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Integrating understanding of hydrology, geomorphology and ecology to better predict periphyton abundance in New Zealand rivers

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Periphyton (the algae dominated community that grows on the bed of rivers) provide a rich food source for the upper trophic levels of stream ecosystems and can also provide an important ecological service by removing dissolved nutrients and contaminants from the flow. However, in excess, periphyton can have negative effects on habitat quality, water chemistry and biodiversity, and can reduce recreation and aesthetic values. The abundance of periphyton in rivers is influenced by a number of factors, but the two key factors that can be directly influenced by human activities are flow regime and nutrient concentrations. River managers in New Zealand are required to set objectives for periphyton abundance that meet or exceed national bottom lines, and they then need to set limits on freshwater quality and quantity in their region to ensure these objectives are met. Consequently, the ability to predict periphyton abundance under different conditions is crucial for management of rivers to protect ecological and other values.

Establishing quantitative relationships between periphyton abundance, hydrologic regimes and nutrient concentrations has proven to be difficult but remains an urgent priority in New Zealand. A common index for predicting periphyton abundance has been the frequency of floods greater than 3 times the median flow (FRE3), and this has been successful on a regional average but can be quite unreliable on a site-specific basis. This stems largely from our limited ability to transform flow data into ecologically meaningful physical processes that directly affect periphyton removal (e.g., drag, abrasion, bed movement). The research we will present examines whether geomorphic variables, such as frequency of bed movement, are useful co-predictors in periphyton abundance-flow-nutrient relationships.

We collected data on channel topography and bed material size for 20 reaches in the Manawatu-Wanganui Region which have at least 5 years of flow, nutrient concentration and periphyton biomass data (laboratory measures of chlorophyll a and percentage cover of thin films, filaments and mats/sludge). For each reach we set up a 1-d hydraulic model and established relationships between discharge and a number of hydraulic and geomorphic variables, including the discharge required to partially and fully mobilise the bed sediment. These were then related to the flow and periphyton monitoring records to examine the strength of relationships.

Relating periphyton biomass data to antecedent flow data allowed us to identify threshold flows for periphyton removal. These flows were found to be 0.9 - 9.8 times the median flow, depending on the site, with the average across sites being 3.3 times the median flow. Results also showed that general mobility of the gravelly/cobbly bed material was not required to remove periphyton but that mobility of over-passing sand (through its abrasive action) is a key control on periphyton abundance. Relationships between soluble inorganic nitrogen and periphyton abundance were found to be strong at sites where sand is mobilized infrequently but weak at sites where sand is mobilized often. Overall results indicate that integrating understanding of geomorphology, hydrology and ecology can improve prediction of periphyton abundance in New Zealand rivers.