4 What is Risk?

Chapter Index

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Introduction (Index)

Public consultations in resource management are driven by differing perceptions of risk, but three related concepts are often confused: risk, probability, and uncertainty. This handout presents a useful definition of risk and shows how our assessments of risk are influenced by estimates of probability and uncertainty.

A Definition of Risk (Index)

In common usage, the term risk usually refers to the probability of an undesirable event, such as an accident or financial loss. Risk and probability are used interchangeably. However, this only captures one component of risk – whether the event occurs rarely or often. A full understanding of risky decisions requires a second component – whether the loss is small or large. Combining the two, we arrive at the technical definition of

risk = expected loss

This definition is very useful. It helps us understand that very unlikely, catastrophic events can pose larger risks than frequent events, and reminds us that we need to consider both the probability and the severity of a loss when we make risky decisions.

risk = expected loss = probability of event * severity of loss incurred

probability = chance that an event occurs

uncertainty = when a quantity is not known exactly

Estimating risks (Index)

When estimating risk in real-world situations, both the probability of events and their associated losses are generally unknown. They have to be estimated based on the best available information and reasonable assumptions, introducing substantial uncertainty.

Many considerations go into estimates of probability and loss:

- Which factors influence whether the event occurs, and how can we approximate them in a model?

- What are the likely effects of the event, and how can we measure them?

The answers to both of these questions are strongly influenced by individual interests and perceptions. In particular, we tend to be less concerned about losses of uncertain magnitude, that occur further into the future, or that affect others. Conversely, we tend to be more concerned about well-defined losses that affect us directly in the near future. These biases can lead to drastically different assessments of risk, especially when we have to choose between a well-known immediate loss and an uncertain future loss.

Qualitative judgements are usually necessary to bridge the gap from theory to implementation and from technical details to broader communication (see our Chapter 11).

Box 1: Ford Pinto

During the design process for the Pinto in the 1970s, Ford was faced with a choice: Keep a gas tank design prone to burst into flames during rear-end collisions, or change it to a safer design. Improving the tank would have incurred a fixed and immediate loss, such as production delays and the costs of redesigning both the car and the production line. Not improving the tank posed serious risks of injury to the drivers, and future financial risks to Ford. Based on the estimated probability of rear collisions resulting in fires and the estimated cost of lawsuits, Ford decided not to modify the gas tank. The expected loss of not changing the tank was smaller than the cost of improving it. However, this assessment left out several important factors influencing the estimated costs: The costs associated with negative publicity when sued for reckless homicide, the possibility of juries awarding punitive damages in the millions, and the cost of recalling 1.5 Million cars.

(Source: Pitfalls of decision analysis by D von Winterfeldt - 1993, in Analyzing and Aiding Decision Processes, Humphreys et al., North-Holland Publishing Company)

As the Ford Pinto shows, risk assessment is tricky business even in situations where many of the elements are relatively well understood and documented (e.g. accident rates, crash test results, legal precedents). In the management of natural resources we also have to deal with our limited understanding of biological systems, and the diversity of interests affected by each decision.

Comparing Risks (Index)

Estimates of risk strongly depend on our assumptions and the scope we choose for the analysis (e.g. which losses do we include?). The most meaningful approach, therefore, is to compare the estimated risks associated with clearly defined alternative choices. In this case, both the probability and severity of losses can be evaluated as a trade-off between alternative outcomes.

For example, when choosing among harvest strategies for a fish stock, we might model harvests of 10%, 30%, and 50%, and evaluate the future abundance of the stock under a few different assumptions about the life cycle. This allows us to estimate the probability of extinction associated with each harvest strategy. However, in real-world settings the disagreement is often about the scope and severity of losses, rather than the probability of the event.

Continuing the example, stakeholders may tentatively agree with the estimated probability of extinction, but hold different views about the inherent uncertainty of the estimate, the balance between long-term losses associated with extinction and short-term losses due to foregone harvest, whether a particular expected loss is acceptable, and who bears the brunt of these different losses if they occur.

Risk assessments are influenced by three implicit assumptions:

- If a risk assessment considers only the probability of undesirable outcomes (as in "risk of extinction"), then the implicit assumption is that consequences are of equal magnitude across all cases. This works well when comparing similar cases, such as the probability of not meeting management targets under alternative harvest strategies for the same stock. However, the implicit assumption of equal consequences presents serious pitfalls when comparing diverse cases, such as species at risk (e.g. bear vs. Butterfly), or diverse alternatives, such as transit options (car vs. bus vs. bicycle)
- If a risk assessment considers both the probability and severity of undesirable outcomes, then the implicit assumption is that the quality of information is roughly the same for both components of risk. In most cases that doesn't hold true. Difficult questions of scope (i.e. which consequences are included) and distribution (i.e. who suffers the consequences) move to the forefront of the analysis and result in estimates of severity that differ by many orders of magnitude. In comparison, methods for estimating the probability component of risk have been more solidly established, and provide a more defensible basis for public policy discussions.
- If a risk assessment is set up to rely on quantitative estimates, then implicit assumptions are that sufficient information can be compiled, that the scope of feasible analysis roughly matches the scope of the decision problem at hand, and that sufficient resources are available to complete the analysis. This typically holds true for large-scale or high-priority issues. However, the vast majority of decisions in environmental management occur in a day-to-day operational setting where quantitative risk assessments are just not feasible. Decision support for these common situations means developing a toolbox of rough, qualitative approximations that encourage risk-based decisions (see our Chapter 11).

As we probe our way through the twilight of uncertainty, the choice is not between "risk" and "no risk" , but between many different courses of action, each with many different risks (i.e. sets of uncertain consequences). The good news is that we have evolved a mental toolkit that is actually quite adept at weighing risks, if they are presented in an intuitive format (See our Chapter 2)

Box 2: Recovery options for Snake River Chinook salmon.

Snake River chinook, listed under the U.S. Endangered Species Act for more than a decade, have to pass through 8 hydroelectric dams, once as juveniles on their way to the ocean, and again on their return migration to the spawning grounds. Recovery plans need to seek a balance between many different potential benefits and losses, and any one technical analysis will only provide a piece of the puzzle. Consider the following situation:

- One report compares a few different strategies for capturing and transporting salmon past the dams.
- Another analysis looks at the potential reduction in migration mortality and potential increased access to habitat associated with decommissioning one of the dams.
- A third analysis considers the potential downstream effects of accumulated pollutants that would be released by breaching the dam.
- A fourth report attempts to predict the economic repercussions of reduced power production.

Each of the possible consequences will affect some people more than others (e.g. local residents, low-income families), and no one uncertain outcome should be considered in isolation of the others.

Effective public consultation Chapter 1 ensures that risks are considered from many perspectives, and reduces the chances of ending up with a Ford Pinto.

(Sources: Trading off: the ecological effects of dam removal. EH Stanley and MW Doyle - 2003. Frontiers in Ecology and Environment 1(1): 15–22. / Upstream: salmon and society in the Pacific Northwest. National Research Council - 1996. Washington DC.)

Confront risk estimates! (Index)

Considerations of risk are an important part of the public debate in the management of natural resources. When you encounter some risk-based assessment, ask the following questions:

- Are they talking about risk or probability?
- If it really is risk (i.e. expected loss), which factors did they consider in the estimate of loss, and who's likely to bear the loss?
- If they actually mean probability, what is your assessment of the associated losses?
- Which factors did they consider in the estimate of probability?
- How uncertain are the estimates of probability and loss?
- Are there other assessments with drastically different estimates of risk?

With these questions answered, you can then participate constructively in the consultation process, and let the other participants know:

- Whether you agree with the scope and methods of the risk assessment
- Whether you agree with the estimates of probability and loss
- Whether any of the proposed options corresponds to your values and risk preferences

Online Resources (Index)

- The **Canadian Environmental Protection Act** (CEPA) regulates the use and manufacture of toxic substances in Canada. The *Guide to Understanding CEPA* describes risk assessment procedures for new and existing substances, taking into account both the potential hazard (i.e. loss incurred) and the likelihood of exposure (i.e. the probability of the event). The guide is available at www.ec.gc.ca/CEPARegistry/the_act/

- The **British Medical Journal** had a theme issue dedicated to risk communication, with many practical tips and illustrative examples. Especially noteworthy are the articles by Paling, Gigerenzer and Edwards, and the illustrative examples submitted by practicing physicians. Go to bmj.bmjjournals.com/content/vol327/issue7417/ (Note: In these articles the term risk generally refers to probability, not to expected loss.)
- FoodRisk.org is a portal to a wealth of resources related to food safety, including tutorials and an extensive on-line library.