

# **A web-based tool for assessing the effects of land and stream management practices on stream condition in the Melbourne region**

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## **Key Points**

- Stream macroinvertebrate assemblages of streams are sensitive indicators of stream condition
- The urbanstreams.net bugmodels tool allows interactive prediction of changes in assemblages resulting from change in forest cover or urban stormwater drainage across the Melbourne region
- The tool allows assessment of likely effects of management actions for individual reaches

## **Keywords**

Macroinvertebrate, assemblages, prediction, Melbourne, SIGNAL, LUMaR, impervious, forest

## **Introduction**

The mix of macroinvertebrates (insects, molluscs, crustaceans and worms longer than ~0.25 mm) living in a stream reach is a sensitive indicator of the ecological condition of that reach. This is because macroinvertebrates are ubiquitous and diverse, with a wide range of responses to environmental stress, and have life-cycles of months to years, making them good integrators of impacts over long time periods (Rosenberg & Resh, 1993). Metrics such as SIGNAL (Chessman, 2003), provide a useful summary of condition by averaging the sensitivity to disturbance of the macroinvertebrate families collected in a site. However, using such metrics for condition assessment alone fails to provide guidance on how different management actions are likely to alter condition (for better or worse).

Walsh and Webb (2013; 2016) developed models of the distributions of 60 macroinvertebrate families in the Melbourne region, that explicitly aimed to predict the effect of two primary human activities in the region: forest clearance and construction of urban stormwater drainage systems. They used a measure of attenuated imperviousness (AI) (weighted impervious cover by distance to the nearest downslope drain or stream: Walsh & Kunapo, 2009) to indicate the effects of conventionally drained urban land and a weighted measure of forest cover (AF) that represented decreasing effect of forest cover further away from the stream, and further upstream (Walsh & Webb, 2014). While other human impacts (e.g. water abstraction or intensive horticulture) are likely to have localized impacts on streams, forest loss and urban stormwater drainage explained most of the human-induced variation in macroinvertebrate assemblages across the region (Walsh & Webb, 2013). These models thus permit prediction of the loss or gain of macroinvertebrate families in response to human actions, such as urban development with conventional drainage, implementation of stormwater retention technologies, forest clearance, or reforestation. Furthermore, observations of unexpected presence or absence of macroinvertebrate families at a site with known urban and land-clearance impacts can point to other factors that could be affecting the stream.

In this note, I report on a web-based tool ([urbanstreams.net/tools/bugmodels/](http://urbanstreams.net/tools/bugmodels/)) that uses these models to report current macroinvertebrate assemblage composition across the Melbourne region, and allows the user to explore the effects of altering catchment urban drainage and forest cover on assemblage composition. I

illustrate the use of the tool with data from two reaches: one has been subject to increased urban catchment development over the last decade, and a second has received extensive riparian reforestation. I compare observed macroinvertebrate data with the models' predictions of response to these two effects, to show that the tool allows managers to assess the likely effects of future and past management actions.

### **Step-by-step guide to the tool**

The front page of the tool presents a map of the Melbourne region, with ~600 reaches (that were sampled for macroinvertebrates between 1994 and 2009) indicated by red dots. The user must select a single site (either by clicking on a red dot, or searching by stream and location name from drop-down menus). The tabs need to be worked through for each site individually, but for these examples, two sites are described in parallel (Jacksons Creek, downstream of the growing urban centre of Gisborne [JCKS] and Arthurs Creek at Arthurs Creek Rd [ARTH], in the rural north-east of the region).

Having selected a site, the user moves to the second tab, which: describes the catchment characteristics of each site in 2006 (e.g. JCKS has a catchment area of 120 km<sup>2</sup>, with 0.005 AI and 0.07 AF); and predicts SIGNAL, LUMaR (a new index developed by Walsh and Webb 2013), and the number of families classed as sensitive that are predicted to be found at the reach currently (2006), and in the absence of human impacts. These predictions can also be changed by selecting different habitat, season or processing method of samples.

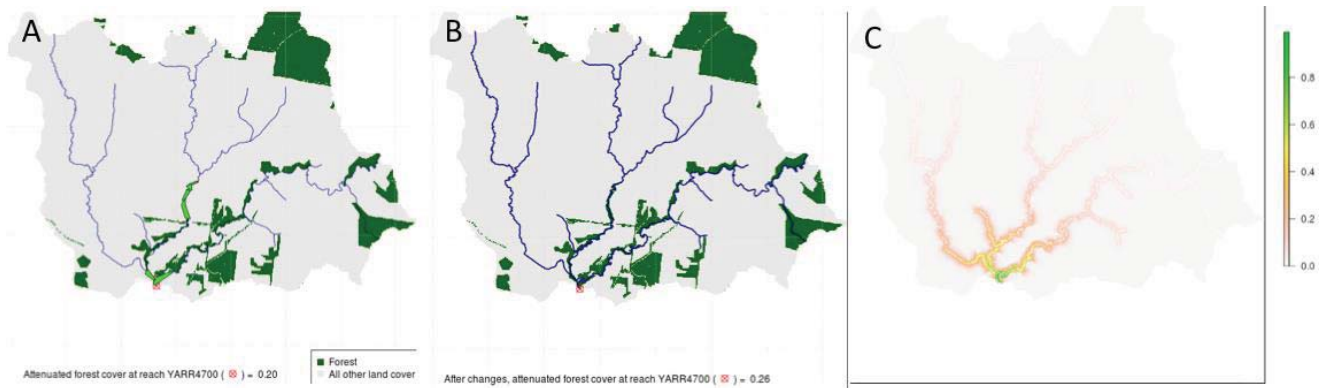
The third tab presents maps of the assumed 2006 forest cover upstream of the reach, and allows the user to a) see the spatial weighting applied in the calculation of AF, and b) add or remove areas of forest anywhere in the catchment to see how that change affects the estimate of AF (Fig. 1). For ARTH, riparian reforestation between 2006 and 2016 has increased AF from 0.20 to 0.26. (The fifth tab presents aerial imagery that can be used to cross-check the forest maps of tab 3).

On the fourth tab, the user can assess the effect of the changes to AF (or changes to AI, or changes to climate) on the predicted macroinvertebrate assemblages. For ARTH, the increase in AF was predicted to increase LUMaR score from 0.45 (poor-good) to 0.52 (good), with little change to SIGNAL score (Fig. 2A). The table of predicted families presented on the fourth tab shows that the improved LUMaR score was primarily a result of predicted reduced occurrence of invasive Physidae.

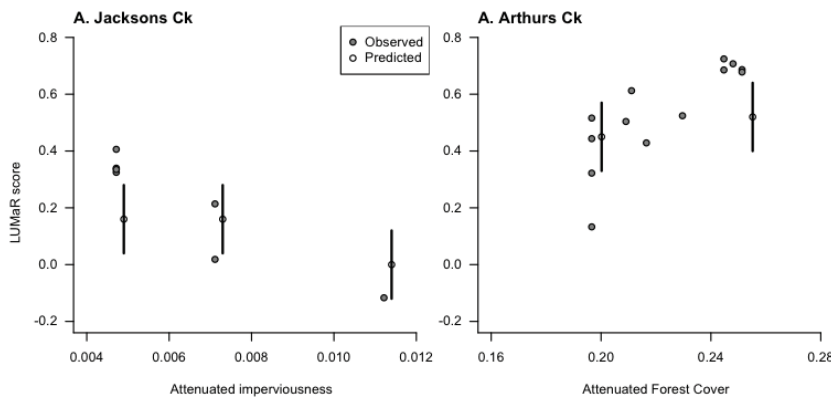
The growth of Gisborne increased AI at JCKS from 0.004 in 1997 to 0.011 in 2011, and the user can simulate the 1997 AI by 'disconnecting' 18 ha of the 2006 66 ha of connected impervious surfaces (when AI was 0.005), and clicking the 'calculate' button, and can simulate the 2011 value by undoing the first change by adding 66 ha. The tool predicts a decline in LUMaR between the two periods from ~0.2 to ~0.0, primarily as a result of reduced occurrence of the sensitive family Leptophlebiidae (Fig. 2B).

The final tab presents changes in predictions over the period 1994 to 2009 (antecedent discharge is a predictor variable in the models, so predictions change marginally with varying flow), and compares the predictions to the limited data for each site that was used to build the models. Currently, the tool only shows predictions for sites that were used to build and test the models, but it is planned to expand the extent of available predictions, as well as revise the models and the formulation of LUMaR.

Figure 2 presents comparisons of the predictions described above for ARTH and JCKS, with data from samples collected over the period in which Gisborne grew upstream of JCKS and the riparian forest grew upstream of ARTH. The predictions of the tool were broadly consistent with the observed changes in the sites.



**Figure 1. Partial screen shots of the forest cover map for ARTH from tab 3. A. 2006 forest cover, with additional forest cover (light green) drawn in by the user to match reforestation since then. B. The adjusted map recalculating AF from 0.20 to 0.26. C. The weighting applied to calculate AF.**



**Figure 2. Observed LUMaR scores in JCKS and ARTH with increasing AI and AF, respectively. The open points with error bars (indicating range in which 80% of predictions fall) show the predicted LUMaR scores for each site at the corresponding levels of AI and AF.**

## Conclusion

Such predictions could be used to estimate the scope of revegetation works required to elicit detectable improvement in stream condition in streams across the region. It is noteworthy that the observed improvements in ARTH exceeded predictions of the models, possibly because the models were based solely on forest cover of all types, while revegetated zones along ARTH are fenced: a factor not quantified by the models. Importantly, the models predict interactive effects between urban stormwater impacts, forest cover, and physiographic variation (Walsh & Webb, 2016). For instance, the beneficial effects of reforestation are likely to be dampened downstream of conventionally drainage urban developments. However, effective imperviousness is an important predictor variable because it points to stormwater retention technologies as effective means of protecting undeveloped streams, and restoring streams degraded by past urban practices.

## **Acknowledgments**

This work was funded by the Melbourne Waterway Research-Practice Partnership with Melbourne Water. I thank Angus Webb for his collaboration on the models used by the web tool; Monica Tewman, Peter Lind, Sharyn Rossrakesh, and Al Danger for providing the data from ARTH and JCKS, and the army of analysts who provided 20 years of macroinvertebrate monitoring data on which the models are based.

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