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PREDICTING FRESHWATER HABITAT CONDITIONS BY THE DISTRIBUTION OF MACROINVERTEBRATES USING ARTIFICIAL NEURAL NETWORK

THESIS

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Contents

List of Figures

List of Tables

Abstract

Stream and river ecosystems play a crucial role in the human existence even though they contribute only 0.00008% to the Global water budget. Rivers and streams are important sources for drinking water, industrial and agricultural water, and recreation. Hence, there is a lasting interest in the control of river health. The second half of Twentieth Century has been a period of intensive study of rivers. Many efforts had been spent for better understanding basic limnological processes including physical, chemical and biological processes. Researches realised that all these limnological processes could not be studied separately but they are in very intimate interrelationship with each other. Any change in any limnological process can upset the balance and lead to disturbance in the freshwater ecosystem. Assessment and prediction of river and stream health gain the great interest in management in order to maintain a sustainable balance in stream and river ecosystem for human activities now and for future generations.

River health had traditionally been assessed solely on the chemical analysis of water samples. In recent years there has been realisation that the structure of plant and animal communities of the river can give us more accurate and integrated information about conditions of river and stream health. Among these biological communities, macroinvertebrates are most widely used because they are abundant and diverse, and are sensitive to changes in water quality, flow regime and habitat conditions they inhabit. Impacts on these animals are relatively long lasting and can be detected for some time after the impact occurs.

The computational approach had been applied to analyse the relationship between habitat conditions and stream macroinvertebrate assemblages. Statistical models had gained some significant successes. However, they still have some constrains in dealing with complexity and highly non-linearity of the stream system. A new generation of computer program called Artificial Neural Network proves to be very efficient for the study complex and nonlinear processes. In the context of the given Master research project, Artificial Neural Networks were applied for modelling Queensland river and stream system.

Two approaches are developed by means of Artificial Neural Networks to study the Queensland river and stream network, which spreads over the territory of the federal state of Queensland (Australia) and covers the catchments of most major and many minor Queensland rivers.

The clean water approach was adopted to determine relationship between presence and absence of macroinvertebrate taxa and physical predictor variables, which are considered relatively stable under human activities. The model therefore studied data from reference sites in near pristine conditions. Validation results provided correct prediction of the presence/absence of these taxa with an average accuracy of 80 %. Trained models were applied to assess habitat conditions of impacted and test sites. The assessment of the health of specific sites was than based on the comparison between observed and predicted site data. Criteria O/E (Observed/Expected) was used to give rapid assessment of habitat at sites ranging from reference to badly degraded conditions.

The dirty water approach did not distinguish site into reference and degraded. Networks had been trained with data from both clean and degraded sites. This approach studied interrelationship among physical, chemical and biological processes. The input layer contained not only physical predictor variables but also chemical variables, which are altered under human impacts. Validation also was made by mean of correct prediction of macroinvertebrate taxa for both reference and impacted sites and provides average accuracy of 76%. Dirty water approach can be applied for quantitative prediction of habitat condition by mean of water quality.

Sensitivity analyses were carried out by manipulating the values of input parameters and assessing the resulting changes in outputs. This method identified the environmental predictor variables best able to predict the presence/absence of each family. The primary intention of this sensitivity analysis was to improve network performance by limiting input variables to those that were sensitive for each model. However, this process also provided new insights into relationships between environmental variation and the occurrence of Queensland stream fauna and enabled the identification of ecological traits of each taxon.

The two modelling approaches provided good results and can be applied for management purposes. Artificial Neural Networks proved to be an effective computational approach to support bioassessment. However, all models developed during this project studied only spatial variations of processes in stream and river ecosystem. Future research should focus on temporal variations of relationships between environmental variables and the distribution of macroinvertebrates as well. Model training and validation using databases from other Australian stream systems would further contribute to a generalisation of the ANN stream models.

Publication and Communications in the Scientific Congress during the Candidature

Paper

Hoang H., Recknagel F., Marshall J., Choy S. (*in press*) Predictive modelling of macroinvertebrate assemblages for stream habitat assessments in Queensland (Australia). *Ecological Modelling*

Conferences attendance

1. 2nd Conference on Postgraduate Research on the Environment, Adelaide, September 13th 2000

Hoang T.H. "Habitat assessment of streams by Machine learning"

2. 2nd International Conference on Applications of Machine Learning to Ecological Modelling, Adelaide, November 27th - December 1st, 2000

Hoang H., Recknagel F., Marshall J. and Choy S. "Predictive modelling of macroinvertebrate assemblages for stream habitat assessments in Queensland (Australia)"

3. 2001 Societas Internationalis Limnologiae XXVIII Congress, Melbourne 4-10th February, 2001

Marshall1 J., Hoang H.*, Choy S. and Recknagel F. "Relationships Between Habitat Properties and the Occurrence of Macroinvertebrates in Queensland Streams (Australia) Discovered by a Sensitivity Analysis with Artificial Neural Networks"

4. FENNER 2001 Biodiversity Conservation in Freshwater, Same Landscape, Different Perspective, Canberra 5-7th July, 2001

Hoang H*, Marshall J., Recknagel F and Choy S "Elucidation of relationships between habitats and macro-invertebrates in Queensland streams by Artificial Neural Networks"

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Declaration

I declare that this work contains no material, which has been accepted for the award of any other degree or diploma in any university or other tertiary institutions. To the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due references has been made in the text.

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Date **Signed**

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