

Analysis and modelling of the flood pulse and vegetation productivity response in floodplain wetlands.

by

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Candidate's Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of the author's knowledge, it contains no material previously published or written by another person, except where due reference is made in the text.

Susan Jennifer Powell

Date:

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Abstract

This thesis aims to develop a conceptual understanding of the flooding patterns and vegetation response of large floodplain wetlands, and to apply this knowledge to develop an inundation and vegetation response model for water management. Applicable to a range of floodplain wetland systems, the conceptual node-network approach was developed in relation to the Gwydir wetlands, NSW, Australia. The Gwydir floodplains and wetlands occur in a dryland setting and are reliant on flows from the upstream catchment that has substantial water resource development. The Gwydir wetlands include a range of ecological values and are listed under international agreements for the protection of wetlands and migratory waterbirds.

The challenge of understanding flooding patterns in the Gwydir wetlands are common to other floodplain systems where shallow inundation, rapid vegetation growth and canopy cover may preclude the assessment of open water flooding from conventional remote sensing techniques. To characterise the flooding patterns a multi-temporal decision tree approach was developed. Based on classification of flooding as open water or from the subsequent high vigour vegetation response, the method uses remotely sensed vegetation indices to map a range of flood events. The results are summarised into homogenous patches with respect to flood frequency and connectivity. Over 250 discrete patches were identified in the study area of which 17 patches could be used to describe over 92% of the floodplains. Using the patch analysis and assessment of connectivity between the patches and channels, the floodplain wetlands were conceptualised using a node-network model of the 17 patches.

Patches were categorised according to vegetation associations and the resulting landscape units used to develop models of vegetation productivity response measured as the fraction of photosynthetically active radiation (fPAR). Phenological attributes such as greenup, maturity, senescence and dormancy were extracted from the time series fPAR to characterise landscape units, and the fPAR response to inflow and soil moisture was modelled. Peak fPAR in the Gwydir is associated with macrophyte communities in the most frequently flooded areas, with fPAR exceeding 0.9 in summer months following inundation. Multiple linear regression models show significant relationship with inflows for many of the wetland landscape units.

The node-network and fPAR models are combined to develop the Inundation and Vegetation Response Model (IVRM) that provides a means of distributing river inflow and climate variables across the landscape and linking these to vegetation productivity response. Sensitivity testing is undertaken for uncertain parameters and further research needs identified. The model is applied to predicting inundation and vegetation response outcomes from predevelopment, current development and future climate change (2030) scenarios. Results suggested that in the most frequently flooded patch, inundation could have occurred over 99%

of the time under the predevelopment scenario, compared to less than 63% of the time under a 'dry' prediction of future climate change. This change could see a reduction in peak fPAR from 47% of the time in the predevelopment scenario, to less than 8% of time under the 'dry' climate change scenario.

This thesis integrates hydrological and ecological understanding, remote sensing analysis, statistical methods, and good modelling practice to develop the IVRM. The assessment framework takes a holistic view of an ecosystem, and explores how a wetting regime influences structure and function. The landscape scale approach uses the lateral, temporal and vertical connectivity, critical to the floodplain wetland functioning, to inform the development the model. The spatial and temporal scales are specific to the geomorphology, hydrology and ecology of the case study catchment, but the principles and methods can be applied to floodplain wetland systems in general.

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