two.

To give some idea of the scale of effects, in a river channel 30 metres wide, running 2 metres deep at a flow of 1.5 metres per second, a log 20 metres long and 1 metre in diameter lying at right angles to the flow (i.e. equivalent to about one-third of the channel cross-sectional area) would cause a 5% increase in the height of the water upstream, equivalent to about 10 centimetres.



Large woody debris is important in creating different habitat for plants and animals, Tumut River, NSW.
Photo Chris Gippel.

In another example, seven accumulations of LWD were removed from the Tumut River in a reach approximately 40 metres wide and 2.5 metres deep. Removing these snags reduced the upstream water surface level by about 20 centimetres, and this effect extended for about 3 kilometres upstream.

In both these examples, the amount of LWD is fairly large, but the effects on water height and potential flooding are relatively small. Research has also shown that several pieces of LWD in line along the channel will not produce any more significant change in water level than a single piece, so long as each is located within about twice the diameter of the next piece downstream. In general, any piece of LWD placed within four diameters of the next piece upstream has little effect on flow.

It is also most important to realise that effects on flood flow cannot be considered just in a single river reach. Supposing we remove LWD from a 2 kilometre river reach because calculations suggest that this action will reduce the duration of minor flood events. What is going to happen downstream? Unless the next reach already has higher capacity for peak flow, inevitably flooding must increase downstream! There are plenty of examples where poorly-planned removal of LWD from one section of a river has led to major problems for downstream neighbours. Clearly, flow needs to be considered along the entire river system, and it is often better not to start a process of removing LWD unless the process can be funded for the entire system. Preferred alternatives, such as reorientating or reshaping debris, are discussed later in this Fact Sheet.

Does LWD accumulate on bridges?

The evidence available to date suggests that accumulation of LWD against downstream structures is much less important an issue in Australia than overseas. This is because many of our rivers have a lower average stream power; the wood that comprises our LWD is much heavier; and, most importantly, because eucalypt trees have a complex branching structure. The latter means it is relatively difficult for even major flow events to roll LWD along in a channel.

Woody debris trapped against a bridge on the Mary River, SE Qld. Photo Ian Rutherfurd.

As a result, the risk to important infrastructure from damage by accumulation of large, whole tree trunks is relatively minor. Of more importance is the risk of accumulation of smaller debris, such as parts of branches that can be trapped against a bridge or a culvert. It is difficult to prevent this from happening, and the preferred approach is for local government and river management agencies to have a regular program of checking for potential accumulations.

LWD and bank erosion

As noted above, LWD does lead to some erosion and reshaping of channels, particularly through the formation of scour pools immediately adjacent to the snag. These pools and undercuts provide essential habitat and complexity within the channel, and the overall effect of LWD is to decrease rates of channel bed movement.

The presence of LWD can sometimes increase or decrease local bank erosion. The size and orientation of the debris, velocity and depth of flow and the character of the material making up the streambed and bank, all influence the potential for erosion. Generally, LWD has less erosive effect on large streams where bank materials are well consolidated and resist erosive forces. Orientation can be particularly important, as large debris can direct flow towards the bank in some situations, whilst in others (or if repositioned) can direct flow away. The physical presence of debris, as well as the presence of pools, can reduce the scouring effect of flow at the toe of a streambank.

Natural load of LWD in the lower Campaspe River, northern Victoria. In undisturbed systems LWD is protecting the river bank. Photo Ian Rutherfurd.

When a tree falls into the channel through bank collapse for example, there is often an initial loss of some bank material. However, experience shows that by the time this erosion is noticed, the erosion process is usually largely complete. In other words, the next major flow will remove much less, if any, bank material. As a rough guide, erosion around debris that obstructs flow, will usually remove an amount of material equivalent to no more than one or two times the projected area of that obstruction. This is roughly the amount of material needed to re-establish the original flow velocity. For example, if a large log had a projected area of 5 metres^2 (its potential 'obstruction area' when viewed from the direction of flow), then the initial erosion around it is likely to remove material equivalent to 5–10 metres^2 of the channel cross-section in order to re-establish flow velocity.

Large woody debris deposited by a flood. Tambo River, Gippsland. Photo Ian Rutherfurd.

Managing LWD

Using the information provided so far, we can now consider how best to manage LWD in streams to reduce or prevent negative effects, while retaining the many positive advantages of LWD to river health. The current emphasis in LWD management is to leave as much wood as possible in the river for habitat purposes. Where there are local problems associated with LWD, for example, where channel capacity is needed for irrigation supply or there are local water level variations, modification of LWD should always be considered before removal.

Balancing competing needs

The challenge for river managers is to find a balance between any possible adverse effects in river level or bank erosion caused by LWD, and the ecological and flow benefits of leaving snags in rivers. Generally, it is highly desirable to have a range of flow velocities and water depth within a river channel, including the zero or near-zero velocity zones associated with LWD that are used by fish for resting and refuge. LWD has the least effect on water levels when it is aligned with the flow, and is located on the channel margins or in other areas of low flow velocity. However, placing all debris on the channel margins then offers little of the habitat diversity needed for ecological health. This is one example of the need to balance or trade-off competing management objectives.

How much LWD is needed?

The timber from many Australian hardwood tree species can last for hundreds of years in rivers, especially if the wood is submerged. Some logs associated with streams in Tasmania have been dated as being several thousand years old. The low slopes of many of our streams, combined with low stream power and the complex shape of logs, means that most LWD can be carried downstream only in the largest channels and during major flood events. In general, most large logs stay where they fall.

It is often hard to know exactly how much timber there should be in a healthy stream. Densities of LWD vary dramatically from stream to stream, depending on the rate at which it is generated from the adjacent riparian vegetation or floodplain, and the rate at which it may be lost through movement during peak flow or by slow decomposition. As a general rule of thumb, the volume of timber in the stream will be about one fifth of the volume of live timber growing on the top of the adjacent stream bank (see Figure 1). Better still, inspect an undisturbed reach of your river, or a similar river nearby, and work out just how much LWD there is along the banks and in the channel. This will give you an approximate guide as to how much LWD should be in the river.

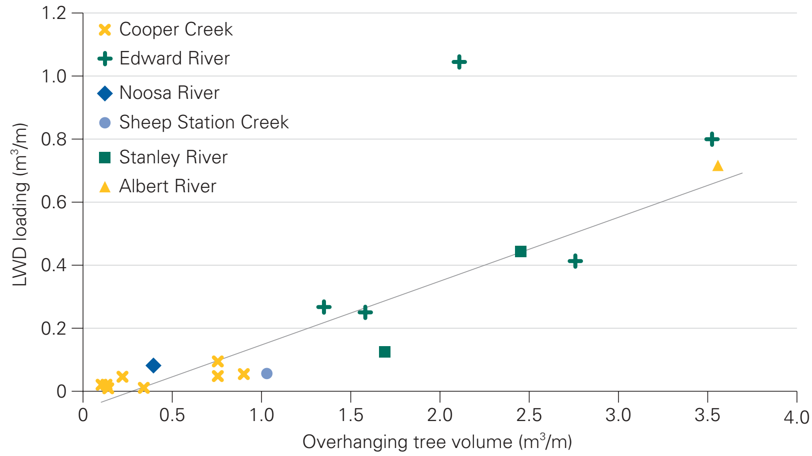


Figure 1: LWD loading and fringing riparian vegetation density.

LWD is not a natural feature of all stream systems in Australia. For example, rivers in the northern tropics may contain low natural levels of wood, because high gradients and high flows tend to flush out debris, and high temperatures result in rapid decomposition of timber. Intermittent desert streams, flowing in regions where riparian vegetation is sparse and stunted, would also be expected to have low levels of LWD. Organisms in these streams are generally adapted to alternative habitats such as those provided by boulders, rock ledges or riffles, and in-stream, macrophyte plants.

Photo Ian Rutherfurd.

Fallen river red gum on the outside of a bend on the Murray River. This shows the natural distribution of timber in this type of lowland stream (i.e. trees tend to remain where they fall).

Unfortunately, across much of southern Australia, when rivers were de-snagged, the timber removed was burnt. Today, a major headache for agencies and community groups wishing to reintroduce LWD into these rivers is finding a suitable source of material. In some cases, road and urban development has provided a source of timber, while in others consideration has been given to the use of 'artificial' large debris materials.

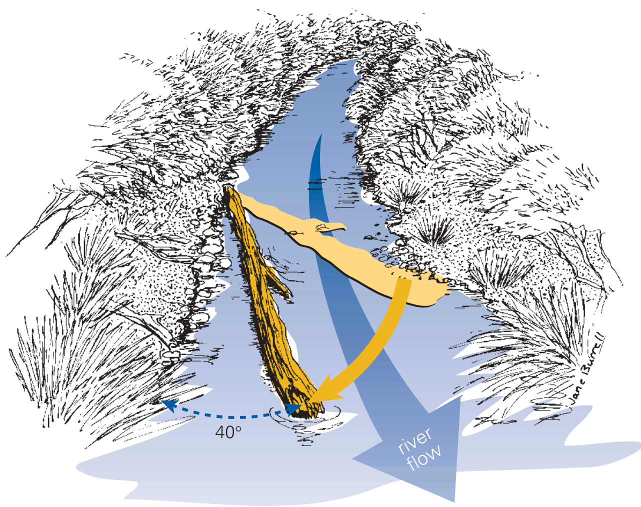
Modifying LWD

Where local flow variations caused by LWD are considered to be detrimental, but full-scale removal cannot be justified on either economic or ecological grounds, LWD modification should be considered. To minimise the effect on flow levels, large items of debris can be moved and placed closer together on the streambed, and in line with the flow. Debris items placed within 2–4 diameters of upstream items will have little additional effect on local water levels.

LWD can also be rotated to modify its effect on flow and water levels. An immediate improvement in the capacity of a river channel to carry peak flows can be achieved by rotating large tree trunks from an orientation perpendicular to the flow, to an angle of 20–40° to the streambank. This will also help to ensure that flow is not directed at the streambank. At this angle, logs have very little hydraulic effect. Remember to concentrate on the large items, as these dominate any hydraulic effects of timber in the channel.

This type of placement pattern is much less obstructive to flow than large and widely-separated items of LWD that are orientated across the channel. Hence, this modification can help to reduce local water levels during peak flow. At the same time, this pattern maintains the total surface area of debris for river plants and animals, and helps to increase the availability of a range of velocity and habitat zones.

It is important to note that best management practice today is to only move or remove logs from streams in extreme circumstances.



How to move logs in the stream in the rare circumstance that they have to be altered.
Illustration Jane Burrell.

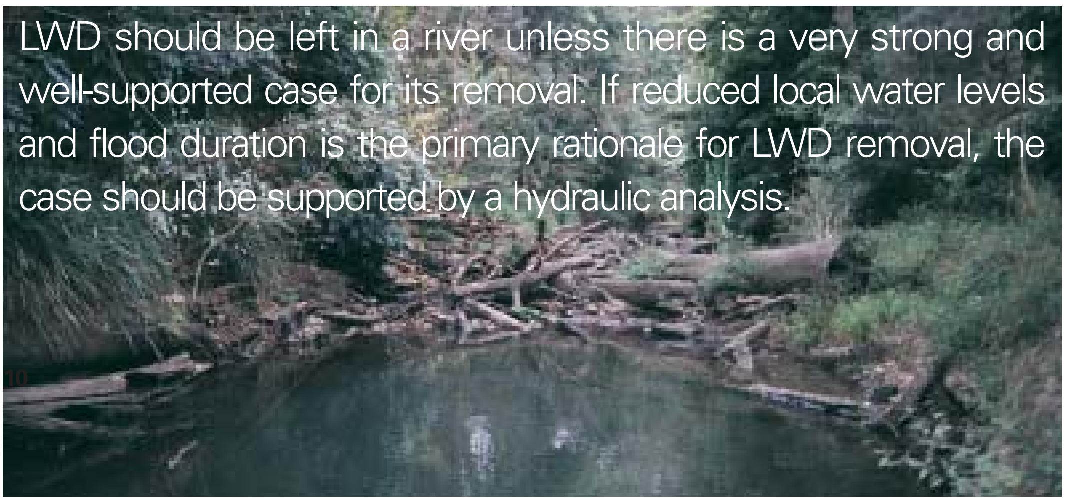
In addition, moving LWD away from the high velocity zone in the centre of the river channel can also improve flow capacity. However, this type of modification requires careful planning as it can cause an increase in maximum velocity in the centre of the river. This could mobilise bed material and cause the bed to deepen. Such relocation, if not well-planned, may cause more problems than simply leaving the debris where it is.

Any plans to modify or move snags should form part of a well-defined management plan, with clear objectives. For example, plans to reduce flooding or local water levels should be supported by hydraulic calculations of the expected effects and benefits of LWD modification. Remember that the higher the flow velocity, the greater the impact of LWD on flood stage.

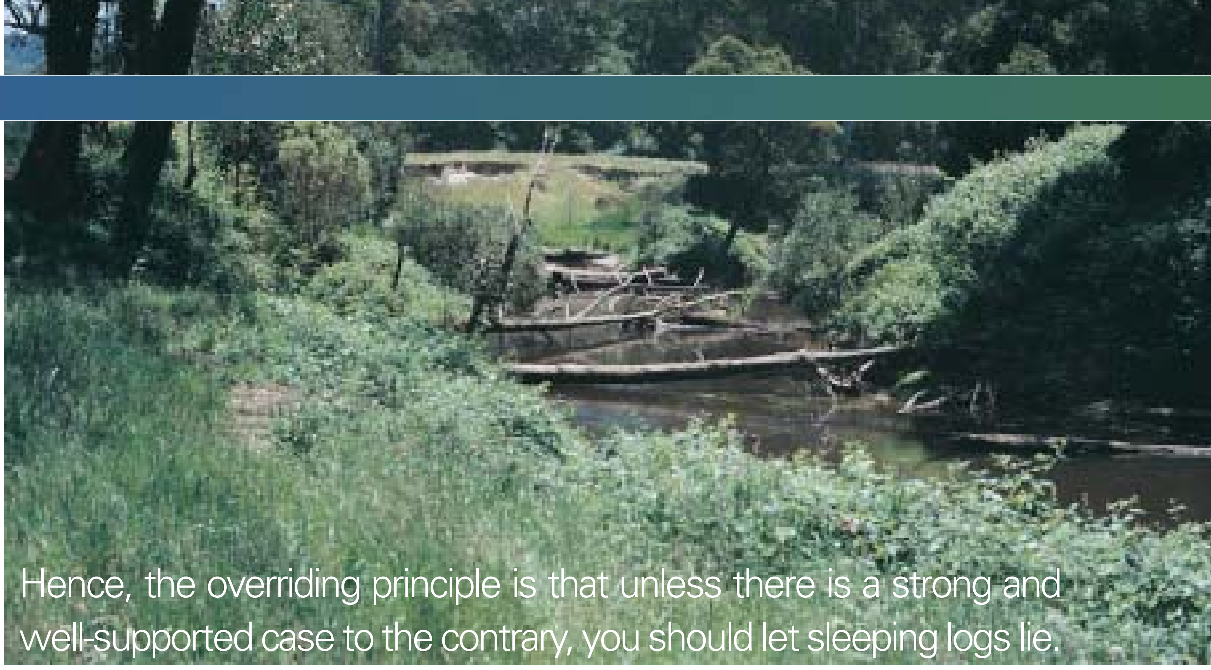
Another possible form of modification, though sometimes difficult to achieve, is the removal of part of a large item of debris. This might involve taking off a major branch that is directing flow into a bank, or removing the uppermost limbs that are thought to affect flow when levels have risen during a flood peak. Lopping of branches near the water surface can also help to prevent the trapping of smaller pieces that eventually form large accumulations. Where it is necessary to remove an accumulation of smaller items that have become trapped on the upstream side of a bridge, culvert or other infrastructure, consideration should be given to storing or relocating them for future habitat restoration elsewhere.

Removing LWD

There are likely to be some situations where it is still justified to remove some woody debris items from a particular river reach. For example, where a valuable asset is threatened by erosion or water levels associated with peak flows, or where safety is a consideration for water-skiers or canoeists. A general principle is that the onus of proof in removing LWD must lie with those wanting to make the change. This is because so much damage has been done to river health by over-enthusiastic de-snagging in the past. The 'precautionary principle' should always be applied. LWD should be left in a river unless there is a very strong and well-supported case for its removal. If reduced local water levels and flood duration is the primary rationale for LWD removal, the case should be supported by a hydraulic analysis.



LWD in the Albert River, SE Queensland.
Photo Ian Rutherfurd.



LWD in a small rural stream in the Otway Ranges, SW Victoria providing habitat and stabilising the bed and river bank. Photo Ian Rutherfurd.

Hence, the overriding principle is that unless there is a strong and well-supported case to the contrary, you should let sleeping logs lie.

It is important to remember that the LWD that might be removed in a single day would have otherwise provided habitat for many generations of fish, perhaps over several hundred years. The progressive loss of riparian vegetation along many Australian rivers means that it will take centuries to replace the LWD that has been removed in the past. As well, in many situations the removal of LWD to solve one problem may lead to more problems through bed incision and bank erosion.

Reintroducing LWD into rivers

In recent years there has been great interest in reintroducing LWD into streams. In some cases, this is motivated by a desire to replace structures which were important in grade control, so reducing erosion of the channel bed and banks. In many cases, an important motivation is to reintroduce complexity and habitat diversity into a stream, and/or to achieve a wide range of ecological benefits. It is very important to be clear about the management objectives for the reintroduction, to plan the work carefully, and to include a monitoring and evaluation strategy so that you know whether or not the project has been successful.

In many situations it is now difficult to provide a suitable source of LWD for reintroduction, and this has helped to stimulate the development and testing of the 'engineered log-jam' technique, where smaller trunks and branches are carefully placed together to have the overall effect of a much larger item of LWD.

In planning the reintroduction of LWD, it is important to make sure that this is likely to have the desired effect. For example, your management objective may be to improve habitat and increase the numbers of fish in a particular river reach. Reintroducing LWD will certainly help to provide additional habitat and complexity in the channel and flow regime, but if fish are absent because of a lack of food sources, LWD on its own may not provide the whole answer. You need to understand the causes of river management problems before designing a project that will meet your requirements.

For efficiency and stability, reintroduced LWD should be placed in zones of low water velocity along the channel margins or on the insides of meander bends. Where it is important to minimise any rising water levels that may be caused by reintroducing woody debris, a series of closely-spaced, progressively smaller items should be placed upstream (i.e. in the backwater) of any large item with a broad trunk or wide root structure.

Projects to directly reintroduce LWD into streams are likely to provide immediate benefits. However, over the longer-term, the re-establishment of native riparian vegetation along riverbanks will ensure a future source of LWD that will rehabilitate degraded river habitats. This is very much a long-term approach as it may take centuries for newly-planted trees to mature to the point where they provide good LWD. The best approach is to work on revegetation for the longer-term, but also to undertake the direct reintroduction of LWD to provide immediate effects. Other Fact Sheets in these series discuss the importance of revegetating streambanks to achieve management objectives such as habitat for wildlife and improving water quality. It is important to complete in-stream LWD restoration and any channel stabilisation works before beginning riparian restoration, including replanting. It is inefficient to revegetate the riparian zone, only to later threaten part of that work by dragging large logs over the top on their way for replacement in the stream. In-stream work should be scheduled carefully, bearing in mind periods of environmental sensitivity, for example a wet season when streambanks will be susceptible to damage, or fish spawning periods.

Best location to position snags is on the outside and downstream of bends. Illustration Carolyn Brooks.

An artificially placed log in Reedy Creek, NE Victoria (placed by North Central CMA). Photo Ian Rutherfurd.

These photos (A–D) show the construction of an engineered log jam that is designed to increase aquatic habitat and diversity in the river channel. Even after the large flood shown in Photo C the log jam remained in place, with Photo D showing how the log jam structure is changing the river channel to create a range of different habitats for plants and animals. Williams River, NSW. Photos Andrew Brooks.

On the basis that maximum habitat diversity is created by producing maximum hydraulic and water depth diversity, then reintroduced LWD should be positioned to produce weirpools and scour holes. Scour holes will only be produced in fast-flowing streams where there are periodic flow events of sufficient power to move the bed materials of sand, gravel or cobbles. Logs should be positioned perpendicular to the direction of flow or pointing slightly upstream, and they must be well-anchored to the bed so that they cannot be washed away or fall into the scour hole. The recent introduction of engineered log-jams on the Williams River in NSW by Brooks and colleagues has been very successful in this regard (more information about this project can be found on the www.rivers.gov.au website).

Planning LWD management works

Proposals for removal, modification or reintroduction of LWD should be treated like any other development proposal. They may require an environmental impact assessment and public review. This will depend on local planning requirements. Initially, a LWD management proposal should be prepared with a clear set of objectives, supported by hydraulic calculations and specifying the works proposed.

It is important to carefully plan the reintroduction of large woody debris. Photo Melbourne Water.

Aquatic biologists have established broad relationships between the quantity and characteristics of LWD, and fish and invertebrate diversity. These need to be considered by river managers when initially setting the objectives and justifying LWD projects. The general effects of LWD removal on water velocity and flow patterns are now reasonably well-understood. These also need to be taken into account in the planning stage of LWD management projects. LWD management projects should be planned and developed in accordance with the guidelines for river protection, restoration and management in the Australian Stream Rehabilitation Manual (see references).

More information

Much of the research and experience on which this Fact Sheet is based have been gained in the streams of south-eastern Australia. The general principles outlined here are likely to apply universally, but there are specific characteristics and situations that must be taken into account. The following references provide additional, technical information about the role and importance of LWD, as well as technical and quantitative information about its modification or reintroduction. These will assist you in designing and undertaking management of LWD that will meet particular objectives.

A snag artificially added to Ryans Creek, NE Victoria. Photo Ian Rutherfurd.

For further information

Cottingham, P., Bunn, S., Price, P. & Lovett, S. (eds) 2003, 'Managing wood in streams', *River and Riparian Land Management Technical Update No. 3*, Land & Water Australia, Canberra.

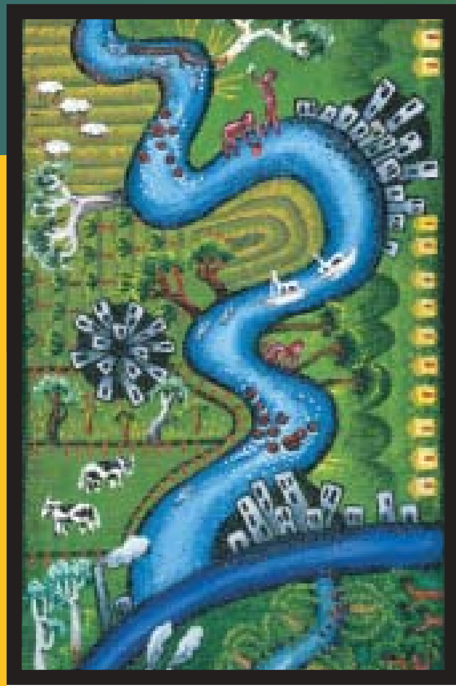
Rutherfurd, I., Jerie, K. & Marsh, N. 2000, *A Rehabilitation Manual for Australia Streams — Volumes One and Two*, Land & Water Australia / CRC for Catchment Hydrology, Canberra.

Treadwell, S., Koehn, J. & Bunn, S. 1999, 'Large woody debris and other aquatic habitat' in S. Lovett & P. Price (eds), *Riparian Land Management Technical Guidelines, Volume One: Principles of sound management*, Land & Water Australia, Canberra.

Treadwell, S. 1999, 'Managing snags and large wood debris' in S. Lovett & P. Price (eds), *Riparian Land Management Technical Guidelines, Volume Two: On-ground management tools and techniques*, Land & Water Australia, Canberra.

A log spanning the Upper Latrobe River, Gippsland. Photo Ian Rutherfurd.

FACT SHEET 7 BACK PAGE



These **Fact Sheets** are grouped according to whether they deal with riparian land, in-stream issues, river contaminants or other matters. They aim to set out the general principles and practices for sound management. Other information that focuses on local conditions and management issues is available from state government agencies, local governments, catchment management authorities, rural industry bodies and community organisations. Together, this information should assist users to understand the key issues in river and riparian management, and enable them to adapt general management principles to their particular situation, and to know where to go for advice specific to local conditions.

Other relevant Fact Sheets

1 Managing riparian land
2 Streambank stability
3 Improving water quality
4 Maintaining in-stream life
5 Riparian habitat for wildlife
6 Managing stock
8 Inland rivers and floodplains
9 Planning for river restoration
10 River flows and blue-green algae
11 Managing phosphorus in catchments
12 Riparian ecosystem services
13 Managing riparian widths

Numbers 1–7 of these Fact Sheets are based on the previous *Riparian Management* series produced in the 1990s. The authors involved in the development of the earlier series were: Michael Askey-Doran, Stuart Bunn, Peter Hairsine, Ian Prosser, Ian Rutherfurd, Brian Finlayson, Ian O'Neill, Chris Gippel and Wendy Tubman.

Further information on river and riparian management can also be found at the Land & Water Australia 'River Landscapes' website.

www.rivers.gov.au

This website provides access to projects, fact sheets, guidelines and other information designed to assist people to better manage river and riparian areas across Australia.

RiverLandscapes

Edited by Phil Price and Siwan Lovett and produced by Land & Water Australia's National Riparian Lands Research and Development Program.

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