Editorial

Integration of Human Health and Ecological Risk Assessment

Health risk assessments and ecological risk assessments of contaminated environments are typically conducted by different groups working largely independently. This results in inefficiencies and, more importantly, in assessments that are less defensible than would otherwise be possible. I would like to argue for integration of health and ecological risk assessment by presenting some of the issues that have arisen at their interface.

Although most health risk assessors do not perceive ecological risks to be relevant to their analyses, the public often makes the connection. As a result, health risk assessors may be caught off guard in public meetings when the public asks how health risks can be described as insignificant when the fish have tumors and lesions or fish-eating birds are estimated to have significant reproductive decrements. Interactions with the ecological risk assessors would prepare them for this response. In many cases, there is no actual contradiction because, for a variety of reasons, nonhuman organisms are much more exposed or more sensitive than humans (*1*). In other cases, the ecological risk assessment may point to health issues that have not be adequately considered.

Conceptual models are representations of the means by which effects may be imposed on an endpoint due to the operation of a source. For health risk assessments, conceptual models include pathways of human exposure to released contaminants. Ecological conceptual models include analogous exposures as well as routes of exposure that are not appropriate to humans, such as respiring water, and indirect effects such as loss of food resources or habitat structure. Joint development of these models might lead to a more complete understanding of processes that occur at a site. In addition, it would ensure that the differences between the models are well understood and justified. For example, dermal exposure is a potentially important route for humans, but the equivalent route for wildlife is preening of the plumage or grooming of the fur, resulting in an oral exposure.

Because of their training and inclination, ecological risk assessors are typically more site focused than health risk assessors and they are less trusting of standard models and default parameters. For example, it is not uncommon for ecological risk assessors to measure uptake of contaminants at a site by plants or other components of the food web, while health risk assessors use default uptake factors that differ by orders of magnitude from the site-specific values. As requirements for the use of standard health risk models and assumptions are relaxed, health risk assessors may find that ecological assessors have relevant data and models to offer.

The spatial and temporal scales of risks are important issues in ecological risk assessments that are neglected in health risk assessments. While health risk assessors tend to focus on the maximally exposed individual at a designated exposure point, ecological risk assessors must consider the distributions of exposures of individuals relative to the ranges and dynamics of populations or communities. While individual highly exposed humans must remain a focus of assessment, greater consideration of the scales of health risks can only enhance the bases for risk management. In any case, the apparent discrepancy between point health risks and spatial ecological risks inhibits comparison and balancing of the two types of risks.

Some issues that present problems of theory for health risk assessors are treated empirically by ecological risk assessors. For example, health risk assessors routinely treat the effects of multiple contaminants as additive. This leaves them open to attacks by the public and environmentalists for not considering synergisms and by responsible parties for not considering antagonisms or other less-than-additive interactions. Ecological risk assessors often use *in situ* toxicity tests, laboratory tests of contaminated media, or biological survey techniques that allow the organisms to integrate the toxic effects and report the results. To the extent that the mechanisms of action are common among human and nonhuman species, the results of these studies can provide an indication of the reasonableness of the additivity assumption.

In many cases, sampling and analyses are performed separately to meet the differing needs of health and ecological risk assessment. For example, humans are assumed to consume fish fillets while wildlife consume whole fish. An efficient assessment program would analyze the carcasses of at least some of the filleted fish to supplement the data available for ecological risk assessment (*2*). Similarly, humans are assumed to consume unfiltered water while aquatic biota are assumed to be exposed to dissolved, not particulate-phase, metals (*3*). Although it may be important to protect the individual who gets his water by dipping a bucket in the river, health risk assessors might use the filtered water concentrations obtained for the ecological risk assessment to also provide an estimate of risks to those who drink processed water.

Since the late 1970s, ecological assessments of contaminants have typically been iterative (*4*). They begin with screening assessments that are based on existing or readily obtained data, simple models, and conservative assumptions or safety factors. These screening assessments are used to focus subsequent testing, measurement, and assessment efforts on the most significant hazards. Later tiers are more realistic and site specific. Health risk assessments are less often iterated, and even when they are, they tend to begin and end with the same prescribed conservative models and assumptions. Risk assessment would benefit from parallel tiered structures of increasingly realistic health and ecological risks.

While health risk assessors are beginning to adopt a weight-of-evidence approach, ecological risk assessors have used this approach to risk characterization from the beginning. This is because ecological risk assessments must typically deal with multiple and diverse lines of evidence including biological surveys, analyses of body burdens and biomarkers, and toxicity tests of contaminated media, as well as conventional single chemical toxicology. This has led to the development of various approaches to weighing evidence including rule-based systems, scoring systems, and epidemiological inference (*1,5–7*) Common approaches for weighing evidence and presenting results should be developed.

Although remedial actions result in risks to humans, these risks are seldom acknowledged. In contrast, consideration of the ecological risks from remediation is unavoidable. When we remove trees and soil to deposit them in a landfill, dredge sediments, or dewater a small stream by pumping groundwater, we kill organisms and destroy an ecosystem for some time. These remedial risks must be balanced against the risks to the ecosystem components that are susceptible to the contaminants and against the often hypothetical health risks (*8*). Inclusion of risks to workers and the public

from the remedial action would make the risk balancing more complete. If the risk management process is to be based on balancing of risks, benefits, and costs, all risks and benefits need to be included.

Communication of risks to risk managers and stakeholders is a difficult process that is made more difficult by separate communication of health and ecological risks. Even when there are no apparent conflicts in the health and ecological risk assessment results, the different modes and styles of presentation typically employed by health and ecological risk assessors are often a barrier to understanding the whole situation. One result is that decision makers tend to focus on the most compelling risk, effectively setting other risks aside. In order to obtain decisions that are best for the environment as a whole, health and ecological risk assessors should work to integrate their results and communicate them in a coherent manner.

Some efforts are already under way to develop an integrated approach to health and ecological risk assessment (*9*). In addition, pressures on the health assessment community are tending to make health and ecological assessments more similar (*10*). However, there are currently no mandates for integrated assessment from regulatory agencies or from the professional societies that define best professional practice. In the absence of such mandates, health and ecological risk assessors should make an effort to better understand each other's practices and to coordinate and integrate their assessments.

Glenn W. Suter, II
Oak Ridge National Laboratory
Oak Ridge, Tennessee

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