

Use of Hybrid EA Models for the Prediction of Chlorophyll-a and Phytoplankton Functional Groups Abundance in Two Shallow Lakes

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ABSTRACT

Twenty-two years of water quality time-series of the two Dutch lakes Veluwemeer and Wolderwijd were subject to predictive modelling by hybrid evolutionary algorithms (HEA). The modeling aimed at forecasting changes of the phytoplankton community in response to the control of external nutrient loadings and fish abundances as consecutively implemented to both lakes since 1979. The water quality time-series of both lakes were structured for HEA modeling in order to reflect the following three different management periods by both training and validation datasets: no management (1976-1978), lake flushing and waste water treatment (1979 onwards) and lake flushing, waste water treatment and food web manipulation (1991-1993). This approach facilitated a comparative analysis for the two lakes and the three management periods. Firstly HEA achieved reasonably accurate results for 5-days-ahead forecasting of chlorophyll-a and phytoplankton functional groups. Secondly hybrid evolutionary algorithms (HEA) achieved similar good forecasting results but also provided model representations for chlorophyll-a and algae functional groups in the form of rule sets. HEA has been designed to evolve both the structure of rule sets as well as the parameter values imbedded in the rule sets by means of a genetic algorithm. With regards to the different approaches for eutrophication management, modelling results have shown that only the combination of external nutrient control with food web manipulation has changed the lakes from hypereutrophic to mesotrophic conditions as reflected by the change in the dominance of algae groups and chlorophyll-a concentrations. HEA provides rule sets for the explanation of these ecological changes. The rules revealed that phosphorus limitation by means of seasonal lake flushing and wastewater treatment with food-web manipulation diminished the abundance of the harmful blue-green algae but enhanced the abundance of harmless green algae and diatoms.

Keywords: hybrid evolutionary algorithms; rule sets; forecasting; eutrophication control; chlorophyll-a, blue-green algae, green algae, diatoms