Ecological Informatics Applications in Water Management

6-7 November 2002

't Pand, Ghent University
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Abstract book

Peter Goethals & Niels De Pauw

Contents

Introduction

Contemporary ecological management deals with large data sets on land use, biological communities, structural and morphological characteristics of water systems and landscapes, physical and chemical composition of ecosystem components, climate, … To support decision making, tools from computer sciences with regard to information handling are therefore very useful. Examples are database development and maintenance, data mining, development of predictive models, data and information visualization, decision support systems, … During this conference, an overview of ecological informatics tools is presented with regard to integrated water management in Flanders, The Netherlands and related activities in Europe.

Programme

Wednesday 6 November 2002

9h30-10h15 Registration and welcome

Introduction

10h15-10h30 ***Niels De Pauw (AECO, Ghent University, Belgium):*** 'Aims and scope of the symposium'
10h30-11h00 ***Peter Goethals (AECO, Ghent University & IBW, Belgium)*** & Niels De Pauw: 'Ecological informatics applications in water management: state-of-the-art'

SESSION 1: Data and information management

Chairman: Edward Vanden Berghe (VLIZ, Belgium)

11h00-11h15 ***Peter Schalk (ETI, University of Amsterdam, The Netherlands)***: 'Biodiversity informatics: sharing knowledge'

11h15-11h30 ***Klaas Deneudt (VLIZ, Belgium)***, Edward Vanden Berghe & Jan Mees: 'An inventory of the lateral input for the Sea Scheldt'

11h30-12h00 Health Break / Poster Session

12h00-12h20 ***Jan Breine (IBW, Belgium)***, Hugo Verreycken, Ilse Simoens, Ulrika Beier, Erik Degerman, Herbert Wirlöf 'Development of fish community databases in Flanders (V.I.S.) and Europe (FIDES)'

12h20-12h40 ***Veronique Adriaenssens (AECO, Ghent University, Belgium)***, Peter Goethals, Andy Dedecker, Tom D'heygere & Niels De Pauw: 'Data collection in the Zwalm river basin for the prediction of the effect of restoration actions on macroinvertebrate communities'

12h40-13h00 ***Filip Raymaekers (AMINAL Division Water, Belgium)***: 'Concepts for a new Flemish water management information system' **(in Dutch)**

13h00-14h30 Dinner / Poster Session

SESSION 2: Decision support systems and practical applications of ecological informatics in water management

Chairman: Harm Duel (Delft Hydraulics, The Netherlands)

14h30-14h50 ***Willy Huybrechts (IN, Belgium)*** & Guy Engelen: 'The EcoVisie decision support system tool for ecosystem management in Flanders'

14h50-15h10 ***Guy Engelen (RIKS, The Netherlands)*** & Hedwig van Delden: 'Decision support systems for water management: solutions evolving with the problems, needs and knowledge'

15h10-15h30 ***Guda van der Lee (Delft Hydraulics, The Netherlands)***: 'Decision support systems for ecological rehabilitation of floodplains'

15h30-15h50 ***Koen Couderé (Resource Analysis, Belgium)***: 'Optimizing water management and safety in the Scheldt river basin using decision support tools'

15h50-16h10 Health Break / Poster Session

16h10-16h30 ***Frederik A. M. Verdonck (BIOMATH, Ghent University, Belgium)***, Colin R. Janssen & Peter A. Vanrolleghem: 'Potential of ecological informatics in probabilistic risk assessment of chemicals in rivers'

16h30-16h50 ***Nico Jaarsma (W+B, The Netherlands)***: 'Prediction of aquatic macro-invertebrate communities using Artificial Neural Networks'

16h50-17h10 ***Lowie Van Liere (RIVM, The Netherlands)***: 'Ecological models in policy advice and evaluation'

17h10 Reception

20h00 Conference dinner (optional)

Thursday 7 November 2002

SESSION 3: Data mining and analysis

Chairman: Cajo ter Braak (Biometris, Wageningen University, The Netherlands)

9h30-9h50 ***Veronique Gosselain (Biology of organisms research unit, FUNDP, Belgium)***, Claude Fauville, Stéphane Campeau, Murielle Gevrey & Jean-Pierre Descy: 'Development of a database and predictive models of diatom communities in rivers: the PAEQANN project'

9h50-10h10 ***Tom D'heygere (AECO, Ghent University, Belgium)***, Peter Goethals & Niels De Pauw: 'Input variables selection in neural network ecosystem models: comparison of senso-nets and genetic algorithms'

10h10-10h30 ***Elie Verleyen (Lab Protistology and Aquatic Ecology, Ghent University)***, Koen Sabbe, Koenraad Muylaert, Dominic A. Hodgson & Wim Vyverman: 'Multivariate tools for data mining and modelling in (paleo)ecological research – reconstructing paleo-environments in East Antartic lakes using diatoms'

10h30-10h50 ***Wim Gabriels (AECO, Ghent University, Belgium)***, Peter Goethals & Niels De Pauw: 'Prediction of benthic macroinvertebrate abundance in Flemish watercourses using artificial neural networks and multiple regression'

10h50-11h30 Health Break / Poster Session

11h30-12h00 ***Wies Akkermans (Wageningen University, The Netherlands)***, Piet Verdonschot, P.J. Goedhart & Rebi Nijboer: 'Prediction of class membership by means of support vector machines'

12h00-12h30 ***Floris Schulze (W+B, The Netherlands)*** & P. van der Veer: 'Extraction of hydrodynamic multivariate power functions from real time datasets using product unit networks'

12h30-13h00 Discussion on future co-operation on ecological informatics in The Netherlands, Flanders, Europe…

13h00-14h30 Dinner / Poster Session

SESSION 4: Ecological modelling

Chairman: Peter Goethals (AECO, Ghent University & IBW, Belgium)

14h30-14h50 ***Peter Van Puijenbroek (RIVM, The Netherlands)*** & Joost Knoop: 'From nutrient emissions to the ecology of shallow lakes: linking data, nodata and models'

14h50-15h10 ***Jan Janse (RIVM, The Netherlands)***: 'Validation and sensitivity analysis of the PCLake model: phytoplankton and macrophytes in shallow lakes'

15h10-15h30 ***Joachim Maes (KULeuven, Belgium)*** & Karin Limburg: 'Modelling the ecological constraints on movement of young-of-the-year herring from the North sea to estuaries'

15h30-16h00 Health Break / Poster Session

16h00-16h20 ***Youri Amerlinck (Hemmis NV, Belgium)***: 'Criteria to select an appropriate tool for ecological modelling'

16h20-16h40 ***Bas Ibelings (NIOO, The Netherlands),*** Marijke Vonk, Hans F.J. Los & Diederik T. van der Molen: 'Fuzzy modelling of cyanobacterial surface water blooms, validation with 12 years of NOAA-AVHRR satellite image'

Conclusions and closing of the symposium

16h40-17h00 ***Peter Goethals (AECO, Ghent University & IBW, Belgium)***: 'Conclusions of the symposium and prospects'
17h00-17h15 ***Niels De Pauw (AECO, Ghent University, Belgium)***: 'Closing of the symposium'

Poster presentations

Eleni Dakou-(Aristotle University of Thessaloniki, Greece), Tom D'heygere, Peter Goethals, Niels De Pauw & Maria Lazaridou-Dimitriadou: 'Comparison of the performance of decision tree and ANN-models predicting benthic macroinvertebrates in the Axios River (Greece)'

Ludwig Triest (Plant Science and Nature Management, Vrije Universiteit Brussel, Belgium): 'Genotyping of Callitriche L. is useful to estimate relationships of clones with environmental variables through multivariate analysis'

Rafael Marcé (Department of Ecology, University of Barcelona, Spain) & Joan Armengol: 'An Adaptive Neuro-Fuzzy Inference System (ANFIS) applied to nutrient load calculations in watersheds under strong human impact'

Tom D'heygere (Laboratory of Environmental Toxicology and Aquatic Ecology, Ghent University, Belgium), Veronique Adriaenssens, Andy Dedecker, Wim Gabriels, Peter Goethals & Niels De Pauw: 'Development of a Decision Support System for integrated water management in the Zwalm river basin, Belgium'

Zainescu A. Gabriel (Leather and Footwear Research Institute, Bucharest), Bratulescu Victoria1,Rusu -Trisca Corneliu & Barna Emil: 'Computer programme for the economic cost calculation of tannery wastewater treatment'

W Liefveld (Institute for Inland Water Management and Wastewater Treatment (RIZA), The Netherlands), U. Pakes & F. Schulze: 'A river habitat simulation model for quantification of ecological effects of low discharge on the Common Meuse'

Wim Gabriels (Laboratory of Environmental Toxicology and Aquatic Ecology, Ghent University, Belgium), Peter L.M. Goethals & Niels De Pauw: 'Self Organising Maps for analysing and classifying benthic macroinvertebrate communities in Flanders'

Tolessa Deksissa (Department of Applied Mathematics, Biometrics and Process Control (BIOMATH), Ghent University, Belgium) & Peter A. Vanrolleghem: 'Dynamic in-stream fate modeling of trace organic pollutants: a case study of LAS in the river Lambro'

Ellen Raadschelders (National Institute of Coast and Sea (RIKZ), The Netherlands), Mariska Harte, Karen van Essen & Hans Hartholt: 'Studying population biology and dispersal of Kentish plover (Charadrius alexandrinus) using a spatial dynamic, individual based model. Including recommendations for environmental management'

Andy Dedecker (Ghent University, Laboratory of Environmental Toxicology and Aquatic Ecology, Belgium), Peter L.M. Goethals and Niels De Pauw: 'Use of Artificial Neural Network (ANN) models and Geographical Information Systems (GIS) to simulate the migration of Gammarus pulex in the Zwalm river basin (Flanders, Belgium)'

Abstracts of oral presentations

Ecological informatics applications in water management: state-of-the-art

Peter Goethals & Niels De Pauw

Laboratory of Environmental Toxicology and Aquatic Ecology, Ghent University, J. Plateaustraat 22, B-9000 Gent, Belgium (peter.goethals@rug.ac.be)

Ecological Informatics is defined as an interdisciplinary framework promoting the use of advanced computational technology for the elucidation of principles of information processing at and between all levels of complexity of ecosystems, and aiding transparent decision-making in relation to important issues in ecology such as sustainability, biodiversity and global warming (Recknagel, 2002, http://www.waite.adelaide.edu.au/ISEI/). Ecological informatics is becoming in particular important in relation to water management. The implementation of the European Water Framework Directive for example entails high needs on a reliable data and information management as well as modelling tools to support decision making on the restoration of water systems all over Europe.

During this presentations, an analysis will be made of the contemporary strengths, weaknesses, opportunities and threats (SWOT-analysis) of the application of ecological informatics in water management.

Biodiversity informatics: sharing knowledge

Peter Schalk

ETI, University of Amsterdam, Mauritskade 61, 1092 AD Amsterdam, The Netherlands

ETI, the Expert Center for Taxonomic Identification, is a Non-Governmental Organisation in operational relation with UNESCO, dedicated to improve on a global scale the quantity, quality and accessibility of taxonomic information. Its focus is on developing software tools to support data management and information exchange, to promote taxonomic human resource networks, on disseminating taxonomic and biodiversity information, and increase capacity building. ETI is hosted at the University of Amsterdam and has self-sustaining branch organisations at universities and research institutions in Brazil, Chile, Japan, Russia, the United Kindom and Uruguay. An ETI branch in India is currently being set up. Branches in Germany, Indonesia and Cuba are under consideration.

This short presentation will focus on ICT tools that were developed and mechanisms on compiling and sharing taxonomic and biodiversity knowledge.

More detailed information on ETI and its activities can be found on its website: www.eti.uva.nl

An inventory of the lateral input for the Sea Scheldt

Klaas Deneudt, Edward Vanden Berghe & Jan Mees

VLIZ, Flanders Institute of the Sea, Oostende, Belgium

By order of the Waterways and Maritime Affairs Administration, division Sea Scheldt, the Flanders Marine Institute develops a database containing information regarding the lateral input into the Sea Scheldt.

Water quality and quantity data of tributaries, industrial discharges and input trough locks are gathered and compiled into a cohesive database. The parameters included are flow, biochemical oxygen demand, particulate organic matter, Kjehldahl N, nitrate and nitrite, ammonium and dissolved oxygen concentration. By determination of the XY-coordinates for the different discharge locations, the data is linked to Arcview and can be visualized by making selections on a GIS-map. Easy access to the contained information is assured by the possibility of making spatial selections for the sampling locations of interest. Data can be extracted from the database on different levels: for every company, nature of discharge, time and place a query for water quality and water quantity data can be made.

The aim is to provide a well-structured inventory of discharge data that is needed for ecological modelling purposes. The database is made structurally compatible with the OMES-database in which it will be incorporated.

Development of fish community databases in Flanders (V.I.S.) and Europe (FIDES)

Jan Breine[1], Hugo Verreycken[1], Ilse Simoens[1], Ulrika Beier[2], Erik Degerman[2], Herbert Wirlöf[2]

[1]Institute for Forestry and Game Management
[2] National Board of Fisheries, Institute of Freshwater Research, Sweden

In Flanders a preliminary database on fish data was developed in 1993. In 2001 a new project started as part of the Milieu Management Informatie Systeem. This Flemish project MMIS intends to make all environmental information better accessible, to attune the environmental information and to support decision making more efficiently. The V.I.S. database (Fish Information System) is a part of this huge project and focuses on collecting and linking all existing data about fish, fish distribution, pollution in fishes, Index of Biotic Integrity, restocking, fish habitats, ... in Flanders. All the data will be organised in a database and made accessible through the Internet.

At present the links between different projects from different institutes are defined. By the end of 2003 the database (Oracle) should be functional.

The National Board of Fisheries in Sweden designed a database (Access 2000) to combine information from 12 different countries collaborating in a European project (FAME). The databank was designed according to the requirements of the Water Framework Directive and taking into consideration other international projects. National data were selected and compiled following a strict protocol. In total 7 files are linked with each other. The database contains information on reporter, site, fish, method, and anthropogenic impact. The data is stored on an SQL server with Internet access for FAME project members by December 2002. The purpose of the database is to enable the development, evaluation and implementation of a standardised fish-based method for the ecological status of European rivers.

Data collection in the Zwalm river basin for the prediction of the effect of restoration actions on macroinvertebrate communities

Veronique Adriaenssens, Peter Goethals, Andy Dedecker, Tom D'heygere & Niels De Pauw

Laboratory of Environmental Toxicology and Aquatic Ecology, Ghent University, J. Plateaustraat 22, B-9000 Gent, Belgium (Veronique.adriaenssens@rug.ac.be)

Data collection and management is an important step in river management. Data are used for the assessment of rivers and they often serve as input or validation set in models. These data need to be reliable because they are often the basis on which the decisions are taken by the river managers. Data can comprise both monitoring data and expert knowledge. Topics which concern data collection in rivers such as 'data collection depending on the objectives', 'sampling site selection', 'variable selection', 'frequency/time of sampling', 'spatial scale of the monitoring', etc. will be discussed in the presentation based on the AECO monitoring network in the Zwalm river basin.

Concepts for a new Flemish water management information system

Filip Raymaekers

AMINAL, Division Water, E. Jacqmainlaan 20, B-1000 Brussel, Belgium

In Flanders, different authorities and administrations have responsibilities related to water management and the related research is mainly performed by different (scientific) governmental institutions, universities and consultancy companies. By dividing these responsabilities and spreading the research activities, knowledge and data, including the relational databases on water systems in Flanders, are managed by different authorities and an integrated overview on the available activities and data resources is missing.

To make an inventory of the scientific research, the water system knowledge and retrieving the gaps and priorities for new research, there is a need to create an integrated survey of the completed, the running and the planned research related to water systems. Supplementary, there is a need for an area and theme orientated survey of all the generated data outputs concerning water, also the data resources which are not included in reports.

Therefore the 'Databank WaterSysteemKennis' (DWKS) is started up. The aim of the DWSK is creating a continuously updated meta-database. The other aim of the DWSK is offering a survey of which data are and will be collected in Flanders. Via the DWSK it has to be possible to check the availability of research data concerning certain themes or research domains.

By making data available and generating a continuous integrated geographical survey on water related research, the DWSK will probably have an interesting added value for institutes and authorities involved in water management.

The EcoVisie decision support system tool for ecosystem management in Flanders

Willy Huybrechts[1] & Guy Engelen[2]

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EcoVisie is developed in a collaboration between AMINAL (Environment, Nature, Land and Water Management Administration), the Institute of Nature Conservation and the Research Institute for Knowledge Systems (The Netherlands). It is part of the Environment Policy program of the Flemish government, under the theme 'Loss of Biodiversity'. Creating larger units of nature and increasing the total nature area by means of nature development in floodplains are policy options for the near future. Four steps can be distinguished.

1. The exploration of the potential of floodplains for the development of nature under different abiotic boundary conditions;
2. The experimentation with, and elaboration of a vision for nature in which the highest possible value for nature should be achieved under the given social preconditions;
3. The socio-economic and environmental evaluation, in which the vision for nature is weighted against the other spatial functions in the area;
4. The factual implementation of the visions in the area.

The present version of EcoVisie provides most of its support in step 2. The instrument is to be used in the preparation and evaluation of visions relative to the development of ecosystems in floodplains, based on abiotic conditions, zoning constraints, and management options. The visions for ecosystems are formulated from the nature's point of view. It combines spatial information relative to the abiotic, environmental, zoning, and management constraints into a single map in a fully iterative and interactive manner. In the course of the exercise, this map evolves to become the ecosystem-vision of the area. The evaluation of the final vision, and the consequences of different choices for actions are translated into a number of indicators displayed on maps or presented in the form of tables. Indicators include: management costs, management subsidies, ecological value, value perceived by humans, number of species, type of species, distribution of species, etc.

The main function of the DSS system is analysis: the system carries out complex, technical calculations, and visualizes and compares the results. For the policy maker and the manager of the area also its communication function is of great importance: the system presents the visions in the form of maps and thus brings them across to the public in an attempt to gain support, possibly in interactive sessions.

The Decision Support System EcoVisie is generic and can be used for Flemish valleys and indeed for any other type of natural area for which the required geographical information is available. In the first phase the system is developed for the 'Vallei van de Zwarte Beek'. Moreover, the system is developed in such a way that it can be expanded with other models, including (dynamic) spatial models.

Decision support systems for water management: solutions evolving with the problems, needs and knowledge

Guy Engelen & Hedwig van Delden

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Decision Support Systems are rapidly gaining interest among planners and policy makers responsible for the management of complex environmental and socio-economic systems such as rivers, watersheds, coastal zones, etc. In contrast only few DSS are currently used to prepare actual policies or management plans. This is not a surprise given the complexity and the interlinked nature of the domains that need to be represented in the DSS. Researchers are far from having the perfect models, tools and data that are the kernel of the ultimate DSS. Moreover, in order to deploy a DSS as a usable and effective instrument for policy makers it is important that it matches their perceptions, experiences and operational procedures and that it enhances their current policy practices. Thus, it is good practice to develop DSS systems as a collaborative effort involving end-users, scientists, domain specialists and technicians. But these are often worlds apart. In this presentation we will share some experiences gathered in the development of DSS systems for water related issues. We will depart from the EcoVisie prototype and show possibilities for its enhancement on the basis of other DSS's that we have developed. The lessons learned in these projects will be shared.

Potential of ecological informatics in probabilistic risk assessment of chemicals in rivers

Frederik A. M. Verdonck[1], Colin R. Janssen[2] & Peter A. Vanrolleghem[1]

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The characterisation of the risk of (new) chemicals to species/communities, when both the exposure/environmental concentration and effects (species sensitivity) are variable and uncertain, is the central issue in Probabilistic Ecological Risk Assessment. The spatial variability of the environmental concentration and species sensitivity is one of the largest components of the total variability. This spatial variability can be accounted for by geo-referencing the exposure, effect and finally probabilistic risk. Geo-referencing makes the risk assessment more refined and realistic. This presentation will focus on the added value of ecological informatics, more in particular the prediction of species presence/absence in aquatic river systems, to improve probabilistic ecological risk assessments.

Prediction of aquatic macro-invertebrate communities using Artificial Neural Networks

Nico Jaarsma

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Artificial Neural Networks (ANN) have been successfully applied to a variety of different water management problems. Examples of these are hydrological modelling, water quality modelling and prediction of drinking water consumption. The use of ANN for purposes of ecological research has only hesitantly begun. The main reason of this might be the lack of transparency of Neural Networks. Until recently ANN was considered a black box technique, however recent developments have made it possible to visualise the contents of these black boxes. This has resulted in the development of so called Product Unit Networks (PUN's), which have also been called 'white box neural network function finders'. These PUN's are able to extract and quantify multivariate power functions from complex data sets. We tried applying these methods to data sets of macro-invertebrate communities and abiotic variables from Dutch surface waters. The first results are promising and show the added value of application of these techniques for ecological research.

Ecological models in policy advice and evaluation

Lowie Van Liere

National Institute of Public Health and the Environment (RIVM)
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Ecological models have been used in the Netherlands to set standard nutrient concentrations and to evaluate planned policy measures. Four examples will be presented.

Why shallow lakes do not recover after phosphorus reduction?
It seemed to be surprising that shallow lakes did not respond as fast as 'one' wished. Even when the Maximum Allowable Concentration of phosphorus was met (0.15 mg P l^{-1}, summer average) the desired ecological status (for instance: clear water, submerged waterplants, pikes that reproduce in the lake) was not reached. The eutrophication model PCLake explained the resilience of the system by modelling the foodweb. This had consequences for the mind-setting in defining standard concentrations for nutrients. Target values had to be much lower than accepted before to reach desired ecological states (0.05 mg P l^{-1}, summer average). Additional measures accelerate recovery, and make it possible to reach clear water, even at enhanced phosphorus concentrations.

Are nation wide standard concentrations for nutrients functional?
Target values in the Netherlands have been derived from datasets of shallow lakes. These values (0.15 mg P l^{-1}, summer average) have been accepted for other water bodies because of the preservation of downstream vulnerable water bodies. If 50% *Lemna* coverage in polder ditches is accepted as a 'good ecological status' PCDitch revealed that ditches had a large range in target concentrations dependent on depth, sediment type and residence time (0.19 – 0.42 mg P l^{-1}, summer average). Dredging, as an additional measure, is not only useful in removing nutrient rich matter, but increases depth too. Both accelerate recovery.

Will manure - and fertiliser policy improve water quality?
Reduction of target N and P surplus have been simulated with sets of coupled models calculating loading end effects in several waterbodies. Only minor effects in regional waters were calculated. In larger waterbodies (rivers, large lakes and the coastal zone of the North Sea the effect was insignificant, even at the reduction of the target P surplus from 40 –1 kg ha^{-1} $year^{-1}$.

Downstream Protective Standard Values.
Vulnerable downstream waterbodies cannot be safeguarded from eutrophication if upstream concentrations are high (even if this does not endanger the upstream water body). Models have been used to calculate Downstream Protective Standards for River Rhine if the lake IJsselmeer had to be protected: 0.08 mg P l^{-1} (summer average), and 1.8 mg N l^{-1} to safeguard the coastal zone of the North Sea.

Development of a database and predictive models of diatom communities in rivers: the PAEQANN project

Veronique Gosselain[1], Claude Fauville[1], Stéphane Campeau[2], Murielle Gevrey[3] & Jean-Pierre Descy[1]

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The PAEQANN project is a European project that aims to use modern modelling technique to model aquatic communities, especially based on artificial neural networks (ANN). PAEQANN stands for Predicting Aquatic Ecosystems Quality using Artificial Neural Networks and its objective is to characterize the impact of environmental characteristics on the structure of aquatic communities (Diatoms, Macroinvertebrates and Fishes).

In the framework of the PAEQANN project, an important database on benthic diatoms has been built. This database contains more than 2500 records, from Austria, Belgium (Wallonia), France and Luxembourg. Each station is described by 9 environmental variables characterising the type of river, and each sampling by at least 20 environmental variables, describing the water quality. All the variables have been standardised in order to be able to carry out single analyses on the whole data matrice. The structure of the database will be presented.

An example of analysis using ANN will be given. It deals with records from good ecological quality situations. Self Organizing Maps and Back Propagation are used to identify and predict benthic communities. A first attempt is made to identify the contribution of environmental variables to the algal community changes. The relevance of expression of diatom counting as relative biomass or as relative abundance is also discussed.

Input variables selection in neural network ecosystem models: comparison of senso-nets and genetic algorithms

Tom D'heygere, Peter Goethals & Niels De Pauw

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The selection of appropriate input variables is an important aspect of modelling. Rigorous methods are needed for detecting which variables are relevant. In this study, two input variable selection methods for Artificial Networks Models were compared: a genetic algorithm approach and a senso-net. Therefore, a database of 360 samples of macroinvertebrate communities in unnavigable watercourses throughout Flanders was applied. Along with the abundances of 92 taxa of macroinvertebrates, the database contained a number of abiotic variables. It was a combination of physical-chemical (temperature, pH, dissolved oxygen concentration and total organic carbon, Kjeldahl nitrogen, total phosphorus concentrations of the sediment), eco-toxicological and structural variables (such as flow velocity and water depth).

A comparison was made between the variables that were selected with both techniques and their predictive performance on the basis of a validation dataset. The percentage of Correctly Classified Instances and Cohen's kappa statistic calculated as the performance measures. Because of the negative effects of irrelevant variables, the inclusion of these techniques in ANN-models is highly advisable. With this technique, the number of input variables could be reduced while the prediction success based on different performance measures increased. The selected variables can also be considered as the critical variables in river restoration and conservation management programmes.

Multivariate tools for data mining and modelling in (paleo)ecological research – reconstructing paleo-environments in East Antartic lakes using diatoms

Elie Verleyen[1], Koen Sabbe[1], Koenraad Muylaert[1], Dominic A. Hodgson[2] & Wim Vyverman[1]

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[2]British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 OET, U.K

Ecological data sets (comprising data on species distributions in relation to environmental factors) are usually complex and notoriously noisy. Multivariate tools such as ordination analysis allow us to separate the signal from the noise by the construction of composite hypothetical gradients (species gradients), which can then indirectly or directly be related to environmental gradients. In paleo-ecological research fossil species assemblages are used to infer paleoenvironments through the development and application of transfer functions. In this presentation, we will demonstrate the rationale behind this technique and possible pitfalls using the reconstruction of East Antarctic lacustrine environments as a case study.

The use of diatoms as indicators of present and past environmental conditions is well established. In order to develop transfer functions for quantitatively inferring climatic changes, diatoms and water chemistry data were inter-calibrated from five different East Antarctic oases. Direct and indirect ordinations using CANOCO 4.0 for Windows indicate that salinity is the most important environmental variable explaining the variance in the diatom flora in East Antarctic lakes. In oligo- to hyper-saline lakes the variance is mainly explained by lake water depth. The ratio of the eigenvalue for the first (constrained) CCA axis with salinity (and depth) as the sole predictive variables to the eigenvalue for the second (unconstrained) CCA axis suggested that salinity (and depth) might yield significant inference models.

The dataset was used to construct a weighted averaging (WA) transfer function for salinity in order to infer historical changes in the precipitation-evaporation balance using CALIBRATE 1.01. The disadvantage of this transfer function is that salinity changes in freshwater lakes are reconstructed inaccurately due to the 'edge effect' and due to the low species turnover along the salinity gradient at its lower end.

In order to infer changes in the moisture balance in the oligo-saline lakes, a second transfer function using weighted averaging partial least squares with two components (WA-PLS2) for depth was constructed. Both transfer functions can be used to quantitatively infer changes in the precipitation-evaporation balance in lake sediment cores from oligo-, hypo-, meso- and hyper-saline lakes in East Antarctic oases between 102-75°E. The transfer function for depth is promising, since it will enable the reconstruction of changes in the moisture balance in small freshwater lakes, which are believed to respond quickly to climate change.

Prediction of benthic macroinvertebrate abundance in Flemish watercourses using artificial neural networks and multiple regression

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Prediction of benthic macroinvertebrates was attempted on a data set of 360 samples taken in unnavigable watercourses throughout Flanders. In addition to data on the abundance of 92 taxa, also information on a number of abiotic variables, among which in situ-measurements of the sediment supernatant water, physical-chemical properties of the sediment, granulometric variables and some structural properties was available. Using this data set, an artificial neural network (ANN) was trained with a back-propagation algorithm, in order to predict abundance of benthic macroinvertebrate taxa present at a sampling site, the abiotic characteristics being the predictor variables. Subsequently, multiple regression was applied for the same purpose. The reliability of predictions generated by both modelling techniques was assessed by means of cross-validation. From this comparison, it could be concluded that with both techniques satisfactory results were obtained, those with the ANNs however being slightly better.

Prediction of class membership by means of support vector machines

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Support Vector Machines (SVMs) are nonlinear predictors that can be used both for classification and regression. In this paper the emphasis is on classification.

In the SVM framework class boundaries are defined by so-called 'boundary observations' or support vectors. Hence support vectors are data points lying in some sense 'between' two classes. The search for these boundary observations is the main task of a Support Vector Machine.

It appears that SVMs can be expressed as quadratic programming problems, which implies that they have a well-behaved loss function and clearly defined stop criterion. This can be considered as an advantage of this method over Neural Networks.

In this paper a data set of freshwater sites is considered, which has been classified into cenotypes on the basis of macro-invertebrate species abundance. An SVM is fitted to these data in order to predict the cenotypes using only environment variables. The performance of the classifier is assessed by means of leave-one-out crossvalidation. The outcome is compared to results obtained with multinomial logistic regression.

Extraction of hydrodynamic multivariate power functions from real time datasets using product unit networks

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A method is presented for extraction of hydrodynamic multivariate, multi-term power functions from real time data and complex processes. Several modifications are proposed to the rule extraction system RF5 in such a way that it is applicable to complex and large datasets. A pruning algorithm is presented that strongly increases the comprehensibility of extracted formulas. The working of the method will be demonstrated by real time problems like the impact of navigatuin traffic on sand exchange between groyne field beaches and navigation channel of the Dutch Rhine.

Modelling the ecological constraints on movement of young-of-the-year herring from the North sea to estuaries

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During winter months, the species composition of estuarine fish assemblages of North Sea estuaries is often dominated by 0-group herring and sprat. The abundance of these young clupeids is determined by migrations between marine and estuarine habitats but it remains largely unclear which ecological processes determine the timing of migrations between sea and estuary. Therefore, we have developed a model to quantify the ecological benefits and costs of remaining in the marine habitat versus moving into the estuary. Habitat selection was evaluated through the use of a dynamic optimisation model. Major costs that juvenile herring encounter were habitat- and size-specific predation and the probability of encountering physiologically unfavourable environmental conditions. Major benefits derived from a habitat were manifested in the size-specific growth rate and in encoutering abundant plankton concentrations. We used a bioenergetics model to quantify fish metabolism and growth. We developed a predation model to quantify predation pressure on herring and a feeding model allowing herring to switch from particulate to filter feeding under turbid conditions. The model was then used to predict the habitat preference of young herring along an estuarine gradient. A sensitivity analysis showed that zooplankton concentration in turbid zones of the estuary during the winter may explain the winter use of estuaries by young-of-the-year herring.

Criteria to select an appropriate tool for ecological modelling

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The use of model building and dynamic simulation can give a better insight in different processes which describe ecosystems or the behavior of the system, so that optimal management of the system can be ensured, resulting in cost reduction and less pollution. This approach uses mathematical models that give a reliable image of the existing system (plant, river, …).
The model base includes several models regarding

- Wastewater treatment
- Water reuse
- River
- Integrated Urban Water Systems

HEMMIS, in partnership with Ghent University, worked out a software platform for dynamic simulation, in which it is easy to integrate your own know-how. The platform named WEST® uses the easy to learn Model Specification Language, which enables the user to adapt and extend the available models or to enter new models into the system.

The Configuration Builder allows for graphical component-based modeling. The Configuration Builder is especially designed for the interactive composition of complex configurations from basic building blocks and supports unlimited size and complexity of system configurations, easy implementation of controllers and an extended model and component library.

In the Experimentation Environment the simulation of the characteristics of the system can be controlled interactively (Dynamic interactive simulation). At any time during the simulation parameters can be changed, using sliders or manually.
A lot of supportive tools are present to help you create a reliable simulation experiment.

1. Trajectory optimization experiment
   Certain model parameters are varied to minimize the *distance* between a simulated trajectory and a given (measured) trajectory. This is mostly done for parameter estimation, but it can also be used for controller tuning and process design optimization.
2. End value optimization experiment
   The most general use of the optimizer where some parameters are varied (possibly constrained) as to minimize a goal function.
3. Sensitivity analysis experiment

The sensitivity of the model with respect to model parameter variations can be investigated.

4. Scenario analysis experiment
   An automatic run of a set of simulations with different values for several parameters can be performed. The values of the parameters are changed within a specified interval according to a linear equally, logarithmic equally or randomly spaced distribution.

All this aspects will be shown in relation to some river water quality cases that have been worked out by different universities.

Fuzzy modelling of cyanobacterial surface water blooms, validation with 12 years of NOAA-AVHRR satellite image

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This paper presents an early warning system for the occurrence of cyanobacterial surface waterblooms. The model is based upon a sound understanding of the ecology of the cyanobacteria that make up the blooms. Surface waterblooms of toxic cyanobacteria are a serious impediment for the use of lakes (drinking water, recreation etc.). In a waterbloom a pre-existing population of buoyant cyanobacteria concentrates manifold at the lake surface, resulting in a thick scum. Routine monitoring data are not sufficient for early warning against the occurrence of these blooms. In a novel approach we combined deterministic modeling with fuzzy logic to describe the three main conditions governing waterbloom formation: 1) a pre-existing population of cyanobacteria, 2) buoyancy of the cells and 3) stability of the water column. The attributes and membership rules of the fuzzy model were based upon earlier field studies of diel changes in buoyancy and vertical distribution of cyanobacteria. The model was applied without further calibration to the large Dutch lake IJsselmeer, and validated using 12 years of NOAA-AVHRR satellite images on which surface blooms are discernable as an enhanced vegetation index (NVI) or increased surface temperature. Surface blooms were observed only on 23 out of a selection of 309 images. The model gives a proper prediction in 19 of these cases (83 %), but fails to predict 4 surface blooms. Surface blooms were absent on the remaining 286 images; here the model predicted 266 cases correctly (93 %), but also produces another 20 blooms. The model does not have a bias towards predicting too many or too little blooms. Surface blooms were predicted during 5,4 % of the time only July-October). The model can be used to predict the occurrence of surface waterblooms in advance on basis of the long-term weather forecast, leaving time for appropriate management of the problem (for instance increased surveillance, ban on recreation). The current model, however only describes surface waterbloom formation in the open water. More persistent blooms in sheltered places are not yet covered. The lake management has expressed a keen interest to convert the present model into a fully operational early warning system.

Abstracts of poster presentations

Comparison of the performance of decision tree and ANN-models predicting benthic macroinvertebrates in the Axios River (Greece)

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In this study, decision trees and Artificial Neural Networks were applied on a dataset of 102 measurements collected at 20 sampling sites in the Greek river Axios. These techniques were used to predict the habitat suitability of macroinvertebrates based on environmental variables. The database consisted of eight physical-chemical, seven structural and one seasonal variable, as well as abundances of benthic macroinvertebrates. For the induction of decision trees, the J48 algorithm was applied while the ANN-models were developed by using the back-propagation algorithm. For the assessment of the models, the percentage of Correctly Classified Instances and Cohen's kappa statistic were calculated. A combination of CCI (%) and Cohen's kappa was necessary for an efficient assessment of the induced models. Overall, both modelling techniques performed well in predicting the habitat suitability of macroinvertebrates. ANNs were more capable of making reliable predictions of very frequently or rarely present organisms, while decision trees resulted in models that could be ecologically interpreted.

Genotyping of *Callitriche* L. is useful to estimate relationships of clones with environmental variables through multivariate analysis

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Species of the aquatic macrophyte *Callitriche* L. (Callitrichaceae) exhibit considerable diversity in chromosome numbers, pollination systems and ecology. Most species are amphibious and the vegetative plasticity of the leaf shape as well as the absence of mature fruits, render taxonomic identification difficult. In running water, clonal patches of most *Callitriche* species possess floating rosettes of spatulate leaves that develop when stems reach the surface. However, submerged leaves and even plants may show only linear leaves. Although *Callitriche* taxa are widespread in rivers of various water quality and often represent the only tolerant macrophyte in more polluted waters, this vegetative plasticity limits the practical use of *Callitriche* taxa as bio-indicators. The objective of this study was to investigate the genotypes of *Callitriche* populations in headwaters of rivers in Flanders (Belgium) and to estimate the clonality among rivers as well as the relationship of these clones and their genotypes with environmental variables.

The genetic variation and clonality in *Callitriche* L. populations from 16 headwaters in Belgium was determined by random amplified polymorphic DNA (RAPD). The presence and absence of amplified products after RAPD were scored for multivariate analysis with NTSYSpc 2.1 (Principal coordinate analysis – PCOORDA- using the simple matching coefficient; Neighbour Joining tree using Manhattan distance coefficient). Water quality variables were temp, pH, cond, $\%O_2$, DO, BOD, alkalinity, T-hardn, Ca-hardn, Mg-hardn, Si, Cl, OPO_4, TP, NO_2, NO_3, NH_4. Substrate quality variables were T-Kjehldal N, TP and particle sizes in 6 classes. Habitat descriptors were indices of diverse organisms (macrophytes, diatoms, invertebrates, fish). Correlations (Peasons product-moment) between the first three axes of the PCOORDA and environmental variables (chemical variables of water and substrates; habitat descriptions) were done with STATISTICA and multivariate analysis of genotypes and environmental variables with CANOCO (CCA with forward selection using Monte Carlo permutation test, after checking the gradient length in DCA).

The correlation of multilocus genotypes with the environmental variables revealed a highly significant relationship of the first axis (PC1) with the saprobity of the water as was estimated from benthic diatom assemblages. A higher number of significant relationships of water and soil variables with PC2 is due to the limited number of samples from harder waters. The CCA showed that the variability among different clones, as characterized by their genotypes, can be explained significantly through ecological indicator values such as the saprobity index (as estimated by diatom assemblages), the index of biotic integrity (based on fishes), total Kjeldahl nitrogen of the sediment, alkalinity, sediment particle size and macrophyte scores

This study showed that multilocus genotypes or gene pools might have a non random distribution in the rivers and in the particular environments. However, the observation that there is no clear relationship along a first axis (PC1) between a gene pool and a particular water or soil quality

parameter is compensated by the highly significant relationship with more general indicators of ecological quality such as the diatom saprobity index and fish index. Indeed, these indices integrate water and habitat quality over longer periods and are an advantage over the punctual water quality estimations. Therefore, the latter might not be sensitive enough to elucidate relationships of gene pools with the environment. Nevertheless, genotypes from harder waters showed clear differences along the second axis (PC2) suggesting that the water typology can be an important factor for understanding the distribution of genotypes and taxa.

An Adaptive Neuro-Fuzzy Inference System (ANFIS) applied to nutrient load calculations in watersheds under strong human impact

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The validity of an Adaptive Neuro-Fuzzy Inference System (ANFIS) for estimating fluvial constituent loads in watersheds under strong human impact is tested. Historical nutrient loads (NT and PT) have been modelled in two watersheds of different size and human impact history, i.e. the Ter River (Spain) and the Mississippi River (USA). The ANFIS methodology and traditional estimates based on modified rating curves and ratio estimators have been applied in order to compare results.

The ANFIS methodology joins the ability of the Fuzzy Inference Systems to model non-linear dynamics and the parameterization power of neural-networks algorithms. We have applied the ANFIS in a Monte-Carlo framework to calculate the bias and precision of the results obtained.

The ANFIS approximation worked as well as a careful implementation of classical methods, i.e. splitting of the series to avoid time-varying concentration vs flow relationships, and the selection of a proper calculation method within each section. It is at this stage where the ANFIS uses the advantage of being model-free and its local mapping features. Neither spliting nor selecting a method for calculation are necessary using ANFIS, thus we could implement the same methodology throughout the data series. Moreover, the application of a single, local mapping methodology avoids the presence of 'steps' in the final load history.

In contrast to 'black-box' neural-network applications, the parameters fitted during the ANFIS modelling can be ecologically interpreted, and become a valuable tool to understand temporal changes in human impact on watersheds.

Development of a Decision Support System for integrated water management in the Zwalm river basin, Belgium

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The Zwalm catchment is part of the Upper-Scheldt river basin and is characterised by an irregular flow regime. Floodings in urbanised areas led to the construction of weirs for water quantity control. Due to these weirs (in combination with numerous other structural disturbances) aquatic habitats are degraded and species migration is obstructed. In addition, several perturbations caused by domestic, industrial and agricultural activities have a serious impact on the river ecosystem quality. To achieve an optimal exploitation of the water system, all stakeholders such as nature conservationists, farmers, drinking water production companies, water quantity managers, … have to be involved in the decision making process. However, due to the enormous amount of information and the complex behaviour of the processes in a river basin, there is a high need for data management tools and models to perform simulations. A Decision Support System (DSS) is being developed to improve the reliability and efficiency of management decisions on the water use by the different stakeholders. The DSS includes information about aquatic species (macroinvertebrates, fish), water quality, habitat quality, stream characteristics, human activities,… Ecosystem models based on artificial neural networks, decision trees and fuzzy logic as well as a migration model based on calculations with overlays in a Geographical Information System (GIS) are applied to predict the response of key features of the riverine environment to proposed management actions. In this manner, the most sustainable actions can be selected, taking the goals of all stakeholders into consideration. The DSS also allows to estimate the time needed to see the effect of restoration actions, what is often important to convince all stakeholders of the effectivity of particular management decisions. In this manner, the DSS is an interesting tool to convince water managers and stakeholders to take specific actions and to elaborate an efficient planning of the restoration activities.

Computer programme for the economic cost calculation of tannery wastewater treatment

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This task is intended to offer a new complete Windows 95 platform containing a techno-economical database on the effectiveness of treatment systems for tannery wastewaters. The specific consumption for chemicals and energy can also be estimated and that means the COSTS for one cubic meter of wastewater treatment(as well as the costs for the treatment and shipping of the sludge resulted from the treatment) can also be computed.
Application of high performance techniques in the management of the wastewater treatment allows to get techno-economical and ecological data both in the current work and when a new technology or tannery is designed or modernized. Computer aided wastewater treatment results in the optimization and reduced production costs.

A river habitat simulation model for quantification of ecological effects of low discharge on the Common Meuse

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A River HAbitat SImuation Model (RHASIM) was developed, to gain insight into the effects of low discharge on the ecological development of the Common Meuse. The model is based on the Physical HABitat SImulation Model (PHABSIM) from the U.S. It is a flexible method by which the changing habitat conditions can be quantified for target species, representing characteristic habitats, for nearly all disturbances in a river ecosystem. The Common Meuse is a free flowing part of the rain-fed river Meuse with low discharges in summer; a natural phenomenon, influenced however by human impact.

Self Organising Maps for analysing and classifying benthic macroinvertebrate communities in Flanders

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Self Organising Maps (SOMs) are a type of artificial neural networks, that can be used for analysing and classifying various types of ecological data. In this study, SOMs were used for analysing and classifying benthic macroinvertebrate communities in Flemish watercourses. A data set, which covered abundances of 92 taxa of benthic macro-invertebrates in 350 sampling sites was used. The classification, produced by SOMs, was compared with results of other methods such as different types of cluster analyses. Characteristics of the data were examined in relation to the resulting classification. The high complexity of the dataset was reflected in the difficulties to find crisp cluster isles in the maps. Ecological interpretations were formulated with regard to relations between community structure, habitat characteristics and antropogenic disturbances. Possible applications of SOMs in river quality management were discussed based on the results of these Flemish watercourses.

Dynamic in-stream fate modeling of trace organic pollutants: a case study of LAS in the river Lambro

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The current methods of exposure assessment in the European union use local models for air, water and soil compartment to estimate chemical concentrations close to the source and a generic multimedia 'unit world' approach to estimate regional Predicted Environmental Concentrations (PECs). However, these models do not account for the spatial heterogeneity and temporal variability of ecosystem characteristics, and as a result, only an average value or 95th percentile is estimated. This PEC is subsequently compared with the predicted no observed effect concentration (PNEC) in view of risk assessment. In reality, both values vary in time depending on the dynamic processes in the ecosystem and physicochemical characteristics of the toxic chemical under consideration. Thus, the aim of this study is to predict the environmental concentration more accurately by including the inherent temporal variations of the PEC. This was done by developing a dynamic environmental fate model using a multi-compartment model (air, water and benthic sediment). Using conceptual dynamic hydraulic model (continuously stirred tank in series) and first order kinetics, a one-dimensional dynamic in-stream fate model has been developed to assess the short-term fate of trace organic pollutants in a natural river. The processes included in the model are biodegradation (both bulk and biofilm bio-degradation), sorption (to suspended particulates and dissolved organic matter), sedimentation, volatilization and re-suspension. The proposed dynamic model was evaluated on the basis of Linear Alkylbenzene Sulfonates (LAS) case study in the river Lambro (Italy). Based on monitoring data collected in February and May 1998 within the GREAT-ER project, the general trend of simulated data sets shown to agree well with the measured time series.

Studying population biology and dispersal of Kentish plover *(Charadrius alexandrinus)* using a spatial dynamic, individual based model. Including recommendations for environmental management.

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The Kentish plover (*Charadrius alexandrinus*) is a characteristic bird species of dynamic coastal habitat in the Netherlands. The population in the Dutch Delta area has strongly declined since the beginning of the 20th century. It has been suggested that this is the result of the decline of suitable breeding area and because of disturbance by recreation. A complex dynamic model has been build in order to evaluate the relation between bird ecology and human pressures and to optimize possible ecological recovery measures. The virtual bird population is strongly declining. This trend can not be altered by creating new breeding areas or by improving existing breeding areas. A year to year varying - but usually very poor - breeding success is strongly related to abiotic factors that can not be controlled by environmental management. We conclude that the described model helps summarizing and analyzing combined expert knowledge and evaluating management options. Bird dispersal behavior could not be analyzed and still many questions remain. However, though building and analyzing the model has shown to be very complex and time consuming, we think that the 'process of modeling' has been very valuable.

Use of Artificial Neural Network (ANN) models and Geographical Information Systems (GIS) to simulate the migration of *Gammarus pulex* in the Zwalm river basin (Flanders, Belgium)

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Ecosystem models can act as interesting tools to support decision making in river management. In preliminary studies, Artificial Neural Network (ANN) models were tested and optimized to obtain the best model configuration for the prediction of the habitat suitability for *Gammarus pulex* based on the abiotic characteristics of their aquatic environment in the Zwalm river basin (Flanders, Belgium). For assessment of the model predictions, the percentage of Correctly Classified Instances (CCI) as well as Cohen's kappa (CK) were calculated. Although, these ANN models are in general quite robust with a rather high predictive reliability, the model performance has to be increased with regard to simulations for river restoration management. In particular, spatial-temporal expert-rules have to be included. Migration barriers along the river and the migration kinetics (downstream drift and upstream migration) of the organism can deliver important additional information. In this way, ANN and GIS models were combined to simulate respectively the habitat suitability and the migration of *Gammarus pulex*. A monitoring campaign was set up, selecting a part of the Zwalm river basin: the Dorenbosbeek, the Verrebeek and the upstream part of the Zwalm river itself. To know the possibility for migration a resistance model was constructed for *Gammarus pulex*, using ecological expert knowledge and information found in literature. This resistance model includes the migration resistance for upstream (migration) and downstream (drift) movement through the water column. Migration over land and through the air were not relevant here. The resistance is determined for each river stretch of 50 meter. The migration resistance depends on the activity of *Gammarus pulex*, the period of activity (Gammaridae in general are most active during the summer months, probably because of increased sexual activity), the abundance of occurrence and the habitat suitability along the migration paths (stream velocity, dissolved oxygen, pH are important variables). If the minimum migration resistance from one point to another and the distance between both is calculated, it is known which is the most easy way to migrate from one point to another and the migration time can be calculated. Finally, ANN models are used to predict the habitat suitability for *Gammarus pulex* after several restoration options. The migration models are applied to calculate the migration time to the restored parts of the river. In this way, decision makers have an idea whether and when a selected restoration option has the desired effect.

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