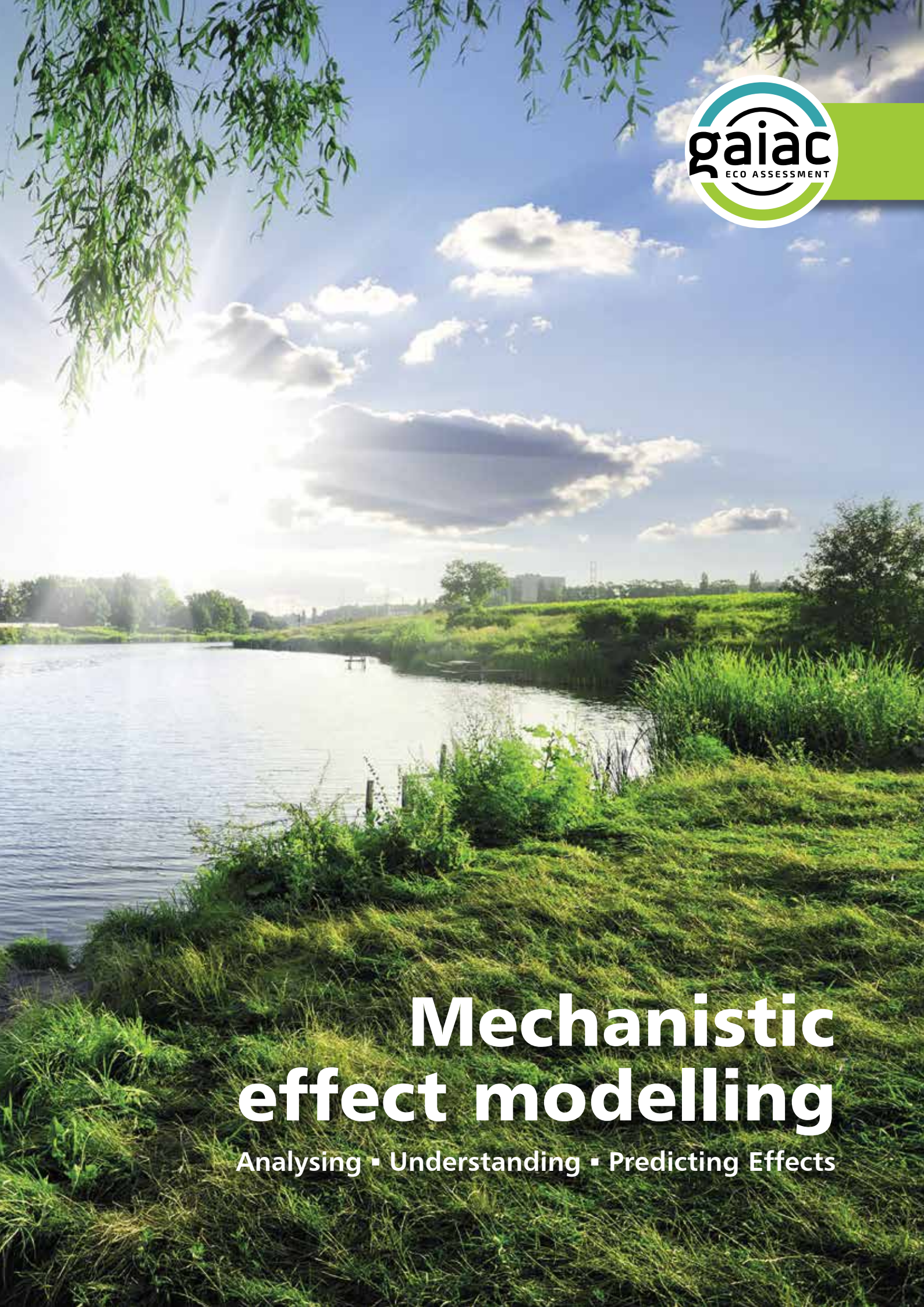


gaiac ECO ASSESSMENT

Mechanistic effect modelling

Analysing ▪ Understanding ▪ Predicting Effects

Mechanistic effect models

gaiac develops solutions for sustainable environmental management and offers expertise in the areas of applied research and risk assessment in ecotoxicology and ecology.

In the field of modelling, we deem it important that…

- data and modelling go hand in hand
- model development is target oriented
- models are tested against independent data

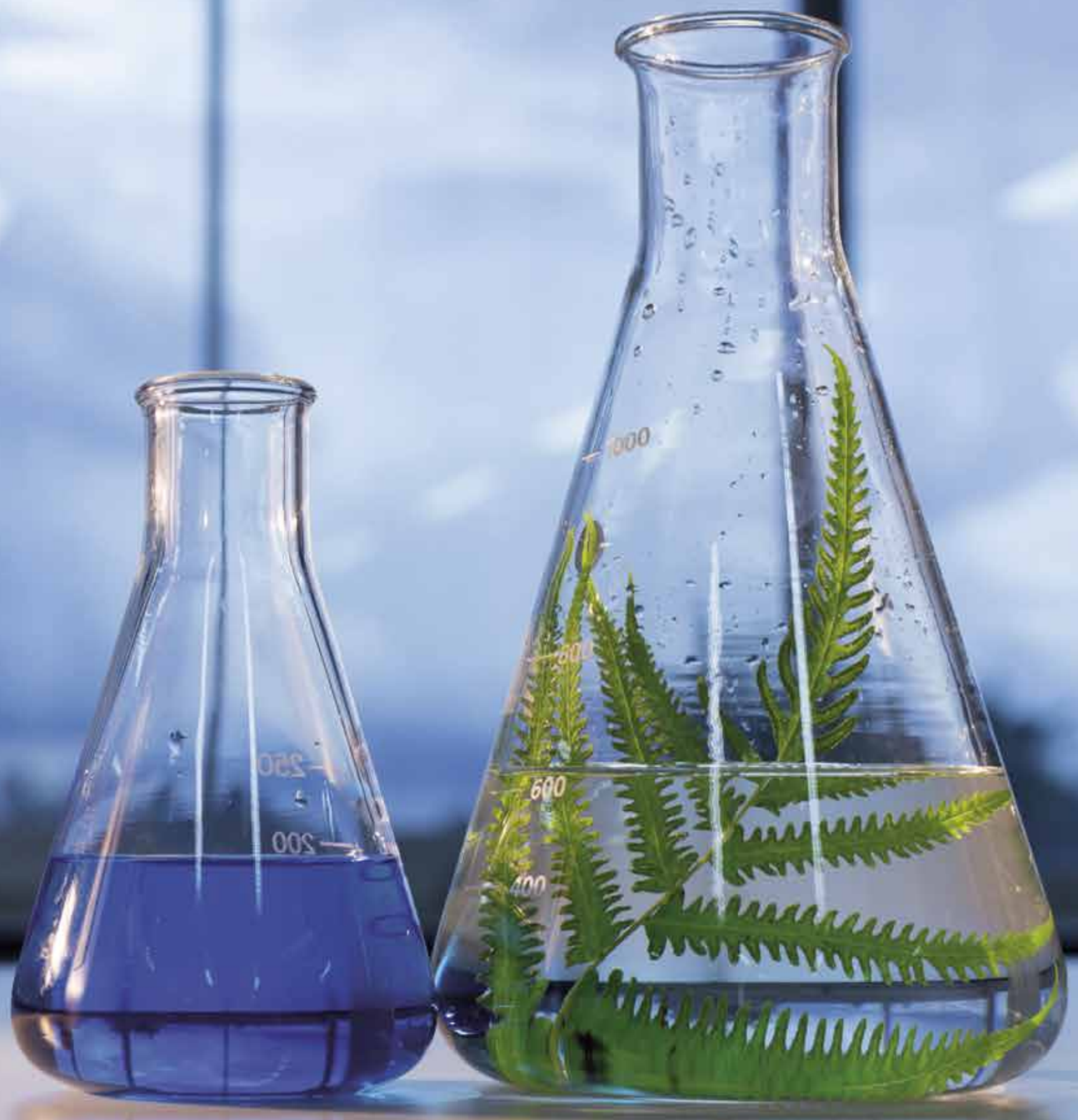
Mechanistic effect models support the risk assessment of chemicals at different levels of biological organization and risk assessment tiers.

Modelling can be particularly helpful when…

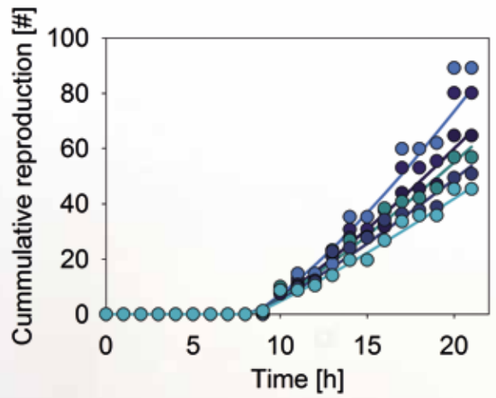
- quantifying effects on specific protection goals
- interpreting higher tier studies
- complementing and jointly interpreting information from different toxicity studies
- reevaluating experimental studies
- facilitating the extrapolation to untested situations

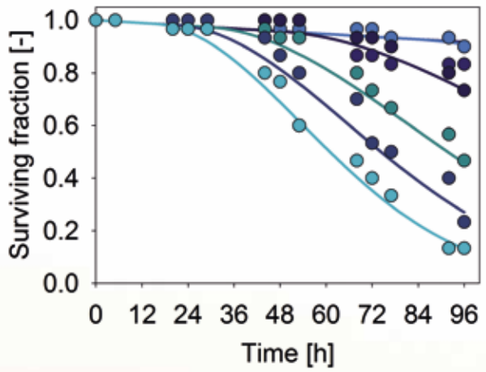
The advantage of mechanistic model applications includes the…

- prediction of long-term effects on population endpoints from acute toxicity studies
- linkage of realistic exposure and effects
- simulation of stressor combinations
- reduction of animal testing



Toxicokinetic-toxicodynamic models





Toxicokinetic-toxicodynamic (TK-TD) models allow for the analysis of ecotoxicological data by taking into account the processes leading to an effect. Toxicokinetics include the processes of uptake and elimination of chemicals. Toxicodynamics link the internal concentration to a lethal or sublethal effect in a quantitative way.

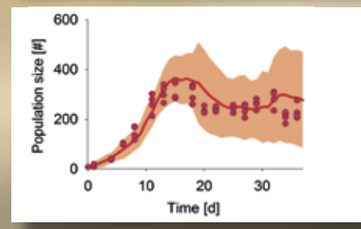
Applications of TK-TD models include the...

- extrapolation of chronic exposure based on results from acute toxicity testing
- prediction of sublethal endpoints and mortality under time variable exposure (e.g. FOCUS scenarios) based on results from standard toxicity testing
- test of the reciprocal principle of exposure and effect to assess whether or not the time weighted average approach is applicable
- analysis of various toxicity study outcomes
- evaluation of delayed effects

Dynamic energy budget (DEB) models offer a coherent way for the interpretation of sublethal effects on life history processes such as growth and reproduction.

The **General unified threshold model of survival (GUTS)** integrates various toxicokinetic-toxicodynamic models into one framework and allows the simulation of survival under predefined assumptions.

Individual based models



Individual based population models (IBMs) allow the straight forward propagation of chemical effects observed at the organism level to responses at higher levels of biological complexity, such as populations and communities.

Individual based models can be used for the…

- prediction of population dynamics under time variable exposures (e.g. FOCUS scenarios) based on results from standard toxicity tests
- evaluation of the recovery potential of populations after pulsed exposure
- analysis of higher tier tests such as mesocosm studies
- simulation of various ecological scenarios (laboratory to field conditions), including resources, climatic conditions or spatial dimensions

In IBMs, individual organisms are considered as unique entities that show certain behaviors, change over their life cycle and thereby differ from each other. Individuals interact with each other and their environment, and, as in reality, modelled population or community dynamics emerge from these interactions.

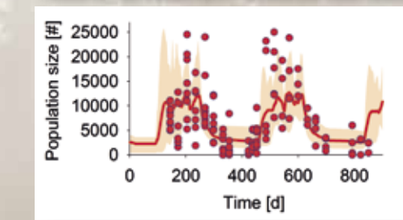
Lakes and ponds

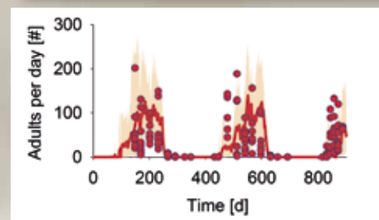
We simulate populations in **standing waters** under field and semi-field conditions for phytoplankton, zooplankton, aquatic insects and other invertebrates.

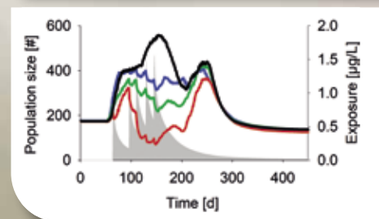
Both simple and complex ecosystem and hydrodynamic models can be added to provide an appropriate environment containing the most important biological and physico-chemical drivers.

Our population and community models…

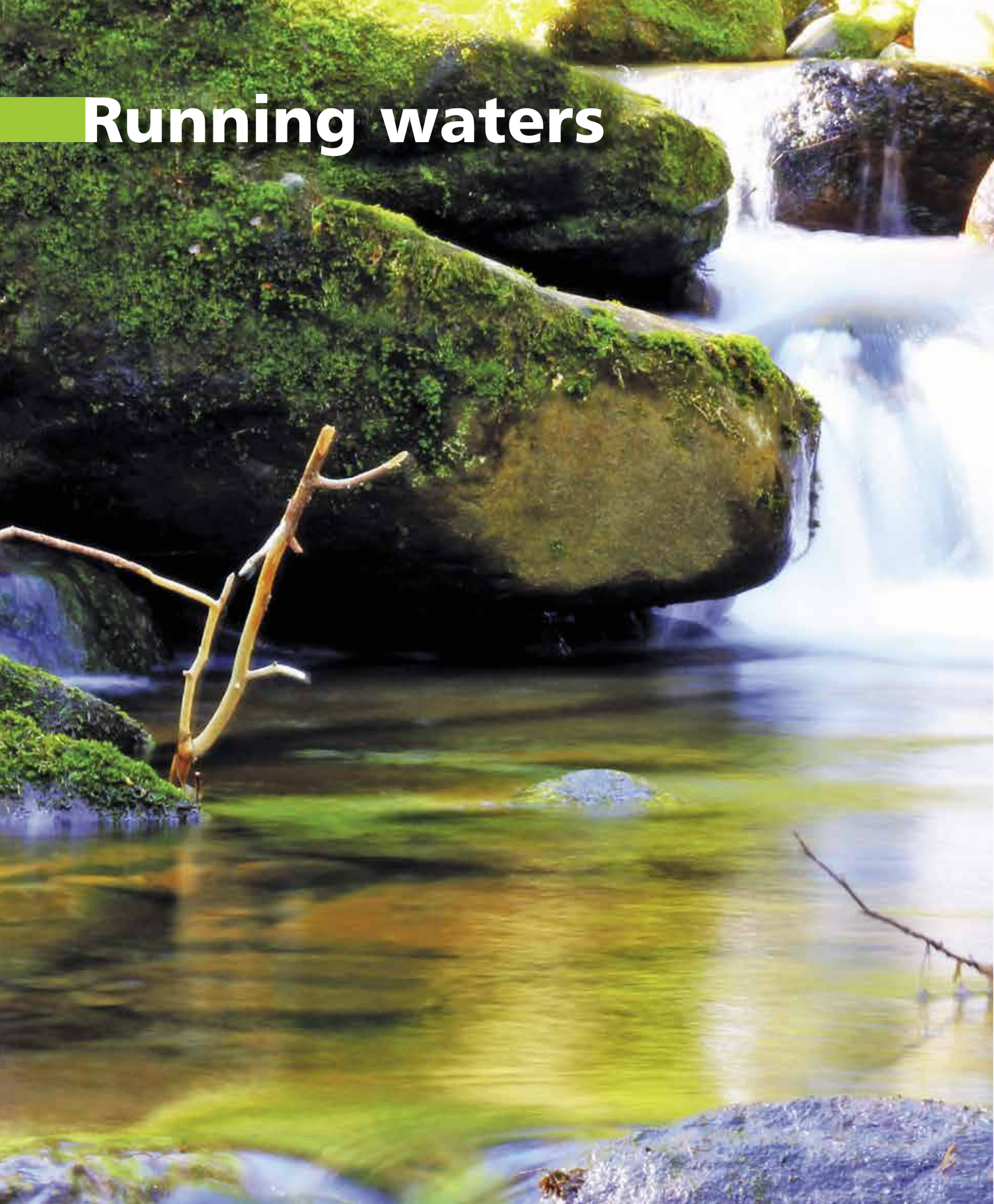
- combine TK-TD and individual-based model approaches to extrapolate population responses under field conditions from laboratory toxicity tests
- are tested based on outdoor mesocosm or field studies
- link complex exposure and species specific ecological scenarios
- allow for quantitative evaluation of direct and indirect effects as well as ecological recovery







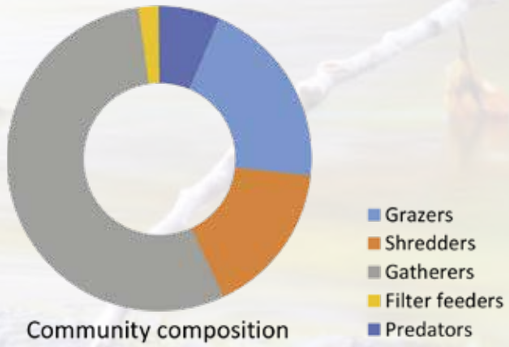
Running waters



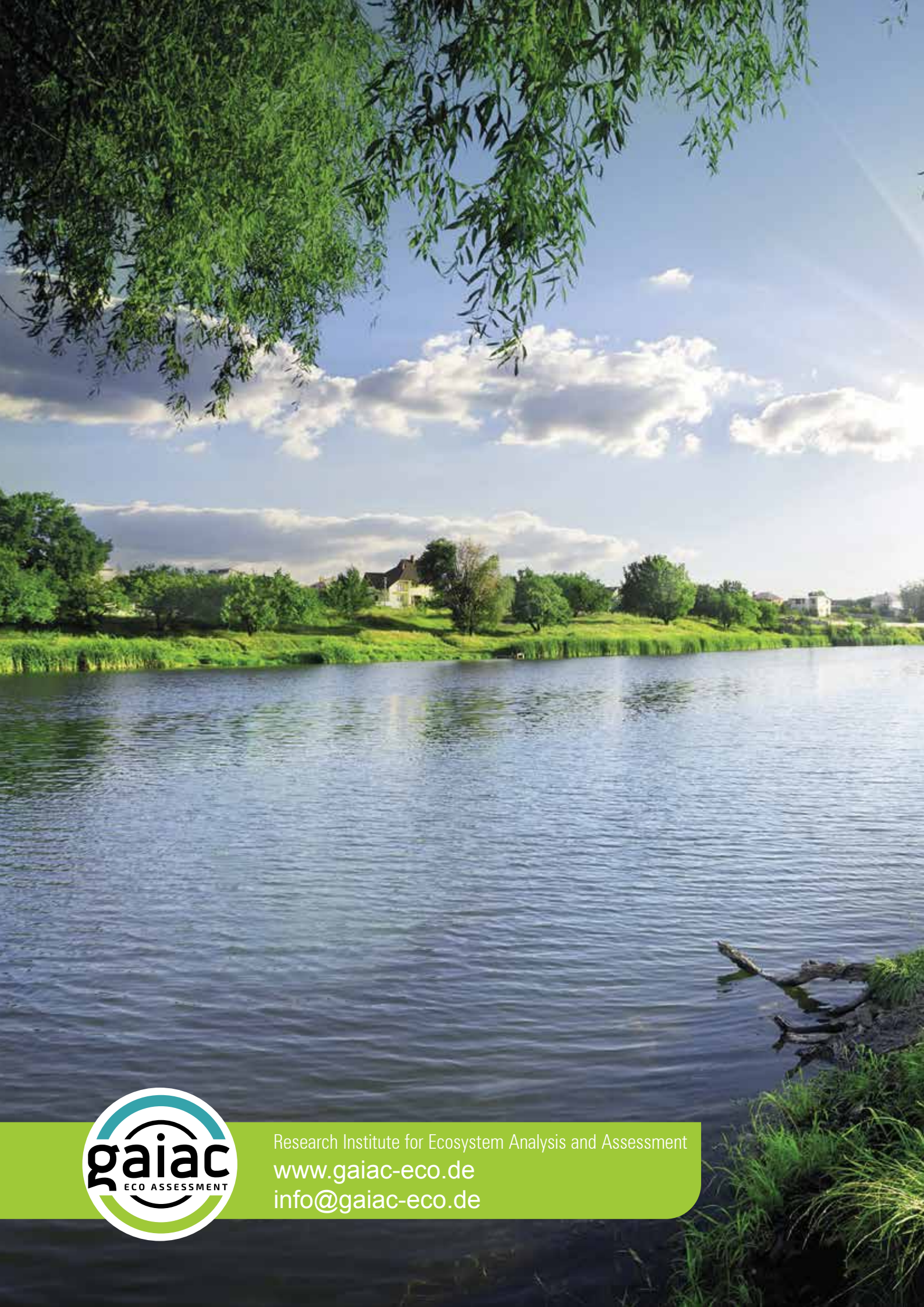
We develop spatially explicit individual-based population and community models for **running waters**.
The aquatic assemblages include focal species from different groups such as mayflies, amphipods, isopods, snails and fish.

The models integrate functional species traits, GIS spatially explicit habitat information and TK-TD modelling approaches to simulate lethal and sublethal community level effects. Life histories of community members are modelled based on dynamic energy budget models. Community dynamics emerge from the interactions of individuals with each other and their environment.

Model outputs such as the functional composition of the assemblage as well as the dynamics of individual populations can be evaluated in a risk assessment context.



Community composition



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