Book Review

Risks and Decisions for Conservation and Environmental Management

Mark Burgman, Cambridge University Press, 2005. ISBN 0-521-83534-8 (hardback, $120.00), 0-521-54301-0 (paperback, $60.00) and 0-511-08126-X (ebook, $48.00)

Environmental risk analysis is a truly multidisciplinary subject, but most of us only have training and specialized competence within one of the traditional disciplines of science, social science or the humanities. It is therefore challenging to write a textbook on the subject with the aim to cover all aspects, and with an intention to "create a professional standard for 'honest and complete' environmental risk assessments." Mark Burgman, the author of *Risks and Decisions for Conservation and Environmental Management*, is however not "risk adverse" and this is not his first book on environmental risk assessment either (Burgman *et al*., 1993).

Honest risk assessments are defined in the preface as "those that are faithful to assumptions about the kinds of uncertainties embedded in an assessment, that carry these uncertainties through chains of calculations and judgments, and that represent and communicate them reliably and transparently." With these clear programmatic statements the reader is guided through the book. The first part covers philosophical, psychological and social aspects of risk assessment. In a second part, the tools of the trade are introduced, and in the last part the assessment work is linked to the other steps of the risk analysis process (communication and management).

The book (488 pages) is organized in twelve chapters in what seems to be a well-thought structure. All concepts are illustrated with examples, both from environmental risk assessments and from risk analyses in other fields of society. Each chapter is closed with a discussion summing up what the author regards as the important lessons learned and his specific recommendations to achieve better environmental risk assessments. The book is well written and easy to read. The numerical examples are carefully explained, but the text still assumes some familiarity with probability and statistics concepts. A first year university course in statistics is therefore highly recommended.

The first chapter (25 pages) starts out with a general discussion of risk assessment fundamentals and risk perception. Failure to communicate uncertainty is one topic and different lists of endanger species is an illustrative example of the lamp-post effect, i.e. scientists are biased towards their own field of interest. The frequentist and Bayesian approaches to probability are also introduced together with coverage of reasoning around the probability concept in risk assessments. The second half of this twenty-five page chapter covers risk perception and "the pathology of risk perception." The author describes what he call "psychological disabilities" and states that "in general, people are poor judges of risk." In my view this seems to be a slight understatement of the abilities of a species that has survived for a million years.

The second chapter goes to the very heart of risk assessment; uncertainty. Many of us are familiar with the concepts of variability (natural variation) and various forms of uncertainty in probabilistic modeling, but it is perhaps more seldom that we deal with linguistic uncertainty. This short chapter (16 pages) sums up the important aspects of both epistemic and linguistic uncertainty and provides several interesting examples from the environmental arena. Risk management is described as a cyclic process in

the equally short third chapter (20 pages). Risk assessment in other disciplines is briefly touched upon and the author also gives credit to the subjective and context dependent aspects of risks.

Expert judgment is a vital component in many if not most environmental risk assessments. Chapter four outlines in sixty-five pages the various options for using expert judgments in risk assessments. The issues of overconfidence and bias among experts are given thorough consideration. Many methods to aggregate expert opinions and seek consensus are also discussed, and in the final remarks to this chapter the author notes that "expert opinions have become widespread and accepted as scientific support tools in conservation and environmental management." One could challenge this method, both for being outside the domain of applicability for science and for not being inclusive enough. I will return to the question of stakeholder involvement reviewing chapter twelve below.

In chapter five (20 pages), the author goes more deeply into the technical methods of risk assessment. First conceptual models and influence diagrams are introduced, and then the various tools for hazard identification. Here general methods (checklists, brainstorming, and risk matrices) are touched upon, as well as tools more familiar to engineering such as HAZOP (hazard and operability analysis) and FMEA (failure modes and effects analysis). The method introduction continues in chapter six (24 pages) with risk ranking. This popular form of risk assessment is first described, followed by a critical discussion on weaknesses and performance, wrapping up with three examples (one from ecological risk assessment).

Ecotoxicology, and also human toxicology, is covered in chapter seven (38 pages). Dose-response relationships are an obvious opening to these subjects and are followed by a disentangling of NOEL (no observed effect level), NOAEL (no observed adverse effect level) and related statistics. Safe doses, reference doses and benchmark doses are briefly described in another section. Different forms of extrapolation are dealt with, e.g. to low doses and from SARs (structure activity relationships) and among species (illustrated by an example). Transport, fate and exposure are also outlined. Finally, this chapter evaluates several studies with regard to the treatment of uncertainty.

Chapter eight (35 pages) describes event trees, fault trees and the interface between logic trees and decisions. These are another set of methods with a long history in engineering, but where applications are now emerging in toxicology and ecology. The correspondence between decision trees, decision tables and expert systems is explored, together with examples from modeling with CART (classification and regression trees) and Bayesian networks. The author also observes that the structural uncertainty – in choosing logic tree representation – seldom is reported.

Interval arithmetic and its applications in risk analysis are presented in chapter nine (22 pages). The short text gives both a motivation and full description of this simple method to carry uncertainty through risk calculations. The calculations are shown with various examples and also linked to the previous presentation of logic trees. Chapter ten (54 pages) provides the probabilistic extension with an introduction to Monte Carlo analysis. The modeling process is first summarized; followed by a brief presentation of some often used statistical distributions and a discussion of the selection criteria. Dependencies, two-dimensional simulations and sensitivity analyses are covered next, before six examples of use in environmental risk assessments. In addition, the author critically evaluates limitations and strengths of Monte Carlo

analysis. Probability bounds analysis ('p-bounds') is given a short description as an intermediated bounding method, between Monte Carlo and interval arithmetic. In the summing up discussion to this chapter it is observed that managers and policy-makers may despair when confronted with the wide range of potential risks. However, the author holds the firm position that a representation of the full range of possible outcomes is a strength, rather than a weakness and reason for criticism.

Chapter eleven (52 pages) focus on the testing of hypotheses and the power of statistical tests. Statistical control charts, familiar from quality engineering, are here presented as a tool for environmental monitoring. Receiver operating characteristic curves are also treated in this chapter as a tool to assess the effectiveness of repeated binary decisions by simultaneous consideration of type I and type II errors.

The theme for the last chapter, twelve (53 pages), is decisions and risk management. Here the author aims to illustrate how risk management can make use of results and insights from risk assessments. It begins with a section on policy and risk, highlighting issues such as comparative risk, perceived risks and acceptable risks. The next section on strategic decisions exemplifies different criteria, risk regulation and how model-based assessments can fit in. "The advantages of deciding under uncertainty" is the heading for a subsection that I believe is important for the message of the whole book; namely that replacing point estimates with probabilistic or bound estimates provide a new spectrum of decision possibilities and the opportunity to achieve a better outcome. Stochastic analyses, info-gap theory and multi-criteria decision analysis are dealt with in other sections. Risk communication and stakeholder involvement is discussed in the last eleven pages, and the author conclude that "risk communication and management work best when those affected by the risks are involved closely and continuously in the risk assessment process." Several examples are given on stakeholder involvement outside of the domains of nonexpert stakeholders, and consensus building in joint panels could perhaps get better legitimacy than the previously criticized expert panels (see chapter 4 above).

A glossary (33 pages) is provided at the end of the book with explanations of concepts and acronyms. It is followed by an extensive reference list (27 pages), with many of the key papers and textbooks of risk analysis included. The index is however only 3½ pages and could have been more detailed, to facilitate searching and usage of the volume.

In many other textbooks with a similar ambition it is common to have contributions from a whole team of experts. The benefit of such an approach is obviously that all parts can be covered by a specialized expert, but the drawback is that integration will be looser, style and approach will often vary and it may be difficult to see the main theme. There is no risk of that in this book. The main theme, to carry uncertainties through the chains of calculations and judgments, is present in every chapter and section of the book.

How is then the coverage of the current practices of risk assessment? I do not find much that is missing. Certain subjects could have had more in-depth coverage, e.g. structure-activity relationships and transport of environmental pollutants. However, I have to admit bias towards my own research interests here and I would expect similar comments on other parts from another reader. Instead, I like to emphasize the good balance with coverage of methods and examples from risk analyses of environment, human health and industrial operations.

I want to give credit to the author for a very honest and open attitude towards the reader. Risk assessments are value-laden and so is the choice of approach and methods. It is therefore very refreshing that this author clearly positions himself and spells out his own beliefs and attitudes. It is also very beneficial that most methods and approaches are discussed critically, showing both strengths and weaknesses. This ensures that we as risk analysts can make more informed decisions when selecting our tools.

Risks and Decisions for Conservation and Environmental Management has a good coverage of most aspects of environmental risk assessment, but the reader must of course consult more specialized literature to get a deeper understanding of specific methods. It is then very helpful that the reference list is extensive and near complete. I have already used it myself to locate more information on methods new to me. My impression is that this textbook can be very useful to anyone interested in environmental risk assessment. It explains the basics to the newcomer, while the experienced risk analyst is likely to get a new perspective on the methods used.

This book could also be used for teaching state of the art environmental risk assessment at both the graduate and the undergraduate level. The book would probably be ideal for a short-course to give students in environmental science an introduction to risk analytical methods, but it can also be part of the readings for a more extensive course in environmental risk analysis. There is only one item missing to make this book suitable for teaching or self-study and that is the lack of questions and exercises. However, a perfect companion is available in the problem-oriented text *Should we risk it?* (Kammen & Hassenzahl, 1999).

Overall, *Risks and Decisions for Conservation and Environmental Management* is a solid text and in my opinion one of the best textbooks available on environmental risk assessment. It probably has no rival in the coverage of all kinds of uncertainties embedded in an assessment and the methods to carry these uncertainties through in all the steps of a risk analysis. I can therefore recommend this book wholeheartedly, to risk analysis professionals and experienced policy-makers as well as to new students of the subject.

— Tomas Öberg

University of Kalmar

1. Burgman, M. A., Ferson, S., & Akçakaya, H. R. (1993). *Risk assessment in conservation biology.* New York: Chapman & Hall.
2. Kammen, D. M., & Hassenzahl, D. M. (1999). *Should we risk it? Exploring environmental, health, and technological problem solving.* Princeton, NJ: Princeton University Press.

Manuscript of article published in Risk Analysis 25, 25, 1685-1687.

[DOI: 10.1111/j.1539-6924.2005.00700.x]