Repairing biota: what to do in the catchment

Strategy 1. Identify biodiversity refuges

Suitability of strategy: suitable for all urban areas.

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
1a. Catchment and system-wide survey of biota	Surveys of instream fauna are essential to identify waterway refuge sites. Refuges may not only be within the site's catchment, but also downstream of the site. Ideally, hundreds of sites should be surveyed across the urban network – including anthropogenic waterways; however, it is possible to use species distributional models to predict sites where biodiversity will be high (e.g. zonation).	All areas. Note, biodiversity refuges are most likely to occur in peri urban areas, but some refuge sites need to be located in lowland areas because these are likely to contain a different suite of species. Stormwater detention ponds may be refuges for adult biota or may be ecological traps - i.e. locations where reproduction and survival of young are low. Biodiversity refuge (definition) - A site of high native diversity (animals or plants). These are areas where adults or juveniles are protected from urban stressors. They are often sites of high breeding success and individuals move out of these sites to recolonise other less healthy sites. Refuges are critical to the resilience of the system.	[1, 2]	There are numerous system-wide surveys across Australia, e.g. the Sustainable Rivers Audit. SEQ Healthy Waterways, EPA Vic Rapid assessment. Surveys can be used to identify refuges and also to determine key threats.

Strategy 2. Create/protect refuge stepping stones across the urban landscape

Suitability of strategy: suitable for most urban metropolitan areas, but most likely to be successful where a city's peri urban areas are relatively pristine. Less successful where prior agricultural land use has caused the loss of many species from the wider landscape.

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
2a. Create/protect instream refuges (e.g. reaches of the stream/river with gentle flow and good water quality) See *Repairing biota at the site* factsheet, all strategies	Many freshwater animals spend 100 per cent of their life in the water (e.g. fish, mussels, many crustaceans). The long-term persistence of these animals across the urban landscape (i.e. meta-community) requires numerous healthy pools or river reaches where species can survive, breed and disperse out to the wider river network.	Protecting lotic refuges will be most easily achieved in parts of the catchment/urban landscape where stormwater has been managed at the catchment scale. Refuges can also be created around flow regulating structures (weirs) and in anabranches with little flow connection to the river. In general, intermittent refuges are easiest to create/protect in peri urban areas. See the associated factsheet for the specific suitability of individual actions.	[1, 3, 4]	See associated factsheet
2b. Create/protect wetland refuges (e.g. wetlands with good water quality, macrophytes and intact riparian vegetation	Many of the obligate aquatic animals can live in still, as well as flowing water habitats. Thus, creating and protecting healthy wetlands can support their long-term persistence in urban areas. Wetlands (floodplain and non-floodplain, natural or man-made – e.g. wetland biofilters) can be particularly important for protecting these aquatic animals from disruptive high velocity urban flows.	Newly created wetland refuges will be most successful if they are located relatively close to the waterway network (i.e. floodplain wetlands) – so that biota can easily colonise the area, as well as disperse from the refuges to newly repaired sites. Most successful in areas where soil and groundwater is not highly contaminated with nutrients or other chemical pollutants.	[1, 2, 5]	Refer to wetland restoration manuals
2c. Create/protect remnant bushland	Many freshwater animals are semi-aquatic (e.g. turtles) or have a terrestrial life stage (e.g. insects, frogs). These species, particularly aerial insects, often use remnant bushland as habitat. Protecting or creating patches of bushland can help them move through the urban fabric. Remnant bushland is likely to support more species and higher numbers of animals than restored parkland and should be protected as a priority.	Where the biota of management interest are aerial dispersers – i.e. move easily between terrestrial green patches.	[6-11]	

Strategy 3. Improve connectivity among refuges

Suitability of strategy: most suitable where Strategy 2 (this factsheet) has already been implemented. Actions that promote dispersal may not be suitable if they accelerate the spread of invasive non-native species.

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
3a. Protect and repair riparian vegetation and address instream barriers See *Repairing lateral connectivity* and *Repairing longitudonal connectivity* factsheets, all strategies	The ability to move effectively along the length of a river, along a riparian corridor or between the riparian zone and remnant parcels of bushland is fundamental to the dispersal and recolonisation ability of biota. Without this ability animals are unlikely to reappear at restored sites. Care must be taken not to establish connectivity to a site where survival is low (e.g. ecological traps).	Where the biota of interest are species that are prone to suffer local extinction. This is often species that are found in low abundance, such as large species, predators and habitat specialists. Note that landscape connectivity is not as important for birds that can travel long distances through the air. Care should be taken that enhancing connectivity does not create ecological traps or allow predators (e.g. fish) to access sites where they naturally would not be present. See associated factsheet for specific advice.	[1, 5-8, 12, 13] but see [14-16] for caution	See associated factsheets

Strategy 4. Limit the invasion and spread of non-native species

Suitability of strategy: where non-native species are not present within the urban area, or they are present but have a restricted distribution, i.e. they are not present at the restoration site.

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
4a. Educate residents about the impacts of non-native species	Many people in urban areas release pet animals (fish, newt, turtles) into waterways. Educating people about the negative effects these non-native species is an important component of alien species management.	All areas, particularly where there is evidence of aquarium fish in waterways.		
4b. Intensive removal of non-native species	Eliminating non-native species once they have arrived is the only sure way to guarantee that they won't spread.	Where the non-native species is in low abundance and constrained to a small area (i.e. recent invasion). Or in high value isolated systems where re-invasion is less likely (e.g. certain floodplain wetlands).	[17, 18]	[19]
4c. Use barriers (existing) to limit the dispersal of invasive non-natives	Existing barriers, such as weirs, causeways and dams typically prevent fish passage and can be used to limit the spread of non-native species.	Where the non-native species has increased its abundance and distribution (i.e. created a self-sustaining population); but where the non-native species are located downstream of the restoration site (i.e. upstream sections of the river do not contain the alien species).	[14]	

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
4d. Use biocontrol or other methods	Specially designed viruses and genetic modifications (e.g. daughterless carp, cyprinid herpesvirus) can be used to control some invasive species.	Where the technology is available. This approach should be used with extreme caution to ensure that it does not put other biota at risk.	[17, 18]	

Supporting documents

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Strategy 1. Identify biodiversity refuges

Strategy 2. Create/protect refuge stepping stones across the urban landscape

Strategy 3. Improve connectivity among refuges

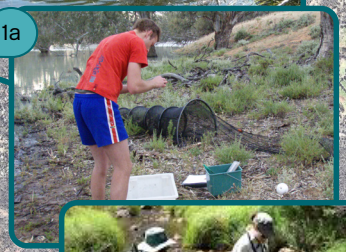
Strategy 4. Limit the invasion & spread of non-natives

protect remnant bushland

2c

catchment wide survey of biota

1a



improve longitudinal connectivity

3a

4b

use barriers to limit the dispersal of invasives

protect high quality wetlands

2b

4b

intensive removal of non-natives

create / protect instream refuges

2a

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Legend
Sampling site
Refuge