Instream plant distribution across a variable landscape

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Key Points

- Instream vegetation is a critical component of many stream ecosystems, however, studies related to instream vegetation remain limited in Australia.
- We surveyed 82 sites across the Port Philip and Westernport region for instream vegetation presence and cover.
- Urbanisation is apparently negatively related to instream vegetation occurrence, likely due to high velocity flows.
- The data from this study will improve our understanding of where different instream species occur and help target further research and management interventions.

Abstract

Plants growing within stream channels (instream vegetation) are critical components of stream ecosystems, providing many ecosystem benefits. We lack an understanding, however, of the distribution and drivers of these plants in a southeastern Australian context. To better understand the distribution of instream vegetation, we surveyed instream vegetation presence and cover across 82 sites in the Port Philip and Westernport region of Victoria, Australia spanning a range of environments.

In total, only eight sites did not support any instream vegetation, with amphibious plant species present at 71 sites aquatic plant species present at 37 sites. The mean number of instream plant species across all sites was 4 for amphibious species and 1 for aquatic species. Urbanisation appeared to reduce the instream vegetation richness (most likely from frequent high velocities and floods), and forested sites higher in the catchment also tended to have lower vegetation richness. The most prevalent instream plant species were native *Persicaria decipiens* (Slender Knotweed) and *Cycnogeton procerum* (Water-ribbons) for amphibious and aquatic plants, respectively. The second most prevalent species were exotic for both amphibious and aquatic plants and included *Cyperus eragrostis* (Drain Flat-sedge) and *Callitriche stagnalis* (Common Water-starwort), respectively.

The baseline data collected for this study fills an important gap in our understanding of stream ecosystems in southeastern Australia and will inform future instream vegetation research and management.

Keywords

Macrophyte, aquatic vegetation, Stream restoration, Flow regime, Geomorphic complexity, Species distribution

Introduction

Plants growing within the stream channel (instream vegetation) are important components of many stream ecosystems (Franklin et al., 2008). Instream vegetation provides habitat and refuge for fish, macroinvertebrates and other aquatic and terrestrial fauna (Kail et al., 2015). These plants are also important components of aquatic foodwebs, acting as primary producers and substrate for periphyton (algae and bacteria) and also help regulate nutrient fluxes, improving water quality (Bakker et al., 2016; Bornette & Puijalon, 2010).

Instream plants can also act as important ecosystem engineers by modifying stream flow hydraulics, and/or acting as physical obstacles to fine sediment transport (Gurnell, 2014). Propagules (seeds and vegetative fragments) can be trapped by instream plants, influencing plant dispersal via water (hydrochory) (McKendrick et el., 2024a; O'Hare et al., 2011). The trapping of fine sediment and seeds can lead to feedbacks in which fine sediment/seeds are retained leading to further plant establishment and vegetation growth.

Anthropogenic alteration to the flow regime through regulation and urbanisation has drastically changed stream ecosystems, including instream vegetation communities (Lacoul & Freedman, 2006; Vietz et al., 2016). Flashy flows (frequent and high velocity floods) driven by stormwater runoff, or more homogenised flows in regulated systems, often result in degraded stream environments, including instream vegetation communities, reducing plant diversity and function (Mouton et al., 2019; Walsh et al., 2005). Furthermore, both exotic and native instream plant species can become problematic in altered stream environments (Catford et al., 2011).

In this article, we present preliminary data on the distribution of instream plant species across the Port Philip and Westernport region, Victoria, Australia. We briefly discuss these findings and how this baseline data may inform further research and instream vegetation management. The main aim of this article is to promote greater consideration of instream vegetation in research and management that aims to promote other biotic communities and abiotic functions in streams that may rely on this often neglected ecosystem component.

Methods

During the low flow period of summer-autumn 2024 (16th January to 28th March 2024) 82 sites were surveyed for instream vegetation. Sites were selected from 506 sites surveyed for riparian vegetation condition on behalf of Melbourne Water in 2021 across the Port Philip and Westernport region. In total, we selected 100 sites to buffer against any issues preventing surveying (e.g. site access). Our subset of sites were selected to cover different combinations of environmental factors including geomorphology, catchment area, forest cover, slope, effective imperviousness and mean annual runoff.

Instream vegetation was assessed using a transect method at each site in which six, 1 m wide belt transects were evenly spaced along a 100 m reach. Within each belt transect, plant species occupying the typical low flow channel were identified and their cover visually estimated (1 to 100%). This delineation was less clear in dry stream beds and was delineated subjectively based on morphology (i.e. where the flow path would most likely be after rain).

Plant species were classed as either terrestrial, amphibious or aquatic (see Figure 1 for examples of commonly observed species during this study). We did not consider terrestrial species further in this study. Aquatic species include those that are typically fully or mostly submerged and require water all of the time to support their structure and function. Amphibious species include those that require their above ground parts to be out of water most of the time but tolerate their below ground parts being inundated most to all of the time.

Species richness at a site was calculated by summing the number of species (both native and exotic) found at a site across the six transects. Species prevalence across the 82 sites was calculated as the number of sites each species was observed at.

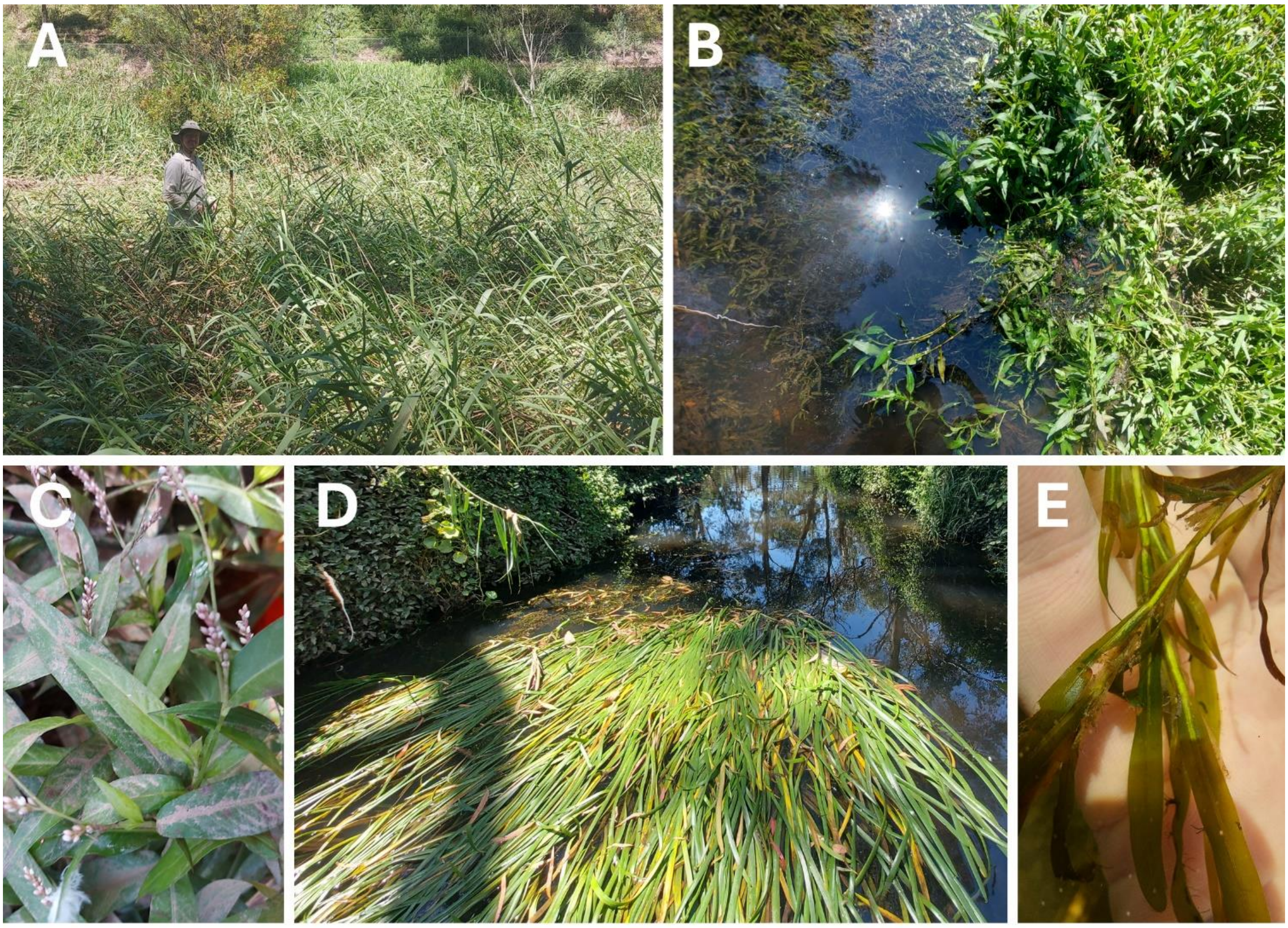

Figure 1. Examples of native amphibious (A–C) and aquatic (B, D and E) instream vegetation species. Presented are the amphibious species (A) *Phragmites australis* and (B) and (C) *Persicaria decipiens* (right half of the photo), and the aquatic species (B, left half of photo; and E) *Potamogeton ochreatus* and (D) *Cycnogeton procerum*.

Results

Of the 82 sites surveyed, only eight had no instream vegetation species. Amphibious species were present at 71 sites, while aquatic species were present at only 37 sites (Figure 2; Table 1).

Based on visual interpretation of richness distribution maps (Figure 2), both amphibious and aquatic plant richness tended to be higher outside of the more urbanised areas and/or where forest cover was low. However, initial assessments indicate that aquatic species richness may be more evenly distributed across the study region than amphibious species richness.

Across all sites, there were 42 native and 11 exotic amphibious species, and 10 native and four exotic aquatic species identified. The most prevalent amphibious species was the native species *Persicaria decipiens* (Slender Knotweed) (44 sites), followed by the exotic species *Cyperus eragrostis* (Drain Flat-sedge) (37 sites). The most commonly occurring aquatic species were the native species *Cycnogeton procerum* (Water-ribbons) (17 sites) and the exotic species *Callitriche stagnalis* (Common Water-starwort) (14 sites). Figure 3 presents the species prevalence for the highest occurring 15 amphibious species, and all aquatic species.

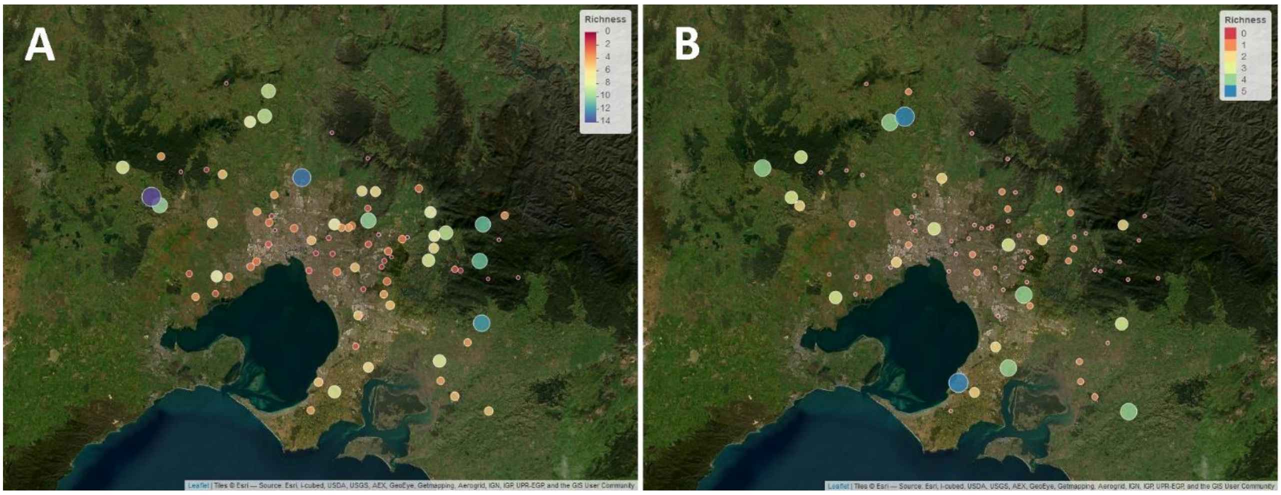

Figure 2. (A) Map of amphibious plant species richness across the study region (0–14 species) and (B) map of aquatic plant species richness across the study region (0–5 species). Smaller to larger points with red to blue colours represent increasing plant richness.

Table 1. Mean number of plant species (richness) and the number of sites with species occurrence for all instream species, amphibious species and aquatic species.

Instream vegetation class	Mean richness ± 1SE	Number of sites
All instream plant richness	5.57 ± 0.49	74
Amphibious plant richness	4.24 ± 0.37	71
Aquatic plant richness	0.96 ± 0.15	37

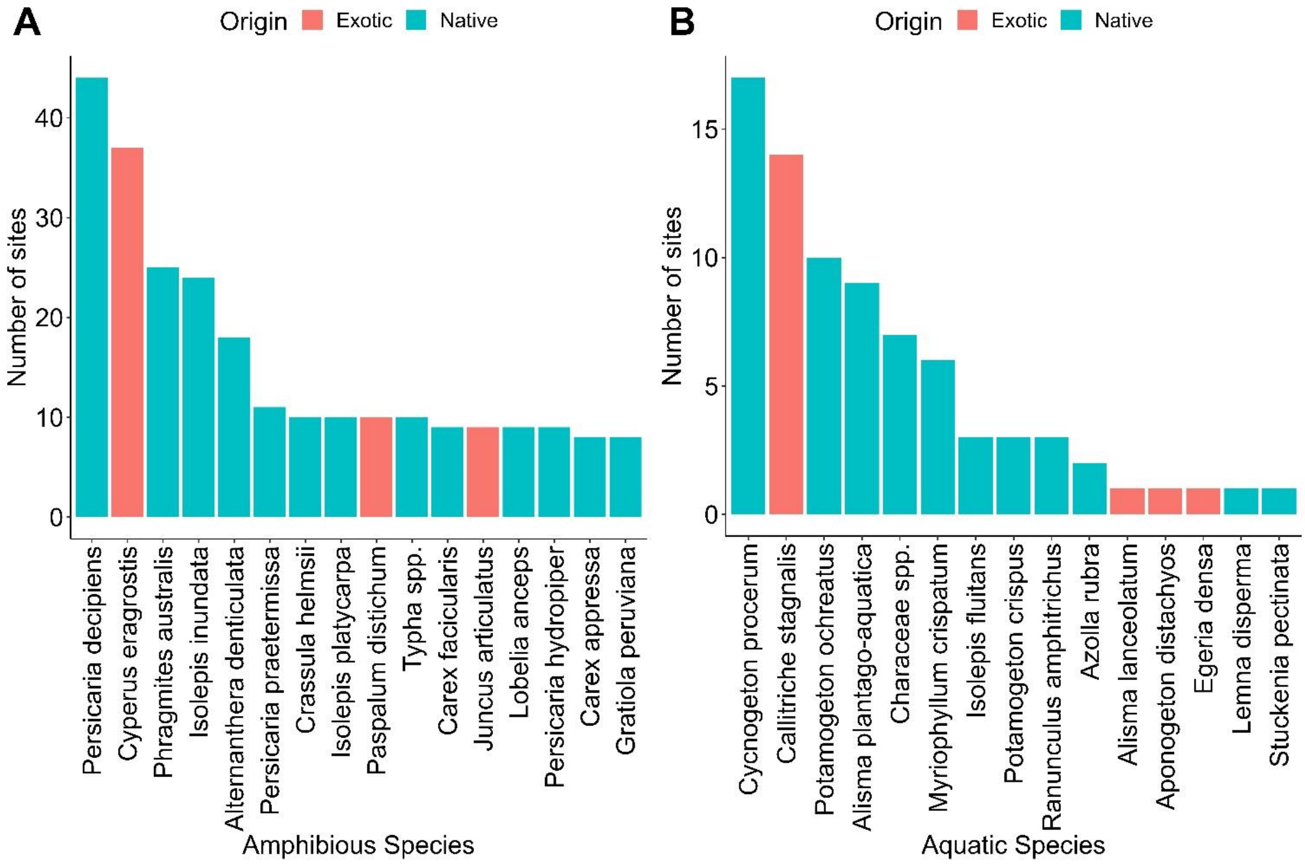

Figure 3. The number of sites (y-axis) in which each plant species occurs (x-axis) for the (A) 15 most common amphibious plant species and (B) all aquatic plant species.

Discussion

Across the 82 sites surveyed for our study, there are a range of instream plant species, both amphibious and aquatic, present across the variable stream types in our study region (Figure 4). However, based on the results, it is apparent that urbanisation is negatively related to instream plant richness. These patterns are consistent with previous research involving a smaller sample size within the study area (Mckendrick et al 2024b) which found a negative relationship between both flood frequency and rate of change (which can be considered indicators of 'flashy' flow regimes) and amphibious plant diversity. Based on the outcomes of this study, and previous studies (e.g. McKendrick et al 2024b), altered urban flow regimes, driven by stormwater inputs piped directly to the stream, are a significant driver of amphibious plants. McKendrick et al. (2024b) also found that aquatic plants were less influenced by flashy flow regimes, which appears to be similar in this study with some urban sites supporting aquatic species, albeit less clearly. Along with flow regime changes, a range of other stressors related to urbanisation may also have an impact on instream vegetation, which require further investigation in the study region. These may include increased light from riparian forest clearing, geomorphic changes and changes to nutrient loads, among other stressors (Bornette & Puijalon 2010; Lacoul & Freedman 2006).

High forest cover, which results in high amounts of shading, was also apparently related to lower plant richness. Many highly shaded sites in the headwaters of the streams also have steep slope gradients and/or more ephemeral flows, along with less fine sediment (data not shown). While many of these streams are minimally degraded by anthropogenic impacts, these streams are unlikely to support many amphibious, and any aquatic species naturally (Figure 4H). Further analyses will identify where instream vegetarian could be expected to occur to improve conceptual models of instream vegetation presence.

The native species *Persicaria decipiens* was the most prevalent amphibious plant species across the study region and was present at half of the sites. This species is likely to stabilise stream margins and, potentially, trap further fine sediment and propagules leading to bench and island development (Figure 1B) (O'Briain et al., 2022). *P. decipiens* seeds readily and can also reproduce vegetatively by rooting at the nodes of stem fragments, allowing migration into deposited sediment. *Phragmites australis* was the second most prevalent native amphibious species and likely performs similar functions to *P. decipiens*, however, this species is sometimes considered problematic from a hydrologic perspective as it can 'choke' stream channels (Figure 1A). Further research into the desired functions vs detrimental effects is needed for *P. australis* and other native species that may be perceived as problematic (e.g. *Typha* spp.) given this species persists well once established (Bankhead et al., 2017).

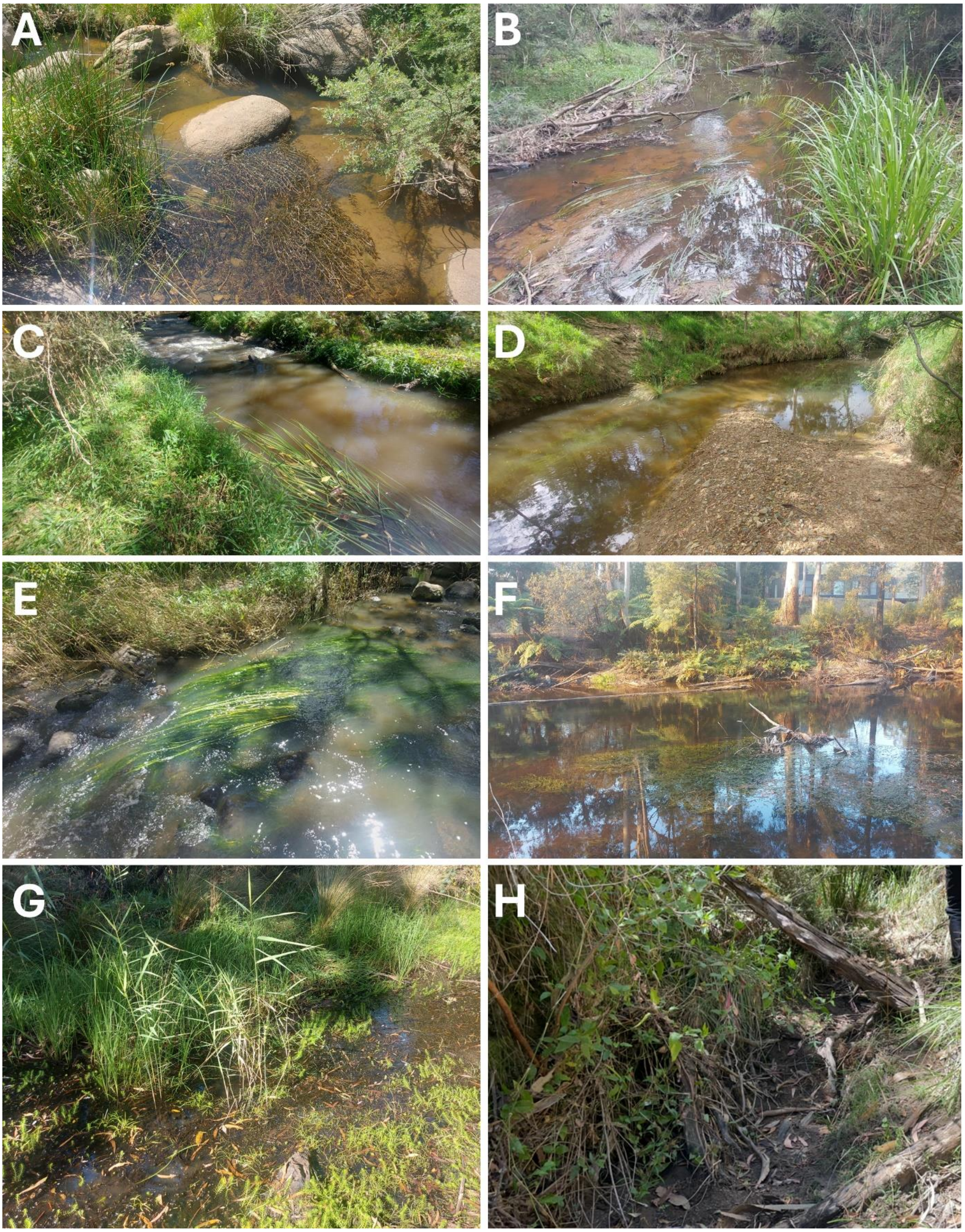

Figure 4. The highly variable stream types surveyed during this study. (A) A boulder dominated, geomorphically complex stream supporting *Potamogeton crispus* (aquatic species) and other amphibious species and (B) a sand dominated stream supporting *Cycnogeton procerum* (aquatic species) and a range of amphibious species. (C and D) Streams with similar amounts of turbidity and shading but (C) has minimal stormwater inputs and supports *C. procerum* while (D) had no aquatic and minimal amphibious species and has a high amount of stormwater input, likely impeding instream plant recruitment. (E) *C. procerum* thriving in a boulder dominated stream with relatively high velocity flows. Dense sand is accumulating within the plant patch allowing further migration of the patch. (F) Dense patches of *Myriophyllum crispatum* in a large river, likely promoted by instream wood promoting stem fragment retention and colonisation. (G) A stream rich with instream species and (H) an ephemeral headwater site with no instream plant species.

The prevalence of exotic plant species was relatively low across the study area overall, however, the second most prevalent amphibious and aquatic species were both exotic. This raises important research questions about the functional role of exotic instream plant species, particularly in degraded urban ecosystems. These plants will still likely stabilise stream beds and margins and promote other ecosystem functions, and may not necessarily be replacing native species in locations that do not support natives.

Management of instream vegetation requires an understanding of both the drivers and functions of these plants in stream ecosystems, which is largely lacking in our study region and in general in Australia. Further analyses of our data in relation to environmental factors including geomorphology (e.g. sediment type, complexity) and land use (e.g. rural vs urban) will improve our understanding of the drivers of these plants and where management interventions could be targeted that will both be successful and provide further ecosystem benefits (Wohl et al., 2024). Revegetation, both actively with plants (e.g. Riis et al., 2007), and passively by promoting seedbank colonisation (e.g. Riis, 2008), are important further research steps. Instream plant revegetation, for example, could be combined with large wood reintroduction to promote multiple ecosystem benefits, with the large wood further facilitating plant establishment (see Figure 4F).

While instream and riparian plants are often considered for their role in stabilising stream banks, these plants may have an important role in sediment and seed trapping and, ultimately, the building of pioneer geomorphic features (Gurnell, 2014). This ecosystem engineering role provided by the plants may improve the complexity of streams that have been homogenised through anthropogenic impacts. Promoting these processes, however, relies on an understanding of the requirements, especially in relation to flow, that will allow these plants to persist and thrive past the revegetation phase.

Management of instream vegetation, and in particular, aquatic species, must take into account the patchy nature of these plants, which often establish in niches in which hydraulics and sediment type are favourable. Instream plant establishment may even be stochastic to some degree, complicating understanding of these plants in our variable streams. This may make revegetation a challenge, as identifying the locations suitable for planting may be at a finer scale than typical for the riparian zone. These challenges, however, present exciting opportunities to improve our understanding of instream plants and their ecosystem benefits.

Conclusions

In this study we investigated the distribution of instream vegetation across a wide range of stream types within the Greater Melbourne region and discussed some potential drivers and management and research implications. Stream degradation resulting from urbanisation is likely important in driving instream plant distribution along with environmental factors interacting in complex ways to ultimately determine where instream plants occur. The data collected for this study will be used to improve our understanding of instream vegetation and where to focus further research, with the ultimate goal of improving these plant communities and harnessing the benefits that these plants can provide to other biota and abiotic interactions.

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