### Conclusion

Ecological restoration is an information rich field of practice in which attention to detail and strong work ethic contribute significantly to project outcomes. There is no upper limit of effort when restoring at the paddock scale (greater than 100 ha). For each project, many opportunities exist to make incremental gains toward improving the ecological function of the local area. Ongoing review of ecological principals, and ongoing development of innovative approaches to apply them, is best practice restoration.

### References

Fazey I., and McQuie A., (2005). Appling conservation theory in natural areas management. Ecological Management and Restoration 6, 147-149.

Jonson, J., (2010). Ecological restoration of cleared agricultural land in Gondwana Link: lifting the bar at 'Peniup'. Ecological Management and Restoration 11, 16-26.

Society for Ecological Restoration International Science & Policy Working Group. (2004). *The SER International Primer on Ecological Restoration*.http://www.ser.org/pdf/primer3.pdf.

# Buffer zones for aquatic biodiversity conservation

*Dr Gina Newton*

*Department of Sustainability, Environment, Water, Population and Communities. Email: gina.newton@environment.gov.au*

Buffer zones are used worldwide as an approach to protect and manage sensitive ecological areas (Boyd 2001). The function and viability of terrestrial and aquatic communities can be improved through the application of buffer zones, by minimising external threats and encouraging land-use management in adjacent areas. The application of buffer zones offers a practical, cost-effective approach to significantly enhance conservation efforts for aquatic habitats and biodiversity.

### Definitions and descriptions

A buffer zone is an area lying between two or more others that serves to reduce the possibility of damaging interactions between or through them (Ebregt and De Greve 2000). It generally refers to the area of land adjacent to a sensitive or 'protected' core area of natural habitat of either terrestrial vegetation or some form of water body (or both).

*Wetland of Murray River in SA. Photo: South Australian Murray-Darling Basin NRM Board*

A buffer zone also often constitutes or overlaps with an ecotone – a zone of transition between two different ecosystems such as the terrestrial habitat surrounding wetlands or adjacent to rivers (Winning 1997). Ecotones are often species diverse, providing critical habitat for fauna that are dependent on both ecosystem types. Research demonstrates that large areas of terrestrial habitat surrounding wetlands may be critical for maintaining biodiversity, and that both habitats must be managed as an integral unit to protect biodiversity (e.g. Boyd 2001; Semlitsch and Bodie 2003).

### Benefits of buffers

A common method for reducing or eliminating impacts to aquatic resources from adjacent land uses and other pressures is to maintain buffers around the resources. For example, there is now sound evidence that providing riparian buffers of sufficient width protects and improves water quality by intercepting and trapping non-point source pollutants and sediments in surface and shallow subsurface water flow (Wenger 1999; Fischer *et al*. 2000). Table 1 provides an overview of the varied specific benefits of using buffers. Some higher level benefits include:

*Maintaining ecological integrity* - maintaining the structure, composition, function, and therefore the integrity and viability of aquatic systems, which are often subject to disturbances originating in adjacent or upland areas.

*Minimising edge-effects* - an edge-effect is an 'artificial' ecotone between the remnant natural ecosystem and the adjacent, often anthropogenically changed ecosystem

(Winning 1997), and is often characterised by disturbances such as weed infestation, dumped rubbish and partial clearing. Applying buffer zones to contain edge-effects can be important for sensitive areas of small size, such as small, disconnected wetlands, or narrow water courses.

*Building resilience against climate change* - climate change has critical implications for Australia's water resources and aquatic systems, including ecosystem function and services (Newton 2009). For natural systems and biodiversity, adapting to climate change impacts requires increasing resilience. Using buffers will contribute to building resilience of aquatic systems under management or conservation regimes.

*Protecting groundwater* - excavations into an aquifer have the potential to cause a local drawdown in the level of groundwater in the surrounding aquifer, potentially affecting the water hydroperiod (a critical variable in maintaining viable wetland communities) in any nearby wetlands that are groundwater dependent (Winning 1997). There is a strong relationship between groundwater drawdown and wetland hydroperiod. Lowered groundwater tables in areas surrounding wetland communities can decrease surface water depth and shorten periods of standing water within wetlands causing a shift in community structure toward species characteristic of drier conditions (Brown et al. 1990; Winning 1997). Buffers may assist with moderating the effects of groundwater extraction (McElfish et al. 2008).

## Design and use of buffers

The success of buffers as a conservation/management tool depends on: setting clear objectives; careful design and management; evaluation of effectiveness to optimise the potential benefits for wetlands and their biota (Weston *et al*. 2009); and importantly, the width of the buffer (Keller *et al.* 1993 in Boyd 2001). Optimal buffer width for a particular wetland also depends on the conservation significance of the wetland and the purpose of the buffer (WRCWA 2000; WAPC 2005).

Castelle *et al*. (1992) suggest four criteria for determining adequate buffer sizes for aquatic systems:

- resource functional value (i.e. ecosystem function and ecosystem service perspective)
- intensity of adjacent land use
- buffer characteristics (e.g. slope, soil type, nature (natural versus artificial barrier, etc.)
- specific buffer functions required (e.g. sediment/nutrient removal, species diversity, etc.).

The recommended buffer zone widths for wetland/riparian ecosystems varies depending on specific objectives (see Table 2). To protect the environmental values of a wetland, as a general guide buffer widths of 30 - 50 m from the boundary of wetland dependent vegetation are recommended. However, buffer effectiveness generally increases with increasing width (Castelle *et al*. 1992). Several studies suggest larger widths, such as 200 to 500 m, are more effective for protecting fauna such as birds and reptiles, or reducing heavy metal pollution.

*Mary River and riparian vegetation near Gympie in Queensland. Photo: Matt White*

Buffers designed specifically to minimise groundwater drawdown or protect inflowing groundwater quality are also recommended at higher widths, such as around 200 to 2000 m.

## Buffers and ecological communities under the EPBC Act

Within a buffer zone, management actions, including restrictions on resource use or development activities, may be used to enhance conservation value (Ebregt and De Greve 2000). Recently buffer zones have been applied to several terrestrial ecological communities listed as threatened under Australia's national environment law, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). For example, minimum buffer zones of 30 - 50 m were specified to enhance protection of small, fragmented patches of woodland, forest, and clay pan communities to help protect them from disturbance such as weed invasion and agricultural spray drift.

Any action or development likely to have a significant detrimental impact on a matter listed under the EPBC Act (such as a threatened ecological community or species) must be referred, assessed and approved (i.e. by the Minister for the Environment) before it can proceed. While not formally part of the ecological community, conservation outcomes can be enhanced by applying a buffer or 'zone of influence' to the listing description. Buffers also assist with guiding appropriate management around an ecological community. Actions within the buffer zone do not necessarily trigger the EPBC Act, but rather should be considered when determining possible significant detrimental impacts to a listed threatened ecological community. For the first time, large, complex riverine and wetland systems are under assessment as potentially threatened ecological communities under the EPBC Act. Using buffers for the listing and protection of these aquatic ecological communities is likely to be an effective approach to enhance protection of these sensitive systems.

*Table 1: Benefits of wetland (riparian) buffer zones for a range of chemical, physical and ecological functions*

| Function | Benefit |
|---|---|
| Water Quality | • Protection of surface water runoff from surrounding land into the wetland (i.e. filtering/trapping of toxics)<br>• Reducing sedimentation (soil erosion, trapping sediment)<br>• Reducing eutrophication (excess nutrients, e.g. from fertilizers) – serving as nutrient sinks for surrounding watershed<br>• Reducing pollution and spray drift (e.g. pesticides/herbicides, heavy metals)<br>• Protection from rising salinity<br>• Protection of inflowing groundwater quality |
| Microclimate | • Maintain microclimatic gradient<br>• Provide shading and moderate water temperature<br>• Provide wind break |
| Hydrology | • Reducing peak floods – water fluctuations<br>• Moderate the impacts of altered hydrologic regimes and flooding<br>• Stabilising stream channels and banks (e.g. enabling roots to hold soils)<br>• Increase flood storage capacity of wetlands<br>• Serving as key recharge points for renewing groundwater supplies<br>• Protecting hydroperiod (which can influence ecology)<br>• Reducing rate of infilling from sedimentation<br>• Influences depth of water table<br>• Enhances stream 'roughness' which affects flow regime<br>• Groundwater interaction – prevention of groundwater drawdown |
| Wetland Fauna Habitat | • Maintenance of ecological processes<br>• Providing feeding habitat - maintain productive food webs in-stream<br>• Provision of a source of carbon to the wetland<br>• Providing leaves and woody debris critical for aquatic organisms<br>• Providing breeding/nesting habitat<br>• Providing shelter/cover/overwintering sites<br>• Protection of biodiversity<br>• Minimisation of invasion by exotic species/weeds<br>• Absorbing 'edge effects' on ecology<br>• Protection from rising salinity |
| Wildlife Corridor | • Contribute to wildlife corridors between wetland and adjacent wetlands or bushland or other habitat fragments (i.e. for dispersal, migration, foraging etc.) |
| Fauna Protection | • Reduce disturbance from surrounding development (e.g. noise, light, movement from residential development; human activities)<br>• Absorbing 'edge effects' on ecology<br>• Provide a transition zone between upland and lowland habitats<br>• Promote gene flow |
| Aesthetics/ Recreation | • Provide buffer between residential areas and nuisance insects e.g. midges, mosquitoes<br>• Create a screen from incompatible scenery (e.g. industrial development)<br>• Provide area for passive recreational activities (e.g. bird watching) |
| Management Tool | • Achieving desired values, processes, functions and other attributes/ ecosystem services of wetlands<br>• Mitigate fragmentation and increase connectivity of isolated habitats<br>• Protection against margin dieback<br>• Biodiversity conservation and reserves of native species<br>• Accommodate for 'fuzziness' of wetland boundaries (i.e. allow for expansion in times of flood) |

Note: Adapted from Boyd 2001; Castelle et al. 1994; Davies and Lane, 1995; Fischer et al. 2000; Emmons and Oliver Resources 2001; Hairsine 1997; McElfish et al. 2008; DPIPWE 2003; DSE 2005; WAPC 2005; WRCWA 2000; Wenger 1999; Weston et al. 2009; Winning 1997).

*Table 2: Recommended buffer zone widths for wetland/riparian ecosystems*

| Aspect | Objective | Recommended buffer width* | References |
|---|---|---|---|
| Temperature | Water temperature moderation/ shade | 12 – 30 m | Castelle *et al.* 1994 |
| | | 20 m[a] | Davies and Lane 1995 |
| | Maintain microclimate gradient | 45 m | Fischer *et al*. 2000 |
| Nutrients | Reduce nutrient inputs (removal) | 100 m[b] | Davies and Lane 1995 |
| | | 200 m (sandy soils) | WRCWA 2000 |
| | (reducing nitrate) | 30 m | Wenger 1999 |
| | | 30 – 48 m | Castelle *et al.* 1994 |
| | (removal of phosphorus) | 9 – 30 m | McElfish *et al*. 2008 |
| | (removal of nitrogen) | 30 – 48 m | McElfish *et al*. 2008 |
| Pollution | Reduce pollution (heavy metal) input | 100 m[b] | Davies and Lane 1995 |
| | | 200 m (sandy soils) | WRCWA 2000 |
| | Reduce pollution (pesticide removal) | > 15 m | Wenger 1999 |
| Sediment | Reduce sedimentation (removal) | 9 – 30 m | McElfish et al 2008 |
| | | 30 m | Wenger 1999 |
| | | 10 – 65 m | Castelle *et al.* 1994 |
| | | 100 m[a] | Davies and Lane 1995; WRCWA 2000 |
| Water quality | Improving/protection of water quality | 5 – 30 m | Fischer et al 2000 |
| | | ≥ 6 m[c] | DSE 2005 |
| | Protection from land use | 30 - 60 m | Semlitsch and Jensen 2001 |
| Ecological processes | Maintain ecological processes/major food webs | 10 – 30 m | Wenger 1999 |
| | (carbon flow) | 20 – 50 m[d] | Davies and Lane 1995; WRCWA 2000 |
| | (large woody debris and organic litter) | 30 – 50 m | Wegner 1999 |
| Bank stability | Protect bank stability | 20 – 30 m | DPIPWE 2003 |
| Biodiversity | Protect biodiversity (species diversity)/ wildlife/ habitat | 30 – 90 m | McElfish *et al*. 2008 |
| | | 3 – 120 m | Castelle *et al*. 1994 |
| | | > 100 m | Wenger 1999 |
| | | 100 – 170 m | Brown *et al.* 1990; Keller *et al*. 1993 |
| | Bird habitat | 40 – 500 m | Fischer *et al.* 2000 |
| | Reptile/amphibian habitat | 30 – 1000 m[e] | Fischer *et al.* 2000; Semlitsch and Bodie 2003 |
| | Mammal habitat | > 50 m | Fischer *et al.* 2000 |
| | Maintain benthic invertebrates in streams adjacent to logging | 32 m | Erman *et al.* 1977 and Newbold 1980 in Castelle *et al.* 1992 |
| Insects | Nuisance insects | 100 – 800 m[f] | Davies and Lane 1995; WRCWA 2000 |
| Groundwater | Protection of inflowing groundwater quality | 2000 m[g] | Davies and Lane 1995; WRCWA 2000; DSE 2005 |
| | Minimise groundwater drawdown | [h]35 – 170 m | Brown *et al*. 1990 |
| Salinity | Protection from rising salinity | 250 m | Davies and Lane 1995; DSE 2005 |

Notes: * generally measured from edge of wetland or each side of stream, except where noted otherwise; a = Measured from seasonally inundated zone; b = Measured from wetland dependent vegetation; c = Low overland flow rates; d = Measured from outer edge of open water; e = 130 - 290 m for critical core habitat; f = Measured from permanent water; g = For sandy soils/in direction of groundwater flow; h = Small wetlands, soil type & slope influence

## Conclusion

Weston *et al*. (2009) suggest that the proposed role of a buffer zone in the conservation of biodiversity should be stated explicitly as one or a combination of: a) provision of habitat, b) provision of corridors and/or c) reduction of disturbance – as each goal potentially engenders different buffer designs, management, and balance between recreational and wildlife needs. The creation of ecologically meaningful guidelines for the establishment of buffers is imperative if they are to fulfil the role of enhancing nature conservation. Such guidelines should be informed by appropriate science, much of which is not yet available, especially in the Australian context (Weston *et al*. 2009). The increasing use of buffers in the description of threatened ecological communities, particularly aquatic systems, and their associated recovery plans represents a valuable approach to enhancing aquatic biodiversity conservation at a national scale and should help inform the development of such guidelines.

## References


Boyd, L. (2001). Wetland Buffer Zones and Beyond: Wildlife use of wetland buffer zones and their protection under the Massachusetts Wetland Protection Act. Wetland Conservation Professional Program, Department of Natural Resources Conservation, University of Massachusetts

Brown, M.T., Schaefer, J.M. and Brandt, K.H. (1990). Buffer Zones for Water, Wetlands, and Wildlife in East Central Florida. Report for the East Central Florida Regional Planning Council, CFW Publication #89-07 Florida Agricultural Experiment Stations Journal Series No. T-0061.

Castelle, A.J., Conolly, C., Emeers, M, Metz, E.D., Heyer, S., Witter, M., Mauermann, S., Erickson, T. and Cooke, S.S. (1992). Wetland Buffers: Use and Effectiveness, Report for Washington State Department of Ecology, Shorelands and Coastal Zone Management Program, Olympia, Washington.

Castelle, A.J., Johnson, A.W, and Conolly, C. (1994) Wetland and Stream Buffer Size Requirements – A Review. *Journal of Environmental Quality* 23: 878-882.

Davies, P M and Lane, J A K 1995, *Guidelines for Design of Effective Buffers for Wetlands on the Swan Coastal Plain*, Report to the Australian Nature Conservation Agency, Canberra.

DSE (Department of Sustainability and Environment) (2005) The Index of Wetland Condition: conceptual framework and selection of measures. Victorian Government, Department of Sustainability and Environment, Melbourne.

DPIPWE (Department of Primary Industries, Parks, Water and Environment) (2003). Wetlands and Waterways Works Manual No 7: Environmental Best Practice Guidelines: Management of Riparian Vegetation.

Ebregt, A., and De Greve, P. (2000). Buffer Zones and their Management. Policy and best practices for terrestrial ecosystems in developing countries. Theme Studies Series, Forests, Forestry and Biological Diversity Support Group. National Reference Centre for Nature Management, International Agricultural Centre, Wageningen, the Netherlands.

Emmons and Oliver Resources, Inc. (2001) Benefits of Wetland Buffers: A study of functions, values and size prepared for the Minnehaha Creek Watershed District.

Fischer, R.A., Martin, C.O. and Fischenich, J.C. (2000). Improving riparian buffer strips and corridors for water quality and wildlife. International Conference on riparian ecology and management in multi-land use watersheds. American Water Resources Association.

Hairsine, P. (1997) Controlling Sediment and Nutrient Movement Within Catchments. Industry Report 97/9, CRC Catchment Hydrology.

Keller, C.M.E., Robbins, C.S. and Hatfield, J.S. (1993). Avian communities in riparian forests of different widths in Maryland and Delaware.Wetlands13, 137–144.

McElfish, J.M.Jr, Kihslinger, R.L. and Nichols, S.S. (2008). Planner's Guide to Wetland Buffers for Local Governments. Environmental Law Institute, Washington D.C.

Newton, G. (2009). Australia's environmental climate change challenge: overview with reference to water resources. *Australasian Journal of Environmental Management* 16:130-139.

Semlitsch, R.D. and Bodie, J.R. (2003). Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. *Conservation Biology*. 17 (5): 1129-128.

Semlitsch, R.D. and J.B. Jensen (2001) Core habitat, not buffer zone. *National Wetlands Newsletter* 23 (4): 5-11.

Steffen, W. (2009). Climate change 2009: faster change and more serious risks. Department of Climate Change and Energy Efficiency, Canberra. http://www.climatechange.gov.au/en/publications/science/faster-change-more-risk.aspx

Van Waegeningh, H.G. (1981) A proposal for the dimensions of protection areas. The Science of the Total Environment. 21: 397 - 403.

WRCWA (Water and Rivers Commission Western Australia) (2000) Wetland buffers. Water Notes WN4 January 2000.

Wenger, S. (1999) A review of the scientific literature on riparian buffer width, extent and vegetation. Office of Public Service and Outreach, Institute of Ecology, University of Georgia.

WAPC (Western Australian Planning Commission) (2005). Guidelines for the Determination of Wetland Buffer Requirements. W A Planning Commission, Perth. http://www.planning.wa.gov.au/Publications/740.aspx

Weston, M.A., Antos, M.J., and H.K. Glover (2009) Birds, buffers and bicycles: a review and case study of wetland buffers. *The Victorian Naturalist* 126(3): 79 – 86.

Winning, G. (1997) The Functions & Width of Wetland Buffers. Hunter Wetlands Research; Technical Memorandum No. 1.