Improving stream management using ecological modelling and DNA barcodes

project summary

Project A4 | Melbourne Waterway Research Practice Partnership

This project will enhance the ability to monitor and improve stream health and biodiversity by developing a suite of interconnected molecular (DNA), spatial and quantitative tools to provide data-driven, comprehensive, landscape-scale decision support.

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Expected outputs & impacts

Advanced DNA barcode reference libraries and DNA metabarcoding for assessing and describing macroinvertebrate biodiversity. Species Distribution Models that quantify the relationship between species presence-absence and environmental descriptors for macroinvertebrate species. New, improved biodiversity rank maps for streams of the region and advanced capabilities for assessing future management scenarios. Habitat Suitability Models for macroinvertebrate species to provide data-driven, landscape-scale design support for protecting and restoring streams.

Background

Freshwater macroinvertebrates contribute to many ecological processes and functions and are essential to maintaining waterway health and ecosystem services such as water filtration and nutrient cycling. Their diverse ecological roles across multiple trophic levels and varying sensitivity to disturbances make them sensitive, informative ecological indicators for biological monitoring of freshwaters.

This monitoring function is critical for adaptive management, planning and accountability. Despite this, species-level knowledge of macroinvertebrates distributions, environmental habitat determinants, and responses to human activities is patchy and inadequate. This longstanding knowledge gap is due to the difficulty of identifying species by morphology, which requires scarce taxonomic expertise and is costly.

Objective

This project will develop high-quality species-level macroinvertebrate datasets through DNA metabarcoding. It will combine this with purpose-built, ecologically relevant environmental data for streams of the Melbourne region to create species distribution models (SDMs). These SDMs will enable spatially continuous estimates of species' occurrence, and fine-grained mapping of biodiversity patterns at unsampled locations across Melbourne's entire stream network.

These SDMs will also allow modelling of likely species' responses to future threats such as climate change, urban growth and their interactions, as well as their responses to management actions such as stormwater management and riparian revegetation. Collectively, these tools will underpin data-driven scenario analysis, planning and prioritisation for conservation, monitoring and adaptive management of Melbourne's streams, and form a model approach for similar efforts in other regions.

Methods

The project will be delivered via the following steps:

1. Design and conduct a comprehensive, unbiased sampling survey that covers environmental gradients of interest.

2. Advance DNA barcode reference libraries and DNA metabarcoding for assessing and describing macroinvertebrate biodiversity.

3. Develop SDMs that quantify the relationship between species presence-absence and environmental descriptors.

4. Use the SDMs to predict changes in macroinvertebrate species distributions arising from different scenarios of climate change and human impact.

5. Develop a biodiversity priority rank map for the streams in the Melbourne region.

6. Use SDMs and Zonation to analyse and map cost-effective prioritisation of management interventions.