Meeting the challenge of re-establishing instream vegetation in a sediment loaded stream – A trial to improve Macquarie Perch habitat in the Hughes Creek, central Victoria, Australia

A joint project of the Goulburn Broken Catchment Management Authority, Arthur Rylah Institute for Environmental Research and the Victorian Fisheries Authority.

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Key points

- Instream vegetation loss and sand deposition have reduced critical habitat for Macquarie Perch in Hughes Creek.
- Establishment of instream vegetation is constrained by flow variability during early growth stages.
- Combining species selection with appropriate growing formats, seasonal timing and planting strategies improves establishment success.
- All species have survived and continue to persist one year after planting, and plant cover increased across all inundation zones within the study area.
- The approach shows strong potential for successful habitat restoration; however further monitoring is needed to assess long-term success and benefits for sand stabilization and native fish populations.

Abstract

Clearing of vegetation and livestock grazing in the Hughes Creek catchment (central Victoria, Australia) has resulted in substantial sand inputs. This has led to loss of instream vegetation and infilling of pools and rocky riffles that provide essential habitat for the nationally Endangered Macquarie Perch (*Macquaria australasica*). The degradation of these habitat features has likely contributed to population declines.

Instream revegetation has potential to stabilise sediments and improve habitat for invertebrates and fish; however plant establishment is often limited by unpredictable flow events during early growth stages. To improve reliability, we trialled an approach integrating targeted species selection, alternative growing formats, and strategic timing and placement of planting.

Nine locally indigenous species possessing rhizomes and stolons were selected for their capacity to colonise and bind sand and recover following disturbance. Planting methods were designed to reduce uprooting during high flows and promote rapid establishment. Species were planted across terrestrial, fringing and inundated zones according to inundation tolerance, with aquatic and fringing species established during low summer flows and terrestrial species planted later under higher soil moisture conditions.

One year after planting, all species persisted and total plant cover increased substantially across all zones, particularly in fringing (3.9% to 45.6%) and inundated areas (to 41.6%). In contrast, unplanted control areas showed limited increases and no colonisation in the inundated zone.

These results demonstrate a promising approach for restoring instream vegetation; however further monitoring is needed to assess longer-term success and the benefits that revegetation provides for sand stabilization and native fish populations.

Keywords
Instream revegetation, sediment stabilisation, macquarie perch, aquatic vegetation, flow disturbance, riparian restoration, sand deposition, river rehabilitation

Introduction

The stream morphology of Hughes Creek in central Victoria was historically characterised by a series of pools, runs, riffles and bars (Erskine 2016). During the early 1900s, vegetation clearing in the catchment led to substantial inputs of sand into the creek, which blanketed large reaches and infilled pools and rocky riffles (Erskine 2016). Sand inputs continued until the 1970s when improved land management practices are likely to have reduced inputs (Erskine 2016). Despite the reduction of sand inputs, the current sediment volume in Hughes Creek exceeds levels historically typical of similar streams in the region (Davis and Finlayson 2000). Much of this sand is mobile even during moderate flows, blanketing new areas of the stream, filling in pools and smothering large structures such as logs and boulders.

This homogenisation of the streambed has disrupted the natural biological processes in the stream. The infilling of pools and rocky riffles that are essential habitat components for the nationally Endangered Macquarie Perch (*Macquaria australasica*) (Figure 1) has contributed to this species' declining abundance in the Hughes Creek (Kearns *et al.* 2012). The lack of available structure in sandy sections has resulted in depauperate invertebrate communities (Downes *et al.* 2006; Lancaster and Downes 2017). Historical accounts also link a sharp decline in Trout Cod (*Maccullochella macquariensis*) to the early establishment of sand slugs in the creek (Davis and Finlayson 2000).

Figure 1 The nationally Endangered Macquarie Perch (*Macquaria australasica*)

Recent laboratory flume trials using a sandy substrate suggest that emergent aquatic vegetation located at the toe of bank can stabilise sandy stream banks, while also creating a deeper main channel (Arora and Kumar 2024). These flume trials used bamboo stakes to simulate emergent stems, similar to the emergent culms of *Schoenoplectus tabernaemontani* (River Club-rush) used in the current trial. Bamboo stakes do not have features such as robust living rhizomes which provide a potentially additional binding effect for sand, and a capacity to recolonise after significant disturbance events.

Identifying an efficient and reliable method of instream revegetation could help stabilise sand in Hughes Creek and slow/reduce the volume of sand blanketing instream habitat. Once established on a large scale, such aquatic and fringing vegetation may facilitate scour in the main channel, possibly leading to a deeper, narrower channel and reducing further loss of pools which provide key habitat for Macquarie Perch. The vegetation itself would create structural habitat currently lacking in some areas of Hughes Creek (Erskine 2016), and support habitat for invertebrates, Macquarie Perch and other native fish species, including the Southern Pygmy Perch (*Nannoperca australis)* (Cornell *et al.* 2022).

Methods

Study site

The Hughes Creek study site is c. 1.25 km in length, located in a rural farming area in central Victoria upstream of Avenel (Figure 2). The site features a mix of sandy banks and depositional benches with some sections of cobble. The site has a history of livestock grazing but as part of the intervention the site was fenced and livestock have been excluded since the time of planting (12 months). Four randomly distributed planting sites were chosen within the site, each 25 to 30 m long. A similar control area was also identified and monitored to assess if any plant recruitment occurred naturally.

Species selection, plant provenance and propagation

Indigenous aquatic and fringing species, with rhizomes or stolons as part of their recruitment strategies, were selected for propagation and planting (Table 1, Figure 2). These asexual means of expansion were considered functionally important to colonise and bind sand, while also giving the species selected the means to recover from significant disturbance once established. Regionally appropriate provenance material was used for plant propagation by Neangar Nursery at Eaglehawk, Victoria. Growing formats, planting zone and densities for each species are outlined in Table 1. Monitoring timelines are provided in Table 2.

Figure 2 Hughes Creek location, Central Victoria

Table 1 Species, planting zone, planting density and growing formats trialled

Species name	Common Name	Zone	Growing formats	Number planted	Planting density
Schoenoplectus tabernaemontani	River Club Rush	Inundated & fringe	Multipac	120	0.5 to 1m spacing
Cycnogeton procerum sp. agg.	Water ribbons	Inundated & fringe	Multipac	120	0.5 to 1m spacing
Carex polyantha	River Sedge	Fringe	Super tube	550	4 to 6 per m^2
Carex gaudichaudiana	Fen Sedge	Fringe	Super tube	250	4 to 6 per m^2
Isachne globosa	Swamp Millet	Fringe	Hiko cell	300	4 to 6 per m^2
Persicaria praetermissa	Spotted Knotweed	Fringe	Hiko cell	280	4 to 6 per m^2
Carex bichenoviana	Plains Sedge	Terrestrial	Forestry tube	100	4 to 6 per m^2
Hemarthria uncinata	Matt Grass	Terrestrial	Forestry tube	100	4 to 6 per m^2
Imperata cylindrica	Blady Grass	Terrestrial	Forestry tube	100	4 to 6 per m^2

Table 2 Timeline for propagation, planting and monitoring

Season	Date	Weeks after planting	Activity
Late winter	August 2024 to February 2025	NA	Plant propagation

Late summer	24/02/2025	0	Baseline monitoring
Late summer	24/02/2025 to 26/02/2025	NA	Aquatic and ephemeral plant installation
Early autumn	12/03/2025	2	First vegetation monitoring
Late autumn	12/05/2025 to 13/05/2026	NA	Terrestrial plant installation
Early winter	12/06/2025	15	Second vegetation monitoring
Mid spring	21/10/2025	33	Third vegetation monitoring
Early autumn	05/03/2026	54	Fourth vegetation monitoring

Growing formats and installation methods

Growing formats and planting densities varied across selected species (Table 1). Commercially available Multipac trays (500 mm × 380 mm × 80 mm) were used to grow *Schoenoplectus tabernaemontani* (Figure 3a). This format allows plants to develop a large, dense rhizome network (Figure 3c), promoting rapid establishment and growth required for successful planting in dynamic environments. *Cycnogeton procerum sp. agg.* (Water Ribbons) was grown in Multipac trays with *S. tabernaemontani* (Figure 3d) to provide (i) a buffer from high flow and (ii) physical protection from waterbird and the exotic Common Carp (*Cyprinus carpio*) disturbance, as netting is not practical in this setting. Multipac planting units were buried flush with the existing creek bed substrate and secured using four timber stakes driven as close to the top of each unit as possible (Figure 3b). This planting method aims to reduce accumulation of detritus and drag on planting units, and minimise the risk of dislodgement under high-velocity flow.

Figure 3 Selection of targeted species: (a) *Schoenoplectus tabernaemontani* (at left) with *Carex polyantha* (at right); (b) *Schoenoplectus tabernaemontani* (emergent) with *Cycnogeton procerum* sp. agg. (floating/trailing); (c) *Isachne globosa;* (d) *Isachne globosa*, colonising vertical bank c. 1 m high; (e) *Isachne globosa*, showing dense rhizomes binding soil at the toe of a vertical 1 m bank; and (f) *Persicaria praetermissa*

Several other more traditional horticultural and forestry growing formats and planting methods were also used (Table 1). Since *Carex polyantha* (River Sedge) and *C. gaudichaudiana* (Fen Sedge) were planted at the water's edge, they were propagated in larger size Super tubes to promote rhizome development and facilitate rapid establishment post planting.

Planting design

Three planting zones were targeted: (i) **inundated** areas of the channel bed (usually inundated), (ii) the channel **fringe** (regular shallow inundation) and adjacent **terrestrial** areas (infrequently inundated) (Figure 5).

Plant installation in the inundated zones was restricted to areas above 300 mm in depth at the time of planting. The planting design for these zones (Figure 6a) aims to stabilise sand at the waterway edge, facilitate sediment deposition, and promote scour to maintain depth in the middle or main channel of the waterway.

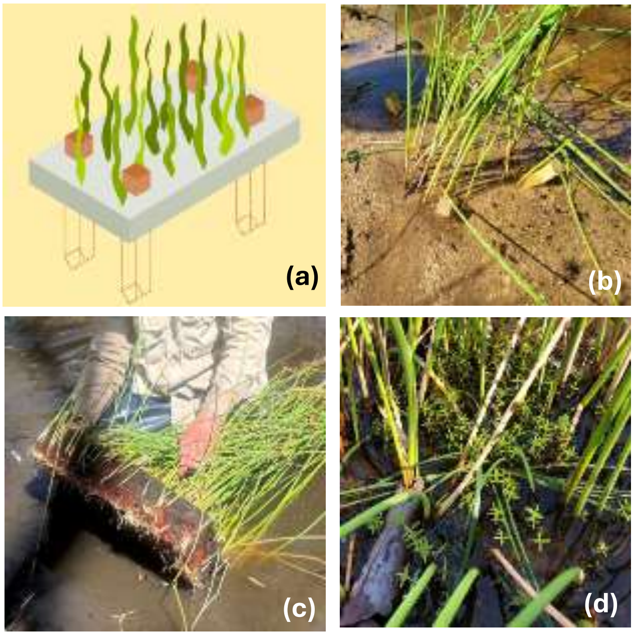

Figure 4 Multipac growing format and installation method for Schoenoplectus (a, b), planting unit showing well developed rhizomes (c); co-planted Cycnogeton procerum sp. agg. and Schoenoplectus (d)

The emergent culms of *Schoenoplectus tabernaemontani* used in the inundated zone planting provide similar structure to bamboo stakes used in flume trials, which can help stabilise sand (Arora and Kumar 2024). This planting configuration included:

- a two-sided planting, applicable where depositional sand banks and benches occur on both sides of the waterway and/or there is no well-defined channel, and
- a one-sided planting, applicable where depositional sand banks/benches occur on only one side of the waterway and/or there is already a well-defined channel to one side of the waterway.

Timing of planting

Planting of aquatics and fringing species occurred in late summer (24th to 26th February 2025), when flows are usually lower, water temperatures are higher, day length is longer and aquatic plants are actively growing. These conditions should facilitate rapid rhizome growth into surrounding sand, aiding the planting to withstand higher velocity flows sooner. Flash flooding/sudden increases in flow velocity immediately following installation can however result in failure. Planting terrestrial species was scheduled later (12th and 13th May), to ensure soil moisture was sufficient for plants to survive and establish (Figure 8).

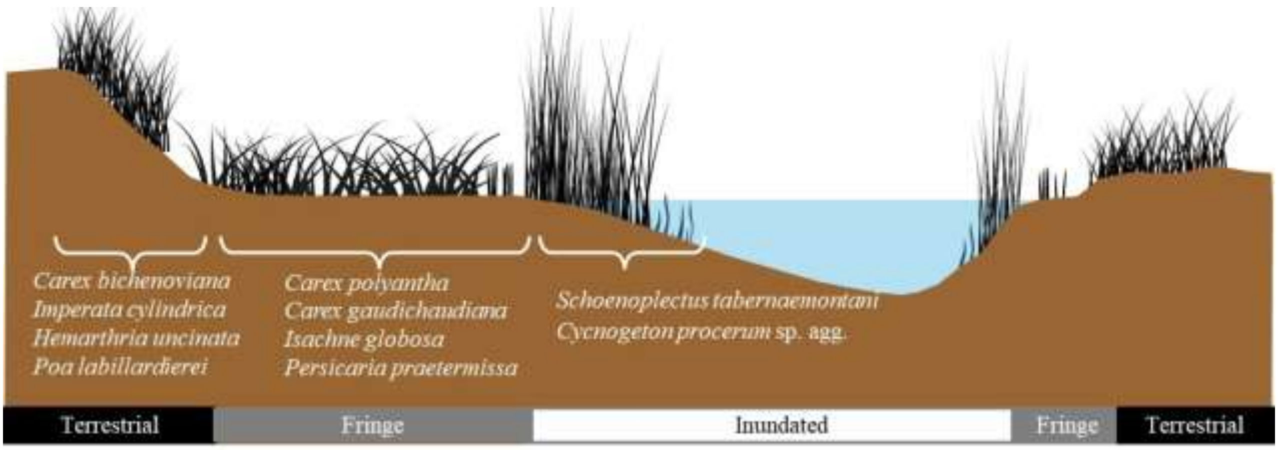

Figure 5 Hughes Creek cross section showing planted species in each of the inundation zones

Monitoring

Pre and post vegetation surveys were carried out along 11-15 permanent transects spanning the three inundation zones and distributed across four separate planting locations within the site. In addition, three permanent transects were monitored in a non-planted control area. At each transect, the number and cover of species present was visually assessed within replicate 1m x 1m quadrats within each inundation zone (Figure 6b). Vegetation was surveyed immediately prior to (0 weeks) and 2, 15, 33 and 54 weeks following planting (Table 2). At each survey, a spot measurement of water depth was recorded along transects within the inundated and fringe zones to provide some understanding of the hydrological conditions over the study period. Fish monitoring and Common Carp removal were also undertaken as part of this project but are not reported here.

Data analysis

Revegetation success was evaluated visually by examining changes in mean (± SE) values of selected indicators in each inundation zone over time in planted and unplanted areas. Response indicators included (i) total summed cover of all species, (ii) cover of each planted species and (iii) total species number. Values across replicate quadrats within each inundation zone at a transect were averaged before averaging across replicate transects in planted and unplanted areas.

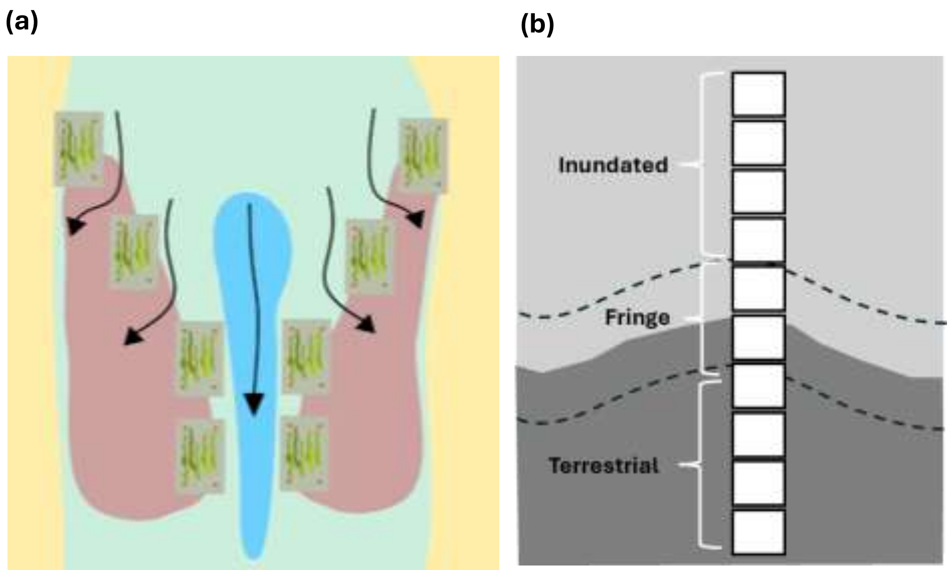

Figure 6 Inundated zone planting design (a) and survey design showing replicate 1mx1m quadrats in each of the three inundation zones at a single transect (b)

Results

Water depths measured at each survey varied from 0.10 to 0.42 m in the inundated zone and from 0.02 to 0.22 m in the fringing zone. Flows were lowest at the start of the trial and increased over time. High rainfall in the two weeks prior to monitoring at week 54 is likely to have resulted in atypical water depths for this time of year at this site.

One year after planting (Forty-three weeks after planting for the terrestrial zone), all nine target species (Table 1) across all three planting zones persisted. Total average plant cover increased from <5% before planting across all zones to between 25% to 45% (Figure 7a), depending on the zone. Total plant cover was highest in the ephemeral margin (45%), and regularly inundated (42%) zones, comprised largely of *S. tabernaemontani*. There was an increase to 25% plant cover in the terrestrial zone. In contrast there was a smaller increase in plant cover (<2% up to 14.3%) across all zones in the unplanted (control) areas (Figure 7b).

Total average species number increased from ≤1.5 species across all zones before planting to between 1.6-2.7 species post planting (Figure 7c). In contrast there were fewer species (1.5 up to 1.67) in the unplanted (control) areas (Figure 7d) across all zones. Within the planted sites, average species number was higher in the fringe and terrestrial zones (2.8 and 2.7 species respectively) compared with the inundated zone (1.6 species).

All six species planted across the inundated and fringing zones had increased in cover after one year (Figure 8). The greatest increase in these two zones was observed for *S. tabernaemontani* (Figure 8a), which expanded from an average cover of <0.5% to 32.97% in the inundated zone, and from 0.5% to 25.31% in the fringing zone. *Carex polyantha* also performed well across these zones, expanding from 0% to 4.35% in the inundated zone and 0% to 7.1% in the fringing zone (Figure 8b). Two species, *C. polyantha* and *C. gaudichaudiana*, initially planted in the upper portion of the inundated zone and fringing zone, have started to colonise the adjacent lower terrestrial zone (Figure 8b and 8d).

Forty-three weeks after planting, two of the three species planted in the terrestrial zone showed marginal increases in average cover, while one species, *Carex bichenoviana* (Plains Sedge), declined slightly in average cover from 0.8% to 0.3% (Figure 8f). The greatest average increase in the terrestrial zone was observed for *Hemarthria uncinata* (Matt Grass) (Figure 8c), although this was marginal, expanding from 0% to 0.2%.

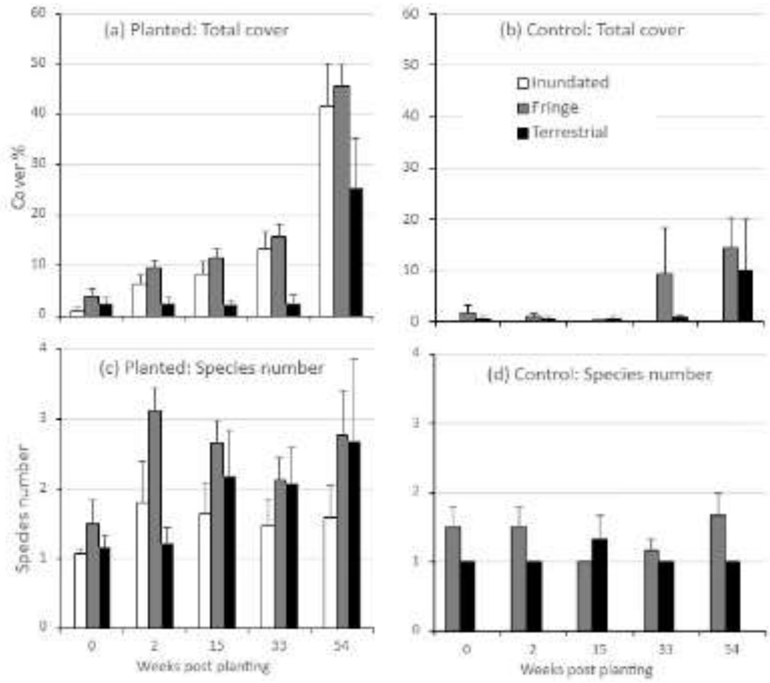

Figure 7 Mean (± SE) total percent cover (a, b) and species number (b, c) in each zone over time post planting on 24 February 2025 in planted (a, c) (n=11-15) and unplanted control areas (c, d) (n=3)

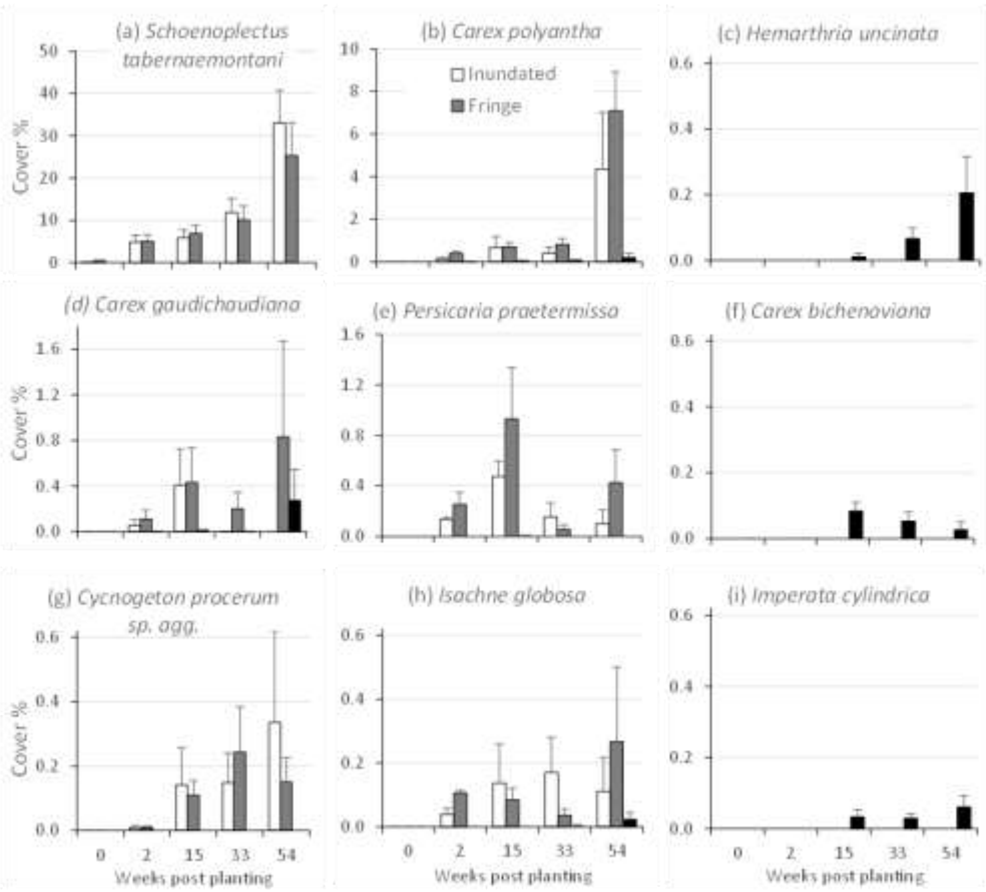

Figure 8 Mean (± SE, n=11-15) percent cover of planted species in each zone over time since planting

Discussion and conclusions

An assessment one year after planting indicated the methods of installation, growing formats used, and species selected resulted in successful plant establishment and expansion at the Hughes Creek trial site. All nine target species planted across all three planting zones have persisted. In particular, *Schoenoplectus tabernaemontani* and *Carex polyantha* have successfully established and are colonising adjacent areas of sand (Figure 9 and 10). *Schoenoplectus tabernaemontani* expanded to form a continuous band just 15 weeks after planting (Figure 10), indicating capacity to stabilise sand in a relatively short time.

There was generally a steady increase in cover for species within the inundated and fringing zones through the cooler months, followed by rapid expansion during the warmer months. *Persicaria praetermissa* (Spotted Knotweed) initially increased in cover during warmer, lower-flow conditions of autumn, declined during the cooler months, and then recovered over summer. Species planted in the terrestrial zone have persisted, with only marginal changes in cover. Further monitoring is needed to see if these species increase or decline in cover over time.

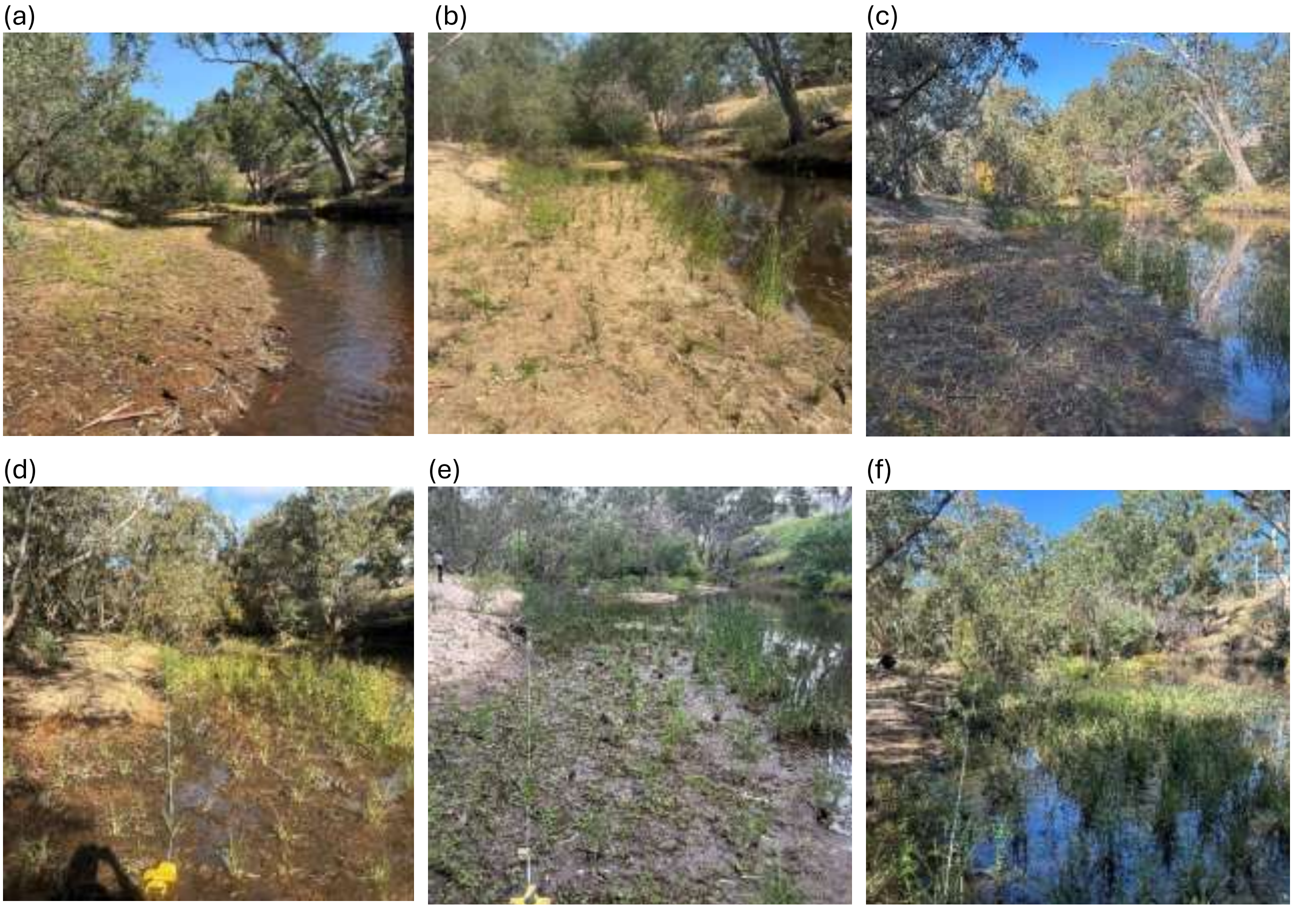

Figure 9 Depositional bench in the fringing zone: before planting (a) and weeks after planting 0 (b), 11 (c), 15 (d), 33 (e) and 54 (f). The bench is heavily planted with *Carex polyantha* with a band of *Schoenoplectus tabernaemontani* visible at the right of each image, where the fringing zone transitions to the inundated zone

Despite the site being fenced, there was evidence of herbivory on several planted species, possibly by deer. Isachne globosa and Persicaria praetermissa appeared to be heavily browsed. There was also evidence of shoot browsing for Schoenoplectus tabernaemontani; however, establishment and expansion of this species was still successful.

(a) (b)

Figure 10 Expansion of *Schoenoplectus tabernaemontani* planting units after 14 weeks, June 2025 (a) and *Carex polyantha* on a shallowly inundated bench after 54 weeks, March 2026 (b)

While these results demonstrate plantings are successfully colonising sandy areas, particularly *Schoenoplectus tabernaemontani* and *Carex polyantha*, it is too early to determine whether this will be sustained over longer timeframes, and ultimately whether it will lead to sand stabilisation and improved structural habitat for Macquarie Perch within the creek bed. Further monitoring of this trial site is recommended to better evaluate any links between plant establishment and structural habitat improvement, and/or the limitation of further structural habitat loss. Ongoing monitoring may also provide insights into the ability of selected species to recover from significant disturbance events, such as high- velocity flows or floods, which were not experienced during the current study.

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