Stakeholder engagement within probabilistic risk assessment

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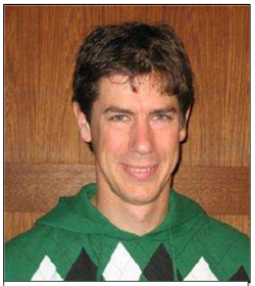
The Hobart risk team



Scott Foster, Statistics

Jeff Dambacher, Qualitative Modelling

Geoff Hosack, Risk, Statistics

Jessica Ford, Statistics

Dave Peel, Statistics

Adrien Ickoniwcz, Statistics

Overview

Risk framework

- points of intersection with the community and stakeholders

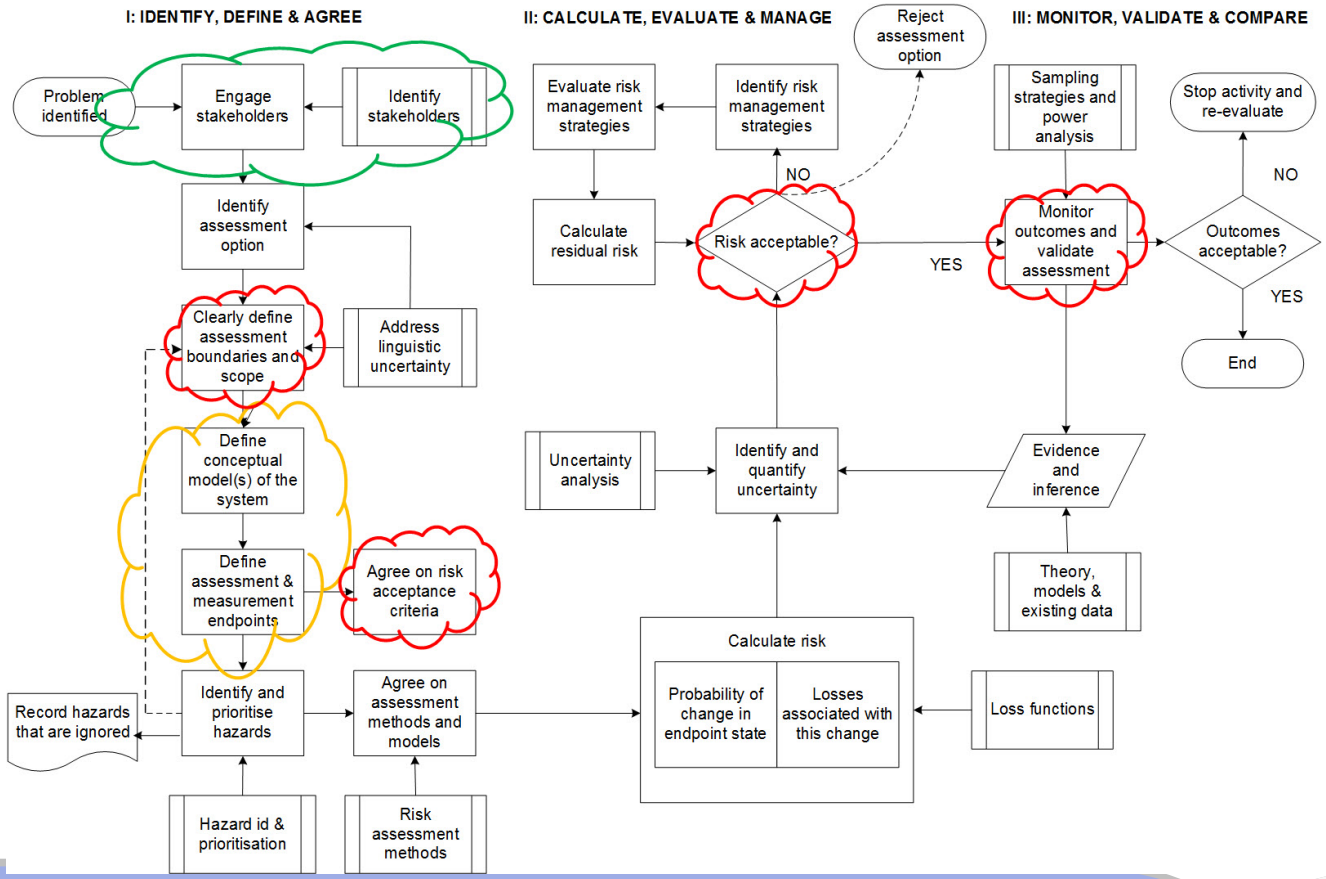
Probabilistic risk assessment

- brief introduction to contextualise

Experiences with stakeholder engagement/participation to date

- early days for gene drive pre-cursors
- limited experience mainly from other risk projects: invasive spp., coal seam gas and coal mines

An idealised risk assessment process



Probabilistic risk assessment

Many definitions of risk, but I prefer

- Risk $R \in [0, 1]$ is the probability of loss $L \in \Re$, measured (ideally) through the distribution function of loss $F_L(l) = \mathbb{P}(L \leq l)$

Values and assessment endpoints

- losses occur through changes in the state S of things that society cares about (endpoints) e.g life expectancy, abundance of a threatened species...
- $Pr(S = s)$ depends on risk factors $\mathbf{X} = (X_1, \cdots, X_k)$, e.g., the number of cigarettes you smoke, abundance of an invasive species, etc., hence $p(s|\mathbf{x})$

Risk factors

- $Pr(X = x)$ depends on human actions, activity or developments a, e.g., cigarette advertising, volume of trade, etc., hence $p(\mathbf{x}|a)$
- can include "reference" condition of endpoints, $X_i = S_{ref}$

Putting it all together - risk calculations

Expected value of loss

$$p(s|a) = \int_{\mathsf{X}} p(s|\mathbf{x})p(\mathbf{x}|a)d\mathbf{x}$$

$$E[L(s)] = \int_{\mathsf{S}} L(s)p(s|a)ds$$

Simplest loss function

$$L(s) = \mathbb{I}\{s > s_q\} \Rightarrow \int_S L(s)p(s|a)ds = Pr(s > s_q)$$

$$L(s) = \mathbb{I}\{s_{q_L} > s > s_{q_U}\} \Rightarrow \int_S L(s)p(s|a)ds = Pr(s_{qL} > s > s_{qU})$$

Why this approach?

Why all the math?

- probability theory ensures coherent approach to uncertainty
- predictions can (at least theoretically) be compared to actual outcomes
- loss function opens door to more sophisticated measure of consequences

What's wrong with qualitative risk assessment?

- can't disentangle linguistic uncertainty (unless carefully defined)
- can't calibrate with real world outcomes (unless numerically defined)
- risk matrix construction may be incoherent (Cox, 2008)

What about "Risk = Likelihood $\times$ Consequence"?

- probabilistically this is the expected value of consequence
- low likelihood/high consequence $=$ high likelihood/low consequence
- society typically more concerned about the former than the latter

Losses, consequences and measurement endpoints

Community/stakeholder input

- Important that assessment endpoints reflect stakeholder concerns
- So go ask them: (i) what do they care about; (ii) how they think things will go wrong.

Challenges experienced to date:

- Long list of values
- Questionable plausibility
- Values at end of complex events chains
- (Indigenous value systems)

Meeting these challenges

Long list of values, $|S|$ is high

- Pick sentinels, canonicals in discussion with community
- Pick basal, keystone organisms
- Look for intermediate bottlenecks in cause-effect pathways

Questionable plausibility, $Pr(S_i = s_i|X) = \emptyset$?

- Explore conceptual model
- Education, outreach
- Judgement call (but by whom?)

Complexity

- Look for intermediate steps in cause-effect pathways
- Measurement versus assessment endpoints (Suter, 2007)

Conceptual models of cause and effect

Conceptual models $Pr(S = s|X)$

- All risk assessments (qualitative or quantitative) are based on a conceptual model of causation
- Some of the challenges associated with community participation in risk assessment based on diversity of conceptual models

Need (ideally) rapid transparency mechanisms

- Graphical methods minimise barriers to elicitation
- Examples in the literature:
  - Signed Directed Graphs
  - Directed Ayclical Graphs
  - Fuzzy Cognitive Maps

References

Cox, L. A. (2008). Whats wrong with risk matrices? *Risk Analysis*, 28:497–512.

Suter, G. W. (2007). *Ecological Risk Assessment*. CRC Press, Boca Raton, Florida, USA.

Thank You

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