SILVER PERCH

BIDYANUS BIDYANUS

ACTION PLAN

Silver Perch *(Bidyanus bidyanus)*. Illustration: courtesy of NSW Government

PREAMBLE

The Silver Perch (*Bidyanus bidyanus* Mitchell 1838) was listed a vulnerable species on 26 October 2001 (initially Instrument No. 299 of 2001 and currently Instrument No. 265 of 2016). Under section 101 of the *Nature Conservation Act 2014*, the Conservator of Flora and Fauna is responsible for preparing, where required, a draft action plan for a relevant listed species. The first action plan for this species was prepared in 2003 (ACT Government 2003). The species was included in Action Plan 29 Aquatic Species and Riparian Zone Conservation Strategy (ACT Government 2007). This revised edition supersedes earlier editions.

Measures proposed in this action plan complement those proposed in the Aquatic and Riparian Conservation Strategy, and component threatened species action plans such as the Macquarie Perch (*Macquaria australasica*), Trout Cod *(Maccullochella macquariensis*), Two-spined Blackfish (*Gadopsis bispinosus*) and Murray River Crayfish (*Euastacus armatus*).

CONSERVATION STATUS

Bidyanus bidyanus is recognised as a threatened species in the following sources:

International: IUCN

Data Deficient (trend declining) – Previously vulnerable.

National

Critically endangered – *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth).
Vulnerable – Australian Society for Fish Biology (Lintermans 2015).

Australian Capital Territory

Vulnerable – Section 91 of the *Nature Conservation Act 2014.*
Special Protection Status Species – Section 109 of the *Nature Conservation Act 2014.*

New South Wales

Vulnerable – Schedule 5 of the *Fisheries Management Act 1994*, regulated take permitted in selected listed stocked impoundments.

Victoria

Threatened – Section 10 of the *Flora and Fauna Guarantee Act 1988*.

South Australia

Protected – Schedule 5 of the *Fisheries Management Act* 2007.

Queensland

Protected – Paroo and Warrego River. Regulated take elsewhere, *Fisheries Act 1994*.

SPECIES DESCRIPTION AND ECOLOGY

Description

Bidyanus bidyanus is a moderate to large fish (maximum length of about 500 millimetres (mm) and a maximum weight of around 8 kilograms (kg)) which commonly reaches 300–400 mm and 0.5–1.5 kg in rivers (Figure 1). The body is elongate and slender in juvenile and immature fish, becoming deeper and compressed in adults. The head is relatively small, jaws are equal in length and eyes and mouth are small. In larger specimens the head is

reduced in comparison to the body giving a humped shouldered look. The scales are thin and small (compared to Macquarie Perch or Golden Perch) and the tail is weakly forked. The lateral line follows the profile of the back. Colour is generally silvery grey to black on the body, with the dorsal, anal and caudal fins also grey. The pelvic fins are whitish (Merrick 1996, Merrick & Schmida 1984).

Distribution and abundance

B. bidyanus are endemic to the Murray–Darling Basin and were formerly widespread through the Basin's rivers and major streams (DEE 2013). The ACT is toward the upper altitudinal limits of the species distribution. Historic and anecdotal reports indicate *B. bidyanus* was found in the Murrumbidgee River as far upstream as Cooma (800 metres above sea level) during the species' annual migrations in the early and mid-1900s (Trueman 2012).

In the ACT region they are historically known from the Murrumbidgee and Molonglo rivers and also from the lower Yass and Goodradigbee Rivers in NSW. *B. bidyanus* have been stocked into many impoundments in the region and continue to be stocked into Burrinjuck and Googong Dams by the NSW Department of Primary Industries (DPI) to provide a recreational fishery. They are also extensively used in the aquaculture and aquaponics industries and are available through the aquarium and live retail restaurant trades (Rowland 2009, Davies et al. 2012).

B. bidyanus have not been recorded in the ACT Government's Murrumbidgee monitoring since 1988. *B. bidyanus* are still caught in Googong Reservoir where they are stocked. There were several angler records and a ranger report of *B. bidyanus* around Casuarina Sands on the Murrumbidgee River in 2002. The occasional report of this species by anglers in the urban lakes and Molonglo River are attributed to fish displaced from NSW DPI stocking in Googong Dam, illegal stocking (including karma releases) or contamination of government stocking (ACT Government unpublished data).

Habitat and ecology

B. bidyanus is found over a broad area of the Murray–Darling Basin and is often found in similar habitats to Murray Cod (*Maccullochella peelii*) and Golden Perch (*Macquaria ambigua*), i.e. lowland, turbid rivers. There are some reports that suggest that *B. bidyanus* prefers faster, open water, but the general scarcity of information on the habitat preferences of the species makes generalisation difficult. The species is not currently found in the cool, fast-flowing, upland streams and rivers of the Murray–Darling Basin, although there are historical sightings up to 700 metres above sea level (M. Lintermans pers. comm.).

B. bidyanus is slow-growing and long-lived in rivers, with a greatest age of 17 years recorded from the Murray River and 27 years recorded from Cataract Dam. A 1.4 kg fish could be 17 years old (Mallen-Cooper et al. 1995). Growth rates in Googong Dam have been variable, with a 2.3 kg fish captured and estimated to be approximately six years old (ACT Government unpublished data).

B. bidyanus undertake a wide range of migrations as juveniles and adults and have been recorded moving over 200 kilometres (km). Adults move upstream in late spring and juveniles move upstream in late summer (Mallan Cooper et al. 1995). *B. bidyanus* mature at 3 years of age for males and 4–5 years of age for females. Spawning commences in spring to early summer, often associated with upstream migrations when large schools of fish were historically observed. Schools of fish spawn in shallow water with a preference for gravel substrate. Approximately 170,000–250,000 eggs per kg of bodyweight are laid (Rowland 2009, Merrick and Schmida 1984). The eggs are approximately 2.7 mm in diameter and semi-pelagic but will sink in non-flowing environments and hatch in 30 hours at 26°C (Lake 1967).

The construction of Burrinjuck Dam in the 1920s effectively isolated the upper catchment from downstream populations. Scrivener Dam isolated the Molonglo and Queanbeyan rivers, and Cotter Dam isolated the Cotter River. The former 'run' of *B. bidyanus* upstream from Lake Burrinjuck has not been recorded since the early 1980s (Lintermans 2002).

This species has been bred artificially in a number of government (non-ACT) and commercial hatcheries and is widely stocked in farm dams and reservoirs in the Murray–Darling Basin and eastern drainages (DEE 2013). The species is of considerable value to aquaculture, estimated at more than $3 million in NSW for the year 2014–15 (Rowland 2009, NSW DPI 2016). Genetic population analysis of *B. bidyanus* populations has indicated significant differences between wild populations and some hatchery or stock impoundment populations. There have also been differences recorded between the wild population in the Paroo Catchment in the northern and those of the wider Murray–Darling Basin (Bearlin and Tikel 2003). The widespread use of the species in aquaculture and stocking has potential to further develop domestic production strains of *B. bidyanus*

B. bidyanus is omnivorous, consuming aquatic plants, algae, molluscs, crustaceans and aquatic insect larvae (DEE 2013). Reports suggest the species becomes mainly herbivorous once they reach lengths of 250 mm (DEE 2013, Clunie and Koehn 2001). However, their diet in Googong Reservoir shows little change with fish size (ACT Government unpublished data).

The Australian Government's Conservation Advice: *Bidyanus bidyanus* (Australian Government 2013) contains a comprehensive compilation of information on the ecology and biology of Silver Perch.

CURRENT MANAGEMENT ACTIONS AND RESEARCH

Fishing closures

Regulations prohibiting the take of *B. bidyanus* by anglers have been in place since the species was listed as threatened in 2001 (ACT Government 2003). Limited recreational take is permitted in Googong and Burrinjuck reservoirs in nearby NSW, where the species is stocked. However, the species is protected in all NSW rivers including the Murrumbidgee River.

Habitat rehabilitation

Many sections of the Murrumbidgee through the ACT are affected by accumulations of sand ('sand slugs') which cause reduced water depth and structural habitat diversity. Since 1998 efforts have been under way to rehabilitate fish habitat (create scour pools) and improve fish passage through the sand slug adjacent to Tharwa with a series of rock groynes built in 2001 and, subsequently, two engineered log jams in 2013 (Lintermans 2004a, ACT Government 2013). Such works are intended to link fish habitat in good condition downstream of Point Hut Crossing with similarly good habitat in the Gigerline Gorge. The works at Tharwa have resulted in scour pools with increased depth.

Monitoring

The Murrumbidgee River through the ACT has been monitored biennially since 1994 using methods suitable for detecting *B. bidyanus* (e.g. ACT Government 2015). If *B. bidyanus* were to become re-established, this monitoring program is likely to detect the species at low to moderate population densities. A database for all ACT fish records has been established by the ACT Government.

Cross-border management

The Upper Murrumbidgee Demonstration Reach (UMDR) commenced in 2009 as an initiative under the Murray–Darling Basin Native Fish

Strategy and involves a partnership of government, university and community groups (ACT Government 2010). The UMDR is approximately 100 km in length, stretching from the rural township of Bredbo in south-east NSW downstream to Casuarina Sands in the ACT. The vision of the UMDR is 'a healthier, more resilient and sustainable river reach and corridor that is appreciated and enjoyed by all communities of the national capital region'.

The UMDR initiative has so far completed a number of documents including an implementation plan, community engagement plan, Carp management plan, monitoring literature review and monitoring strategy, an assessment of fishways in the ACT, study on the effectiveness of the Casuarina Sands fishway, revegetation and weed control, assessment of the sampling methodology for Murray Crayfish and the Tharwa Fish Habitat Project, and successfully worked across the ACT–NSW border to implement its aims. Improvement of upper Murrumbidgee River habitat will benefit the native fish community.

THREATS

River regulation

In the Canberra region, Tantangara Dam reduces flows downstream by 99%, with water from the upper Murrumbidgee River diverted to Lake Eucumbene in the Snowy River Catchment (Pendlebury 1997). At the Mt McDonald gauging station (near the confluence of the Cotter River with the Murrumbidgee River), flow in the Murrumbidgee River has recovered to approximately 73% of natural levels (ACT Government 2004). Flow diversion infrastructure such as the Murrumbidgee to Googong (M2G) pipeline, with the pumping station at Angle Crossing and the Cotter Pumping Station at Casuarina Sands, also affect riverine flows by diverting flow out of the Murrumbidgee River for domestic water supply.

Reduced flows downstream of dams also contribute to reduced fish passage when natural barriers (rock bars, small cascades) that would normally drown out under natural flows cease to do so. Lake Burley Griffin and Googong Reservoir on the Molonglo–Queanbeyan River system reduce seasonal flows in the lower Molonglo River and adjacent Murrumbidgee, reducing the dilution of effluent discharge from the Lower Molonglo Water Quality Control Centre (LMWQCC). The average daily discharge of treated effluent from the LMWQCC is 90 megalitres/day or 33 gigalitres/year, comprising approximately 30–40% of flow in the Murrumbidgee River at Mt McDonald on average, but up to 90% of flow in dry years (e.g. 1998 and 2003) (Consulting Environmental Engineers 2005).

The large areas of still water created by dams may also impact egg and early larval stages of *B. bidyanus*. The drifting semi-buoyant eggs and newly hatched larvae may settle in unfavourable habitats such as the backed up waters of dams and weir-pools, making them susceptible to sedimentation, predation and low oxygen levels.

Barriers to fish passage

Fish habitats are unique in that they are often linear, narrow, subject to directional flow and therefore extremely susceptible to fragmentation. Barriers can be structural (e.g. dams, weirs, road crossings) or chemical (e.g. discharge of effluents, pollutants, contaminants) and can be partial (i.e. only operate under some conditions such as low flows) or total (e.g. large dams and weirs, piped road crossings). In the Canberra region there are a series of barriers that potentially block fish movements on a number of rivers including the Murrumbidgee (Burrinjuck, Tantangara, Point Hut Crossing, and Casuarina Sands weir) and Molonglo (Scrivener Dam) rivers. Only one of these barriers has a fishway installed (Casuarina Sands weir) but maintenance and/or modifications are periodically required to optimise its usefulness. The isolation of fish habitats and fragmentation of fish populations caused by such barriers

makes populations more vulnerable to random extinction events. The effluent discharge from LMWQCC is also thought to provide a chemical barrier that reduces movement of some fish species from the Murrumbidgee River into the Molonglo River (Lintermans 2004b).

Barriers can act synergistically with other threats by preventing recolonisation of streams after local declines or extinctions. For example, the collapse of tailings dumps at Captains Flat in 1939 and 1942 effectively sterilised the river downstream, and the presence of Scrivener Dam has prevented any natural recolonisation by native fish species from the Murrumbidgee River. For *B. bidyanus*, Burrinjuck Dam has prevented connection between the lower and upper Murrumbidgee River.

Introduced species and disease

The establishment of introduced fish species is often cited as a cause of native fish decline in Australia, although much of the evidence is anecdotal. This is because the majority of introduced species became established in the mid to late 1800s when the distribution and abundance of native fish was poorly known or documented. Introduced fish species such as Carp (*Cyprinus carpio*) and Redfin Perch (*Perca fluviatilis*) have relatively recently become established in the Canberra region (Lintermans et al. 1990, Lintermans 1991) and may compete for food with *B. bidyanus*. Redfin Perch may also prey on juveniles of *B. bidyanus.*

Another potentially serious impact of introduced species is their capacity to introduce or spread foreign diseases and parasites to native fish species. Carp or Redfin Perch are considered to be the source of the Australian populations of the parasitic copepod *Lernaea cyprinacea* (Langdon 1989a). Carp, Goldfish (*Carassius auratus*) or Eastern Gambusia (*Gambusia holbrooki*) are implicated as the source of the introduced tapeworm *Bothriocephalus acheilognathi,* which has been recorded in native fish species (Dove et al. 1997). This tapeworm causes widespread mortality in juvenile fish overseas. *B. bidyanus* are also known to be susceptible to a number of diseases including Epizootic Haematopoietic Necrosis Virus (EHNV) and *Aphanomyces invadans* (EUS or 'red-spot disease') and Saprolegnia water moulds.

EHNV is unique to Australia and was first isolated in 1985 on the introduced fish species Redfin Perch (Langdon et al. 1986). It is characterised by sudden high mortalities of fish displaying necrosis of the renal haematopoietic tissue, liver spleen and pancreas (Langdon and Humphrey 1987). Experimental work by Langdon (1989 a, b) demonstrated that *B. bidyanus* was one of several species found to be extremely susceptible to the disease. Seasonal outbreaks are regularly detected in local waterbodies (primarily in Redfin Perch). Its relatively resistant characteristics and the ease with which it can be transmitted from one geographical location to another on nets, fishing lines, boats and other equipment have helped EHNV spread. Langdon (1989b) found that the virus retained its infectivity after being stored dry for 113 days. The Murrumbidgee and the Googong Reservoir populations of *B. bidyanus* have been exposed to the virus.

EUS and Saprolegnia cause ulcers on the body of fish, often leading to mortality. EUS was first recorded in Bundaberg in 1972 and in 2008 was recorded in the Murray–Darling Basin. It has not yet been recorded in the upper Murrumbidgee River (Boys et al. 2012).

Habitat modification

Alteration or destruction of fish habitat is widely regarded as one of the most important causes of native fish decline in Australia (MDBC 2004, Lintermans 2013) and overseas (Dudgeon et al. 2006). Locally, *B. bidyanus* habitats have been impacted by sedimentation of streams (e.g. the Tharwa sand slug), cold water pollution (downstream of Scrivener Dam) and riparian degradation (clearing of the Murrumbidgee riparian zone).

Reduction in water quality

The major reductions in water quality which are most likely to have affected the species in the Canberra region are sediment addition (see below), pollutant discharges to streams and changes to thermal regimes, either from the operation of impoundments or the clearing of riparian vegetation which shades streams. Point source (e.g. such as discharges from industries and sewerage works) or diffuse (e.g. agricultural chemicals) input of pollutants can also have significant impacts. Some pollutants disrupt aquatic ecosystems by mimicking naturally occurring hormones (endocrine disruptors) and so affect sexual development and function and reproductive behaviour (Mills and Chichester 2005; Söffker and Tyler 2012). Locally, pharmaceutical products and oestrogenic activity has been documented in the discharge from the LMWQCC (Roberts et al. 2015, 2016), although the impacts on local aquatic species are as yet unknown. Endocrine disruptors have been found up to 4 kilometres downstream of the LMWQCC and may extend further (Roberts et al. 2015).

Other reductions in water quality that are likely to have had major effects on *B. bidyanus* in the ACT and region are the addition of sediment (see below) and the catastrophic pollution of the Molonglo River following the collapse of tailings dumps at the Captains Flat mine in the mid-twentieth century. These collapses released large quantities of heavy metals including zinc, copper and lead, which virtually removed the entire fish population in the Molonglo River (Joint Government Technical Committee on Mine Waste Pollution of the Molonglo River 1974).

Historical overfishing

Overfishing is unlikely to have played a major initial role in the decline of *B. bidyanus*, either nationally or locally. However, once a population has declined, even relatively low levels of fishing can pose a threat to recovery of the species. There is anecdotal evidence that local anglers targeted the spawning run of *B. bidyanus* from Lake Burrinjuck (Trueman 2012). The current protective management regimes by NSW Fisheries (which prohibits the taking of *B. bidyanus* in rivers and imposes bag and size limits in stocked dams) and the ACT Government (which prohibits the taking of *B. bidyanus* in any public waters) are considered appropriate. Illegal fishing targeting breeding migrations or impacting low population levels is of concern for the conservation of *B. bidyanus* in the local region.

The ACT Government will continue to liaise with NSW Fisheries to ensure cross-border management and protection of *B. bidyanus* is maintained.

Sedimentation

Sediment addition to the Murrumbidgee River has likely resulted in significant decline of habitat quantity and quality for *B. bidyanus.* Sediment in streams may derive from point sources (e.g. roads, stock access points, construction activities), from broad-scale land use or as a result of extreme events such as fires, floods and rabbit plagues. High levels of suspended solids in streams may be lethal to fish and their eggs but the major damage is to aquatic habitat. Sediment fills pools (important refuges for larger native species), decreases substrate variation and reduces usable habitat areas.

Poor land management practices in the mid to late 1800s in the upper Murrumbidgee Catchment resulted in extensive erosion and sediment addition to the river (Starr 1995, Prosser et al. 2001). Wasson (2003) estimated that sediment yield in the Southern Tablelands increased from 10 tonnes/km^2 before European settlement to around 1000 tonnes/km^2 by 1900 before declining again to their present value of 20 tonnes/km^2.

Tantangara Dam has reduced the frequency of winter flooding and increased the occurrence of low flows (<1000 megalitres/day) in winter (Pendlebury 1997). This has probably led to the

continued accumulation of sediments in the river as there are now fewer and smaller high-flow events that previously would have scoured the finer sediments out of the riverbed (Pendlebury 1997).

More recent sources of sediment addition have been from urban development immediately adjacent to the Murrumbidgee River in Tuggeranong in the 1980s and the Canberra bushfires of 2003 (Starr 2003, Wasson et al. 2003).

Changing climate

In addition to the above threats, the species is likely to be susceptible to the predicted impacts of climate change (Koehn et al. 2013). Overall climate change is predicted to make the ACT region drier and warmer (Timbal et al. 2015).

Fish (as ectotherms) have no physiological ability to regulate their body temperature and are therefore highly vulnerable to the impacts of climate change, particularly given their dispersal is generally constrained by linear habitats in freshwaters (Buisson et al. 2008, Morrongiello et al. 2011). Burnt catchments and increased rainfall intensity will result in increased sediment loads in streams (Carey et al. 2003, Lyon and O'Connor 2008), which may persist for decades until the bedload moves downstream (Rutherfurd et al. 2000). As *B. bidyanus* is thought to spawn in response to day length and water temperature, there is a risk that spawning cues can become decoupled with earlier seasonal warming from climate change, resulting in reduced recruitment success.

MAJOR CONSERVATION OBJECTIVES

The major conservation objective of this action plan is to assist, where possible, the re-establishment of *B. bidyanus* in the upper Murrumbidgee Catchment by providing suitable habitat and assisting in-jurisdictional actions to re-establish the species, should resources become available.

The objective is to be achieved through the following strategies:

- Support projects aimed at improving understanding of the biology and ecology of the species as the basis for managing its habitat.
- Protect sites and habitats that are critical to the survival of the species.
- Manage activities in the Murrumbidgee Catchment in the ACT to minimise or eliminate threats to fish populations.
- Increase community awareness of the need to protect fish and their habitats.

CONSERVATION ISSUES AND INTENDED MANAGEMENT ACTIONS

Protection

Bidyanus bidyanus no longer occur as a viable population in the ACT. The species is protected as a threatened species under the Nature Conservation Act. Ongoing improvement to fish habitat in the Murrumbidgee River would also support the species.

Monitoring and research

Knowledge of the distribution of *B. bidyanus* in the upper catchment is generally complete. The ACT *B. bidyanus* population is thought to be largely dependent on the status of the Lake Burrinjuck population, which is itself supported by recreational stocking. Further investigations in Lake Burrinjuck and any migrations from this waterbody are necessary to place the ACT populations into a regional context.

The decline of *B. bidyanus* in the ACT raises concerns about the success of species conservation management and actions. With the exception of recreational fishing regulation and minor barrier remediation, few dedicated

management measures have been directed at the declining *B. bidyanus* since the 1980s. It is unclear if local actions could have been effective in reducing the decline given the many threats to the species (sedimentation, flow and fish passage) and the dependence upon the NSW population in Burrinjuck. The ACT Government will continue to monitor the Murrumbidgee River, which is likely to detect *B. bidyanus* should a viable population re-establish. The ACT Government will liaise with Victorian and NSW fisheries agencies to ensure there is exchange of relevant information on the species.

The ACT Government will support relevant research activities by research organisations that may lead to the successful re-establishment and management of *B. bidyanus* in the upper Murrumbidgee River.

Management

Based on current knowledge of the habitat requirements and ecology of *B. bidyanus,* management actions should aim to maintain riverine habitats with appropriate seasonal flow regimes, intact riparian zones, pool depths, and minimal sediment inputs from roads and surrounding land use.

Protection and revegetation of riparian zones will enhance organic matter contributions and provide shade, which buffers water temperatures, provides cover, prevents erosion and filters sediment from run-off. Minimising sediment addition will protect pools from becoming shallower, thus retaining a critical habitat for the species.

From an ecological community perspective, a low sediment with intact pools and riparian zones, will also benefit other threatened aquatic species such as Macquarie Perch, Trout Cod and Murray Crayfish.

Facilitation of fish passage to connect habitats and assist migration, for example, by improving fish passage past Point Hut Crossing, will assist species re-establishment. Provision of and protection of flow is likely to be critical to allow passage through natural barriers including sand slugs and improve habitat and breeding outcomes for the species.

Engagement

As with any threatened species, the importance of information transfer to the community and people responsible for managing their habitat is critical. Actions include:

- Provide advice on management of the species and maintain contact with land managers responsible for areas on which populations presently occur.
- Keep the guide to fishing in the ACT up-to-date to limit angling target of the species
- Ensure angling signage is up-to-date and placed in relevant areas.
- Report on the monitoring of the species in the Government's Conservation Research Unit's biennial report, which is distributed to a broader audience.
- Liaise with other jurisdictions and departments to increase the profile of native fish conservation.

Further information about conservation and management is in Appendix 4.

IMPLEMENTATION

Implementation of this action plan and the ACT Aquatic and Riparian Conservation Strategy will require:

- Collaboration across many areas of the ACT Government to take into consideration the conservation of threatened species.
- Allocation of adequate resources to undertake the actions specified in the strategy and action plan.
- Liaison with other jurisdictions (particularly NSW) and other landholders (such as National Capital Authority) with

responsibility for the conservation of threatened species.

- Collaboration with Icon Water, universities, CSIRO and other research institutions to facilitate and undertake required research.
- Collaboration with non-government organisations to undertake on-ground actions.
- Engagement with the community, where relevant, to assist with monitoring and other on-ground actions and to help raise community awareness of conservation issues.

With regard to implementation milestones for this action plan, in five years the Conservator will report to the Minister about the action plan and this report will be made publicly available. In ten years the Scientific Committee must review the action plan.

OBJECTIVES, ACTIONS AND INDICATORS

Table 1 Objectives, actions and indicators

Objective	Action	Indicator
1. Protect sites in the ACT where the species may re-establish.	1a. Apply formal measures (nature reserve) to protect the habitat in the Murrumbidgee River.	1a. The potential Murrumbidgee habitat is protected in nature reserve, or an area set aside specifically for conservation of the species if it re-establishes.
	1b. Maintain the protected status of the species within the four nature reserves in the Murrumbidgee River Corridor.	1b. Murrumbidgee River Corridor populations continue to be protected in nature reserve.
	1c. Protect re-establishing populations from impacts of recreation, infrastructure works, water extraction and other potentially damaging activities, using an appropriate legislative mechanism.	1c. Populations are protected by appropriate measures (Conservator's Directions, Conservation Lease or similar) from unintended impacts.
2. Conserve and improve species potential re-establishment habitat through appropriate management.	2a. Monitor the fish community of the Murrumbidgee River and the effects of management actions.	2a. Trends in abundance are recorded for fish species and management actions. Detection of *B. bidyanus* is highlighted.
	2b. Manage volumes, quality and timing of water in the Murrumbidgee River by managing extraction to maintain an appropriate flow regime to conserve the species.	2b. Water extraction from the Murrumbidgee River is managed to prevent over extraction within the ACT.
	2c. Maintain the integrity of the riparian vegetation and reduce erosion and sedimentation through appropriate land management (i.e. run-off, fire and weeds).	2c. Riparian zones are protected from impacts of erosion, sedimentation, prescribed burns. Invasive plants (e.g. Willows, Blackberries) are controlled and are replanted with appropriate native species.
	2d. New alien fish species are prevented from establishing and existing alien populations are managed where feasible to reduce impacts or population expansion.	2d. No new alien fish species establish in the Murrumbidgee River.
	2e. Impediments to fish passage are managed to minimise impacts on the populations.	2e. Fish population re-establishment is not impacted by barriers to fish movement.
	2f. Manage recreational fishing pressure to protect the species.	2f. Appropriate recreational fishing restrictions are in place and enforced to prevent deliberate or inadvertent harvest.

Objective	Action	Indicator
3. Support the re-establishment of riverine populations in the ACT through stocking if it is decided at a regional level that this is feasible.	3. Stock *B. bidyanus* of appropriate genetic provenance as a conservation stocking program if it is considered by all regional jurisdictions to be feasible.	3. Species stocked, if feasible, at a regional level.
4. Improve understanding of the species' ecology, habitat and threats.	4. Collaborate with other agencies and individuals involved in *B. bidyanus* conservation and management. Support research on habitat requirements, techniques to manage habitat and aspects of ecology directly relevant to conservation of the species in the Upper Murrumbidgee.	4. Collaboration with other agencies and individuals involved in *B. bidyanus* conservation and management (Recovery teams, State agencies, universities) where relevant to the Upper Murrumbidgee.
5. Improve community awareness and support for *B. bidyanus* and freshwater fish conservation.	5. Produce materials or programs to engage and raise awareness of *B. bidyanus* and other native freshwater fish threats and management actions.	5. Community awareness materials/programs produced and enhanced community awareness evident.

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