FUTURE TRENDS IN FRESHWATER RESEARCH AND MANAGEMENT

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The past

Rigler (1975) describes the chronological development of limnological research, predominantly based on holistic lake studies (Fig. 1). Each of five main schools of holists still persists.

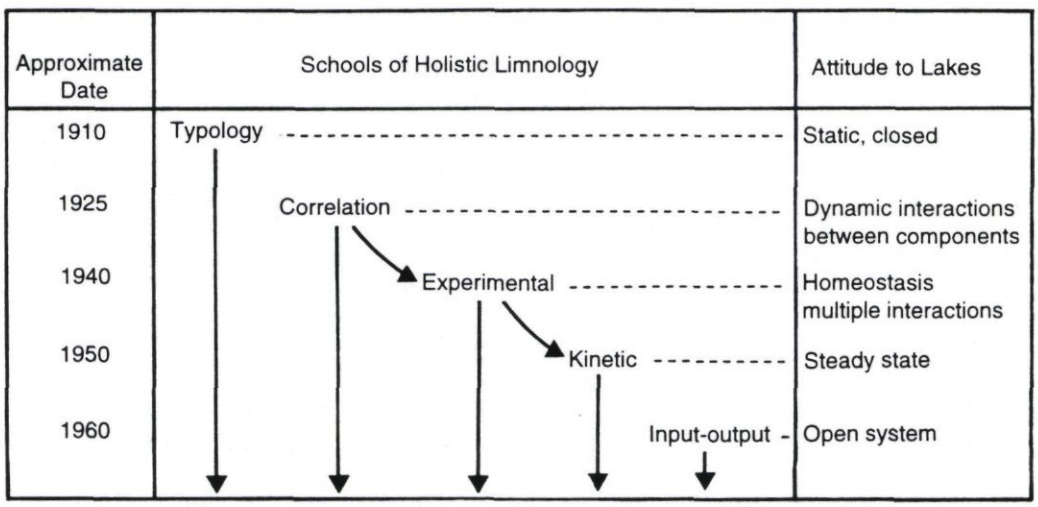

Figure 1. Diagrammatic representation of the sequential appearance of the various schools of holistic, production-orientated limnology. The influence of these schools on the attitude towards lakes is also shown (from Rigler 1975).

Typologists study the properties of the lake that tend to be relatively constant or properties at a point in time. The second school includes the correlations between variables in one lake over time.
Experimental studies are performed by altering one variable artificially. Kinetic thinking implies the complex and permanent exchange of nutrients (especially phosphorus) between many compartments in lakes.
His endpoint in 1960 relates to the open character of lakes with input and output of nutrients. Verdonschot (1987) continued this figure with dynamic, predictive typological research. This is the way, the department of Aquatic Ecology of IBN-DLO is working nowadays with respect to freshwater ecosystems.
In The Netherlands, a comparable development like Figure 1 can be observed, albeit that university chairs and research institutes on freshwater ecology only were established after World War 2 (Dresscher 1978). Since 1957, a small but influential group of hydrobiologists formed part of our Institute (nowadays IBN-DLO). This group concentrated on inland waters and their role in nature conservation. From the beginning, emphasis was laid on the structural aspects of waterbodies. Other institutes and university

groups became active in the same period and they partly concentrated on functional aspects and extensive, multidisciplinary lake research.
Some highlights in the 40-years history of the Hydrobiology Department (now the freshwater section of the Department of Aquatic Ecology) are the watertype investigation of the Sixties (now serving as references), the gradient research of the Seventies (adding to fundamental theory), the experimental research in model ecosystems during the period 1970 till now (with additions to fundamental theory), the water quality assessment methods of the Seventies and Eighties, the acidification research of the Eighties and the ecological typology of the Eighties and Nineties. There has been a gradual change from predominantly microphytes/hydrochemistry oriented to macroinvertebrates/hydrophysics oriented research.

The present

Internationally, but also nationally, some trends can be recognized that give reason to serious concern.

1. There is no more interest for traditional (aquatic) ecology at universities.
2. There is no more interest for taxonomy, which is the basis for ecology.
3. Fundamental research is a dirty word. There is less and less money available and money for (applied) research has to be funded by interested groups in society and industry.

At the same time, there is a need for the traditional knowledge.
How is biodiversity treated without taxonomic knowledge?
How is sustainability treated without ecological knowledge?
How can innovative concepts be developed when contract-research asks for immediate answers on practical questions?

Some important developments in The Netherlands must be mentioned.
In 1990, the Nature Policy Plan (Natuurbeleidsplan) was the first offensive act in the history of nature management. Important elements are Nature Development (instead of Nature conservation and Nature management) and the Ecological Main Structure (EMS). It is the first time that the government gives such far-stretching indications about new nature and development of a system of connected natural areas; at the same time it provides the financial means to realise these plans (at least partially). The skeleton of the Ecological Main Structure is composed of numerous waterbodies like streams, rivers, and lakes. The area outside the EMS consists of the part of The Netherlands that is considered less valuable from the standpoint of natural values. Nevertheless, this so-called white area contains 400,000 km of ditches and many other longitudinal waterbodies with important functions for connection.
The Third Act on Water Management describes an integral management of waterbodies, including the water bottom and the shores. The desired water quality is expressed in chemical, toxicological, and biological terms.
Water authorities need ecological knowledge about their waters: what is a good quality or a reference, which measures lead to a better quality and how can this be monitored and evaluated.

Some figures

Freshwater comprises more than 2500 km2 or 8% of the Dutch territory. Many of these waters have a high natural value, not only because of a diverse community in the water, but also for birds and other animals. There are also many brackish waters with comparable value. The diversity of water types is much greater than in the surrounding countries.
A considerable part of the Dutch flora and fauna is confined to surface waters: 63 fish species, 14 species of amphibians, about 3300 species of macroinvertebrates and 1750 microinvertebrates, about 75 species of aquatic plants, 954 diatom species and 3650 other algae.
Good management of this rich variety requires scientific research.

International trends for the future

The lack of interest for taxonomy and ecology has been recognized. However, there is no reward in the form of, for example, funding by the European Union for proposals to bring together the existing knowledge into a computerized system of ecological taxonomy. In a few years, this will be impossible, because the people with necessary knowledge will have passed away.

In running water ecology, there are several trends to be mentioned.
1. There is a strong tendency to relate ecology to hydrology and hydraulics. The linking of hydrological data to biological data from riverine systems, which is one of the proposed projects, has not yet resulted in an international program, although in several countries, this work has been initiated already by individual scientists. Nevertheless, this is one of absolutely necessary programs, that have to be executed while data are available now. Such a programme links the data of hydrolologists, aquatic ecologists, and fish-ecologists, which should provide a massive tool for the management of rivers in future.
2. At habitat level, the interest in the description and modelling of hydraulic circumstances for the survival of fish species tends to be extended to other organisms as well. Existing models such as PHabsim and Habitat Suitability Indices are being revised, but also totally new methods are being introduced to study species-environment relationships such as co-inertia analysis (Dolédec & Chessel 1994) and Patch Dynamics approach (Pringle et al. 1988).
3. The restoration of streams and even total catchments is in full preparation. An example of such a project is the restoration of the Danube river (estimated total costs about 200 billion USD). The European Union shall start the improvement of the ecological quality of surface waters in 1999, for which a yearly budget of 43 billion USD is foreseen (Statzner et al. 1996). The role of aquatic ecologists, that ought to be dominating, is, however, not in all cases sufficiently guaranteed.

Trends for Dutch freshwater research

In the light of the mentioned acts, the following types of research are needed:
- ecological description of the status of surface waters,

- ecological description of the reference status and/or the desired status,
- development of methods to monitor and evaluate the process of change from present status to desired status,
- development of methods and models that relate management measures to ecological changes,
- selection of target species and target communities.

Nature development
This type of research is necessary for three groups in society:
- policy makers who must decide about ecological standards,
- managers of nature reserves and other parts of landscape,
- managers of waters, responsible for the water quality which is expressed in chemical, toxicological, and biological terms.

The goals of the freshwater section research are to enlarge the knowledge of ecological relations in (regional) surface waters on behalf of integrated water management, nature development, and nature management.
Knowledge of relationships between abiotic environmental factors and biocommunities offers the possibilities and instruments to optimize ecological functions in conditions that are influenced by human activities.

An example of such an instrument is a recently developed expert system, containing a network of so-called cenotypes (abiotic and biotic description of certain waters or habitats). The cenotypes are connected by management measures. A given list of macroinvertebrates can be inserted in the system and finds its way somewhere in the network. From that position, one can read which management measures change the conditions in the water type in the direction of another cenotype.
The expert system will be further developed for more water types and measures.
The so-called 5S-approach (Verdonschot 1995) provides the means to analyse relationships in ecosystems according to five complexes of factors: System conditions, Stream hydrology, Structures, Substances, and Species. It is a hierarchical approach that links these terms in time and space (Fig. 2). For the management of streams, this system is elaborated. It is foreseen to apply it in standing waters as well.

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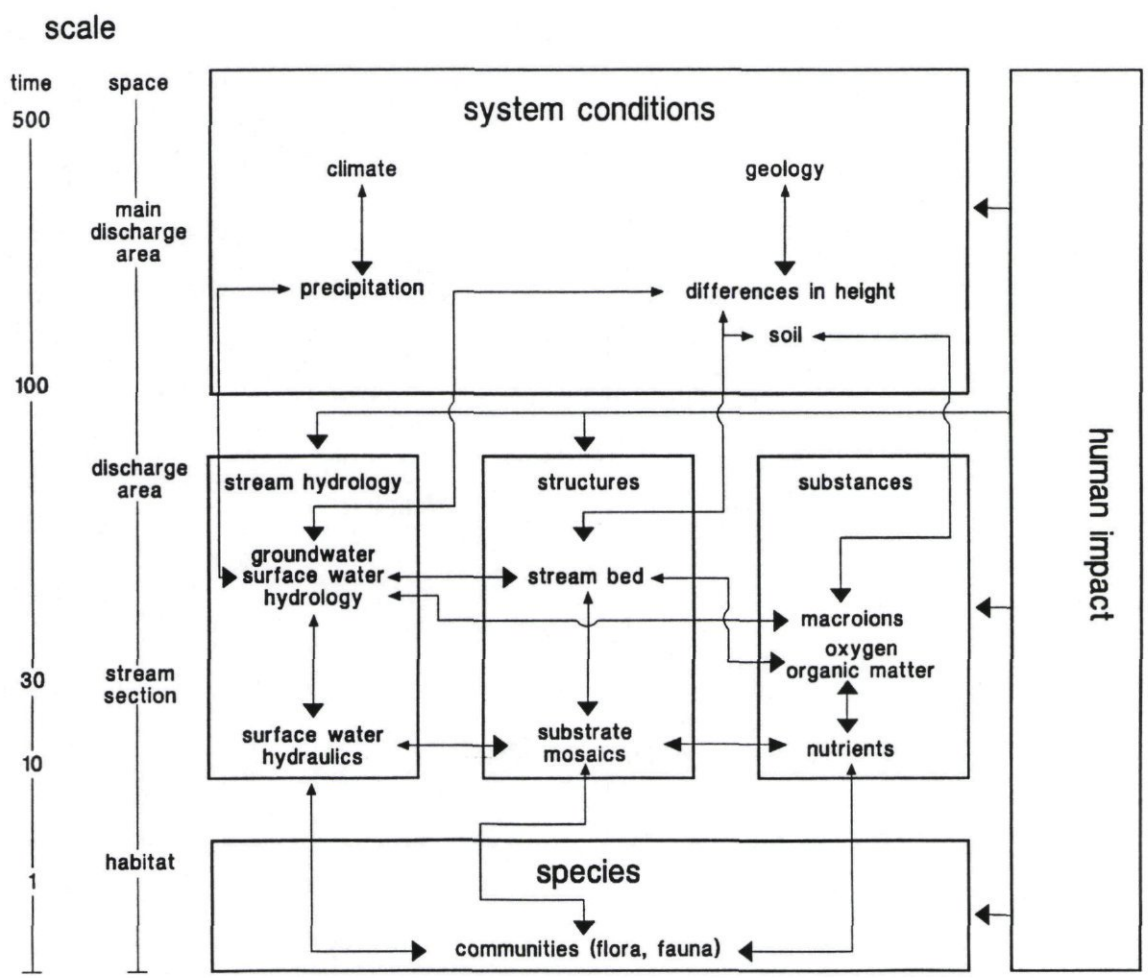

Figure 2. Hierarchical scheme of ecological factors, their relationships and human impact in a stream system; the 5S approach (Verdonschot 1995).