

Abstract

Freshwater ecosystems, vital for global biodiversity, face mounting threats from human-made regulatory structures (e.g., dams, diversions) and climate change. These factors disrupt the natural flow regime—magnitude, frequency, duration, timing, and rate of change undermining ecosystem balance. Research examining the combined effects of flow alterations, water quality degradation, and climate change is lacking, particularly at local scales, limiting effective environmental flow management.

This PhD research investigates how macroinvertebrate assemblages—critical to aquatic food webs—respond to altered flow regimes and water quality stressors in both regulated and unregulated segments of the Goulburn River, Australia. It addresses three key questions: (1) How do macroinvertebrate communities respond to ecologically relevant flow metrics? (2) How do flow and water quality changes during extreme droughts affect these communities? (3) How will projected climate change impact flow indices and aquatic ecosystems?

Using boosted regression trees, the study found reduced flow variability and lower taxa richness in regulated reaches, with unregulated sites hosting 38% more taxa and higher sensitivity (SIGNAL 2 scores). June maximum flow emerged as a key influence. During and after a severe drought, redundancy analysis and TITAN revealed increased richness, abundance, and diversity post-drought, with greater community shifts across sites. Climate modeling with SWAT under RCP 4.5 and 8.5 scenarios projected higher hydrological variability, zero flows in November, and tripled high pulse events—threatening macroinvertebrate habitats.

Overall, this research enhances understanding of how natural flow variability and climate-induced hydrological changes affect freshwater ecosystems. Findings support adaptive, ecosystem-based environmental flow management tailored to local and future climate conditions.