

Environmental Management Science Program

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Estimation of Potential Population Level Effects of Contaminants on Wildlife

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Research Objective

The objective of this project is to provide DOE with improved methods to assess risks from contaminants to wildlife populations. The current approach for wildlife risk assessment consists of comparison of contaminant exposure estimates for individual animals to literature-derived toxicity test endpoints. These test endpoints are assumed to estimate thresholds for population-level effects. For several reasons, uncertainties associated with this approach are considerable. First, because toxicity data are not available for most potential wildlife endpoint species, extrapolation of toxicity data from test species to the species of interest is required. There is no consensus on the most appropriate extrapolation method. Second, toxicity data are represented as statistical measures (e.g., NOAELs or LOAELs) that provide no information on the nature or magnitude of effects. The level of effect is an artifact of the replication and dosing regime employed, and does not indicate how effects might increase with increasing exposure. Consequently, slight exceedance of a LOAEL is not distinguished from greatly exceeding it. Third, the relationship of toxic effects on individuals to effects on populations is poorly estimated by existing methods. It is assumed that if the exposure of individuals exceeds levels associated with impaired reproduction, then population level effects are likely. Uncertainty associated with this assumption is large because depending on the reproductive strategy of a given species, comparable levels of reproductive impairment may result in dramatically different population-level responses. We are working on several tasks to address these problems: 1) investigation of the validity of the current allometric scaling approach for interspecies extrapolation and development of new scaling models; 2) development of dose-response models for toxicity data presented in the literature; and 3) development of matrix-based population models that, coupled with dose-response models, will allow for realistic estimation of population-level effects for individual responses.

Uncertainties associated with the current approach to wildlife risk assessment may have direct impacts on DOE EM satisfactorily fulfilling its mission in two ways. First, risk estimates may be too conservative and therefore remediation may be recommended when it is not needed. Limited remediation funds may be spent for insignificant or non-existent risks and possibly cause a net increase in environmental damage due to unnecessary habitat destruction. Second, risk estimates may not be adequately protective and therefore remedial actions may not be recommended when they are needed. The consequences of this uncertainty is environmental damage and potential NRDA liability. Either of these alternatives results in inefficient use of limited EM funds. This project will provide the tools to better estimate population-level effects and therefore reduce uncertainty associated with wildlife risk assessments.

Research Progress and Implications

This project is being performed in four, interrelated tasks. Progress on each task is outlined below.

1. Development of a database of avian and mammalian toxicity data. Literature search and data acquisition is ongoing for both acute and chronic data for birds and mammals. We are focusing on 12 contaminants that are being addressed as part of the EPA Ecological Soil Screening Levels for Superfund Sites project. We have obtained access to an extensive wildlife

toxicity database from the Denver Wildlife Research Center. This database has provided acute toxicity data for multiple wildlife species for approximately 200 chemicals. In addition, we are extracting data from the National Institute of Occupational Safety and Health (NIOSH) Registry of Toxic Effects of Chemical Substances (RTECS) database. We have obtained data for approximately 150 chemicals and are using these data to identify and acquire primary sources.

- 2a. Development of Dose-Response models. We conducted a literature search to define modeling approaches currently being applied for human health risk assessment. Based on the results of this search, we adopted a modeling approach that is comparable to that employed by the USEPA for human health risk assessment. A two to four parameter logistic model (number of parameters is determined by the attributes of the dose-response data) is fit to literature-derived toxicity data. The resulting model is then used to define the dose level (and 95% confidence limits) that corresponds with selected effect levels. Example models have been developed for approximately 12 chemicals.
- 2b. Development of improved methods for interspecies toxicity extrapolation. Allometric scaling, one of the available extrapolation methods, is based on the premise that excretion and metabolism of toxic chemicals are a function of an animal's metabolic rate, which varies as a function of body weight^{3/4}. Previous research has indicated that acute mammalian toxicity data scales to body weight^{3/4}, while acute avian toxicity data scales to body weight¹. However, because these relationships were derived based primarily on data from drugs, or carbamate or organophosphate pesticides, their applicability to metals and chlorinated hydrocarbons commonly found at contaminated sites is uncertain. To address this issue, we obtained avian and mammalian acute toxicity data for over 200 chemicals for which multiple species had been tested. Mean body weight data for all test species were obtained from the published sources. Lethal dose per animal (LD50 x mean body weight) was calculated for each chemical and test species. Linear regression models of log-transformed lethal dose per animal on log-transformed body weight were developed for each chemical. Body weight scaling factors (e.g., regression slopes) were found to vary widely across chemicals for both birds and mammals. In general, preliminary analyses suggest that the body weight^{3/4} scaling factor may not be appropriate for extrapolation of acute mammalian toxicity data. Whereas the body weight¹ scaling factor may be suitable for acute avian toxicity data. However, due to the wide variability of scaling factors among chemicals, use of chemical-specific scaling may be more appropriate than one general scaling factor.
3. Development of population models for wildlife endpoint species of interest. No progress to report at this time
4. Integration of dose-response, interspecies extrapolation, and population models to provide estimates of population responses associated with varying exposures experienced by wildlife species. No progress to report

Planned Activities

- 1) The US EPA, in cooperation with the Department of Defense, Department of Energy, state agencies, and industry, has initiated an effort to develop ecological contaminant screening levels for soils at Superfund sites. Brad Sample has been invited to be a member of the working group for the development of toxicity reference values as part of this effort. Methods for interspecies extrapolation and dose response modeling developed as part of this project are directly applicable to the joint EPA, DOE, DoD effort.
- 2) Two abstracts based on an overview of project and interspecies extrapolation have been submitted for the November 1998 SETAC meeting.
- 3) We have been invited to present our population modeling research at a USGS sponsored symposium on effects of contaminants on wildlife populations in October 1998. A manuscript of the talk will be published in a peer-reviewed proceedings of the symposium.
- 4) Draft manuscripts on preliminary interspecies scaling analyses and dose-response modeling are expected to be completed by end of FY 1998.