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Probabilistic risk assessment of pesticides under future scenarios: A Bayesian Network approach

Highlights

- We propose a probabilistic causal modelling method - Bayesian network (BN) - to assess environmental risk of pesticides under future scenarios
- BN can integrate different types of information from e.g. climate projections, pesticide exposure models and toxicity testing
- The quantified uncertainty of all component in the BN model are propagated and incorporated in the probabilistic risk calculation

Background

- Climate change (CC) will affect agricultural practice and the use of pesticides. In Northern Europe, increase in precipitation and/ or temperature may cause increase in plant disease and insect pests.
- Additionally, CC can affect the distribution and fate of pesticides in aquatic environments e.g. a higher total load of pesticide run-off may cause higher occurring concentrations (Uleberg & Dalmannsdottir, 2018)
- Probabilistic approaches to risk assessment are recommended to account for uncertainty in pesticide exposure under future scenarios (Carriger & Barron, 2020)

Methodology

Conceptual model

We intend to develop a BN model as a meta-model (Fig. 1), to integrate different types of information in several modules (cf. Moe et al. 2016):

- Climate scenario
- Pesticide properties
- Site & soil variables
- Pesticide use
- Pathway of the pesticide exposure

Information sources for the BN can include climate models, hydrological models and several pesticide models (e.g. WISPE, PRZM and EXAMS; cf. Bolli et al., 2013)

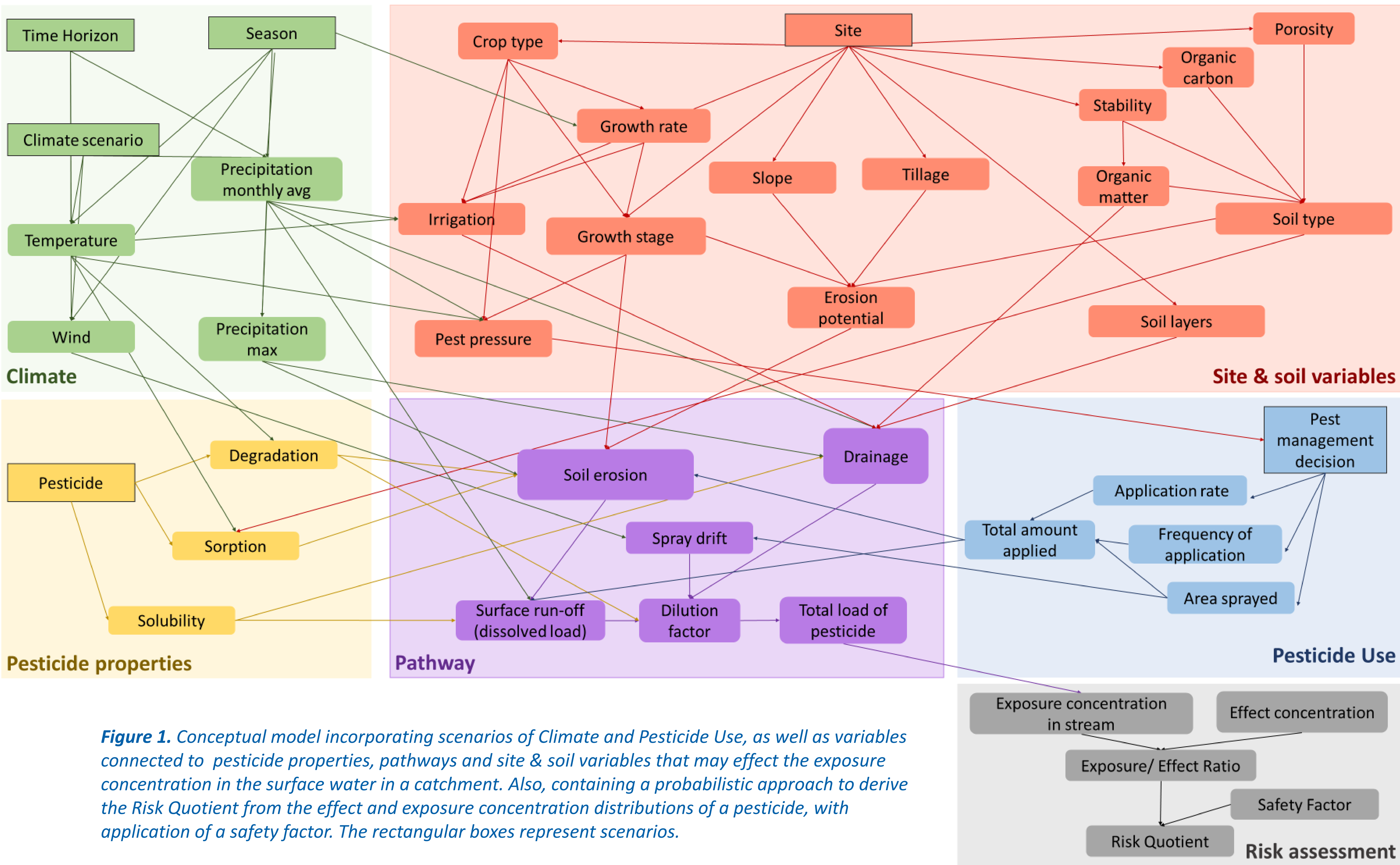
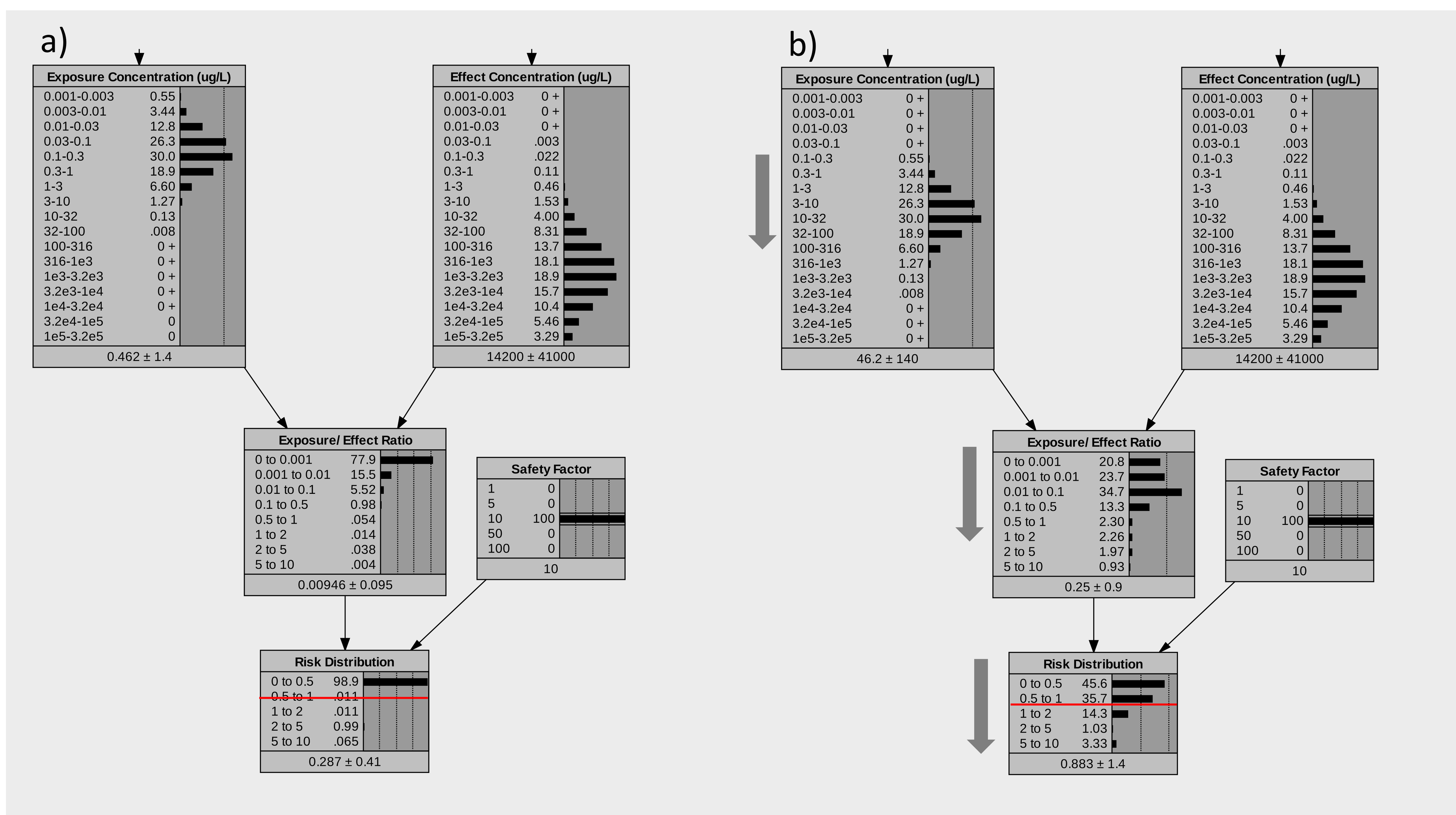


Figure 1. Conceptual model incorporating scenarios of Climate and Pesticide Use, as well as variables connected to pesticide properties, pathways and site & soil variables that may effect the exposure concentration in the surface water in a catchment. Also, containing a probabilistic approach to derive the Risk Quotient from the effect and exposure concentration distributions of a pesticide, with application of a safety factor. The rectangular boxes represent scenarios.

Development of the BN model

- The BN model structure will be a simplified version of the conceptual model (Fig. 1)
- Each node (box) will be defined by a low number of discrete states. For example:
  - **Climate scenario**: RCP4.5, RCP8.5
  - **Time horizon**: 2020; 2050; 2080
  - **Precipitation**: low, medium and high tercile of observed data
- The nodes will be quantified by **probability distributions** (Fig. 2)
- The causal links (arrows) will be quantified by **conditional probability tables** based on data, other models, theory or expert judgement

Figure 2. The Risk Assessment module of the BN with calculated probability distribution of the Risk Quotient (RQ), for the pesticide in a case study from a small agricultural catchment in South-East Norway. The safety factor is set to 10. The red line marks the traditional threshold of RQ > 1 (For more details, see poster 4.06P.1).



Use of the BN model for predicting risk under future scenarios

- The finalized BN model can be run by selecting a set of scenarios (climate scenario, site, pesticide type, pesticide application rate etc.) as evidence
- Given this evidence, probability distributions will be updated throughout the BN
- Fig. 2 illustrates the predicted in-stream Exposure Concentration and Risk Quotient for the pesticide Metribuzin under (a) current conditions and (b) a hypothetical future scenario with increased exposure
- In this example, the probability of the Risk Quotient exceeding 1 increases from 1% to 19%

Future perspectives

Short term:

- The conceptual model will be refined in collaboration with experts on pesticide use and exposure
- The BN model will be trained with data from climate and agricultural models and other available information

Long term:

- The modular nature of the BN enables further extensions such as
  - pesticide mixture and assessment of cumulative risk (see also 2.12P.2)
  - future changes in species sensitivity (see also 7.03PC.1)
- The use of BN models will allow for more refined assessment and targeted management of ecological risks under future scenarios.

References

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