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Using a Bayesian network to assess the population-level risks of endocrine disruptors to brown trout

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Abstract: Much has been learned recently about the biochemical, morphological, and reproductive effects of endocrine disruptors on wildlife, both in the laboratory and in the field. However, relatively little is known about how individual-level effects will impact population persistence. It is possible that the parameter that is the most sensitive indicator of endocrine exposure may not be the most ecologically relevant one. Additionally, to date, much research has focused on directly reproductive attributes such as fecundity or fertility. However, it is possible that more subtle changes induced by endocrine disruptors (e.g., modifications of growth rate or time of maturation) may also have important population-level consequences.

The practical difficulties of performing controlled experiments on entire populations over multiple generations means that the population-level effects of endocrine active substances are unlikely to be revealed through experimentation alone. Further, the dependence of population dynamics on environmental variables other than chemical exposure, such as climate, habitat, and prey availability, implies that any empirical studies will be highly site-specific. Dynamic simulation models represent an alternative means of population assessment. These mathematical representations of a species’ lifecycle can be used to translate effects on the individual to measures of population persistence such as rate of change, extinction risk, or long-term abundance. Models can then be parameterized for different locations using appropriate site-specific habitat and stressor data to assess the susceptibility of a population living under one set of conditions compared with another.

Unfortunately, most natural populations are highly variable, and nearly all predictive models are uncertain. Therefore, it is an open question as to whether any population changes that may be caused by exposure to endocrine disruptors will be distinguishable against the significant noise in model assessments. We addressed this question using a detailed population model developed for brown trout (Salmo trutta) in Switzerland and a set of recent research findings concerning the individual-level effects of endocrine disruptors on this species. Being in the form of a Bayesian network, the model includes rigorous probabilistic representations of natural variability and model uncertainty and is also transparent with regards to causal structure. Elasticity analysis was used to assess the sensitivity of the population to various endocrine disruptor-induced impacts, which were then compared against model prediction intervals.

Keywords: belief networks, causal models, uncertainty, model evaluation, environmental management and decision-making