National Science Challenges

SUSTAINABLE SEAS

Ko ngā moana whakauka

Project 5.1.3 Risk and uncertainty

(starts 2017-18)

Graeme Inglis

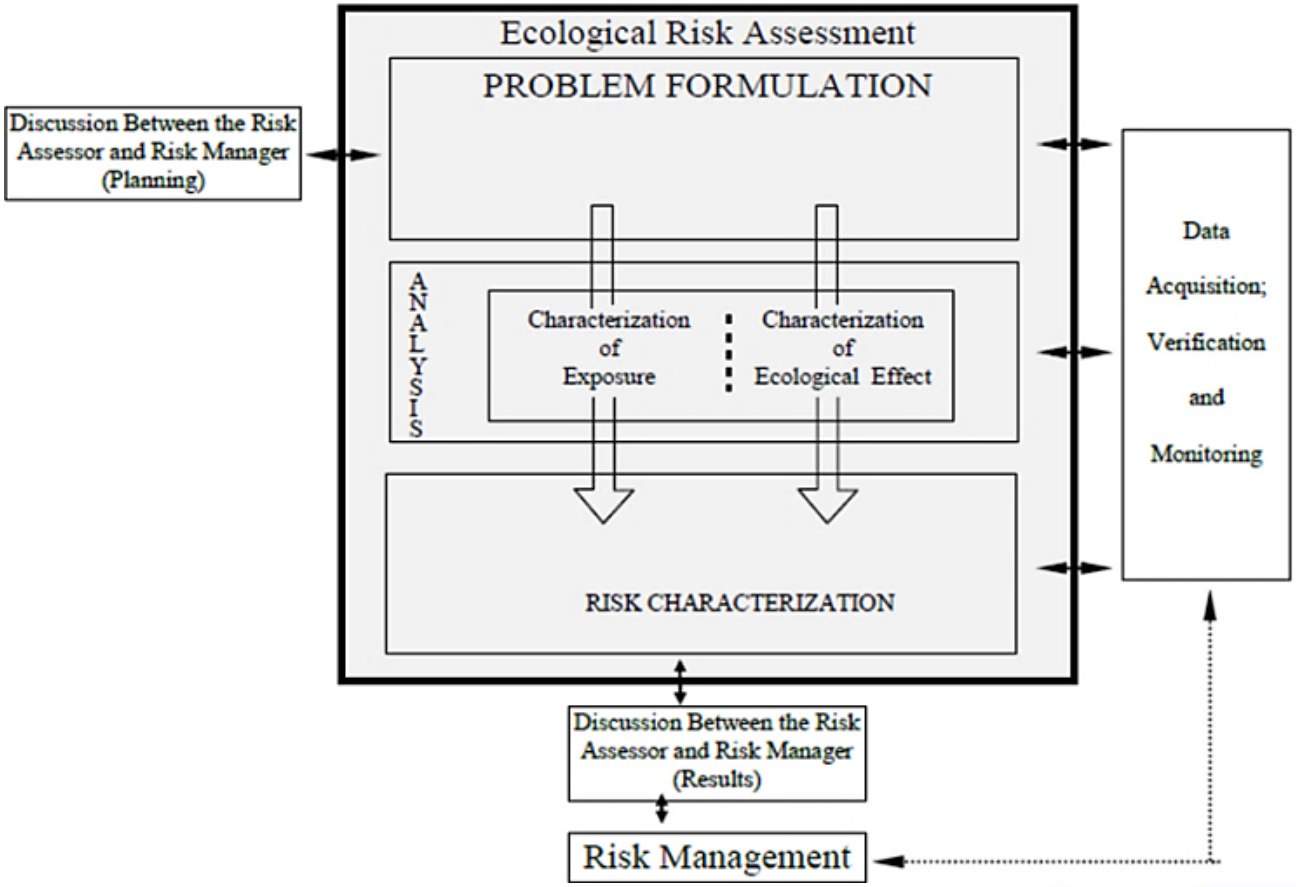
CAWTHRON INSTITUTE | GNS SCIENCE TE PŪ AO | NIWA Taihoro Nukurangi | THE UNIVERSITY OF AUCKLAND NEW ZEALAND | UC UNIVERSITY OF CANTERBURY | THE UNIVERSITY OF WAIKATO | UNIVERSITY of OTAGO | VICTORIA

Risk

The likelihood of undesirable consequences from some future event(s) (i.e. hazard(s))

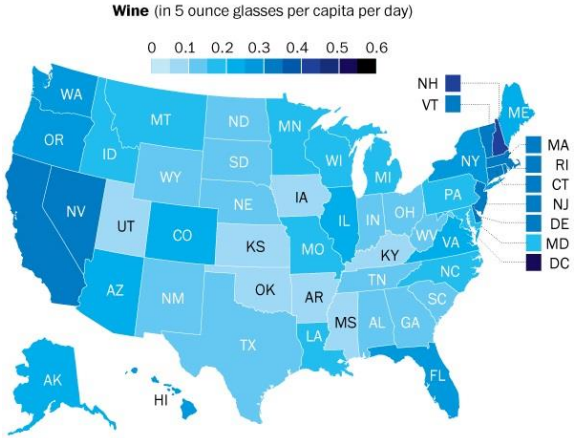
- *What could possibly go wrong?*
- *How likely is it to go wrong?*

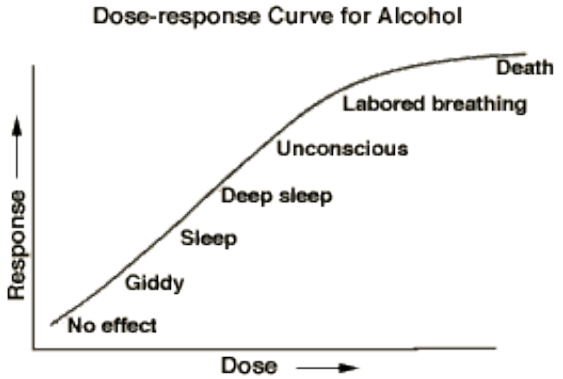
Classic ecological risk analysis



Components of risk assessment

Sources	Stressors	Receptors	Exposure pathways	Endpoints	Risk metrics
Activities that generate stressors	Chemical, physical or biological agents that cause changes in ecosystem components	Ecosystem component exposed to the stressor	Processes by which a stressor is brought into contact with a receptor	Measure of stressor effects	How risk is quantified (e.g., magnitude of effect, margin of exposure, etc





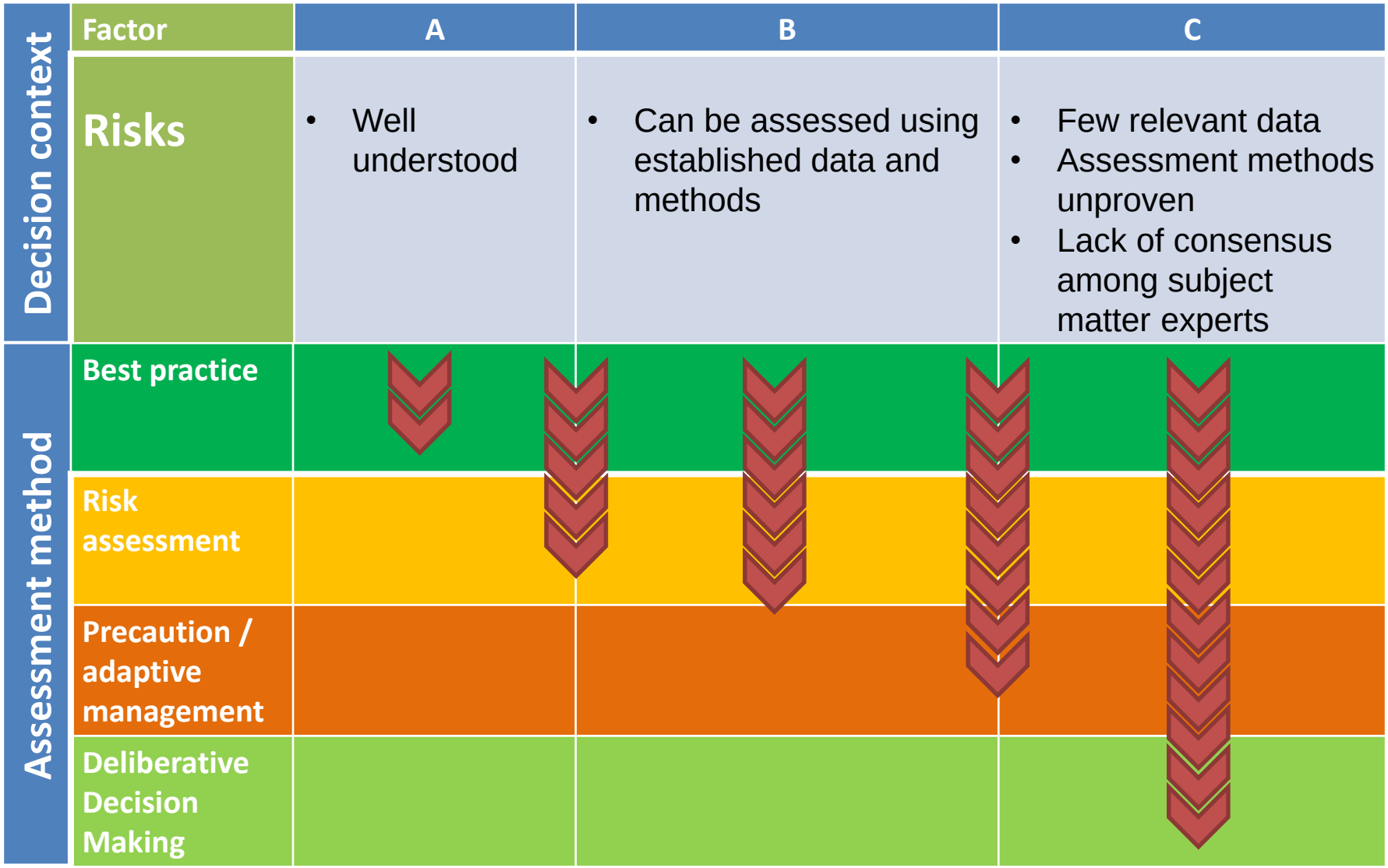
Risk and uncertainty

Decision context

Factor	A	B	C
Type of activity	• Nothing new or unusual • Well understood activity • Good practice well-defined	• New to the geographic area • Infrequent or non-standard activity • Good practice not well defined or more than one option available	• New development or activity • Novel or understudied setting • Multiple, interacting activities • No established good practice
Risks	• Well understood	• Can be assessed using established data and methods	• Few relevant data • Assessment methods unproven • Lack of consensus among subject matter experts
Uncertainty			
Stakeholder interest			

Adapted from: *Oil & Gas UK (2014) Guidance on risk-related decision making. Oil & Gas UK. London. 25 p.*

Risk and uncertainty



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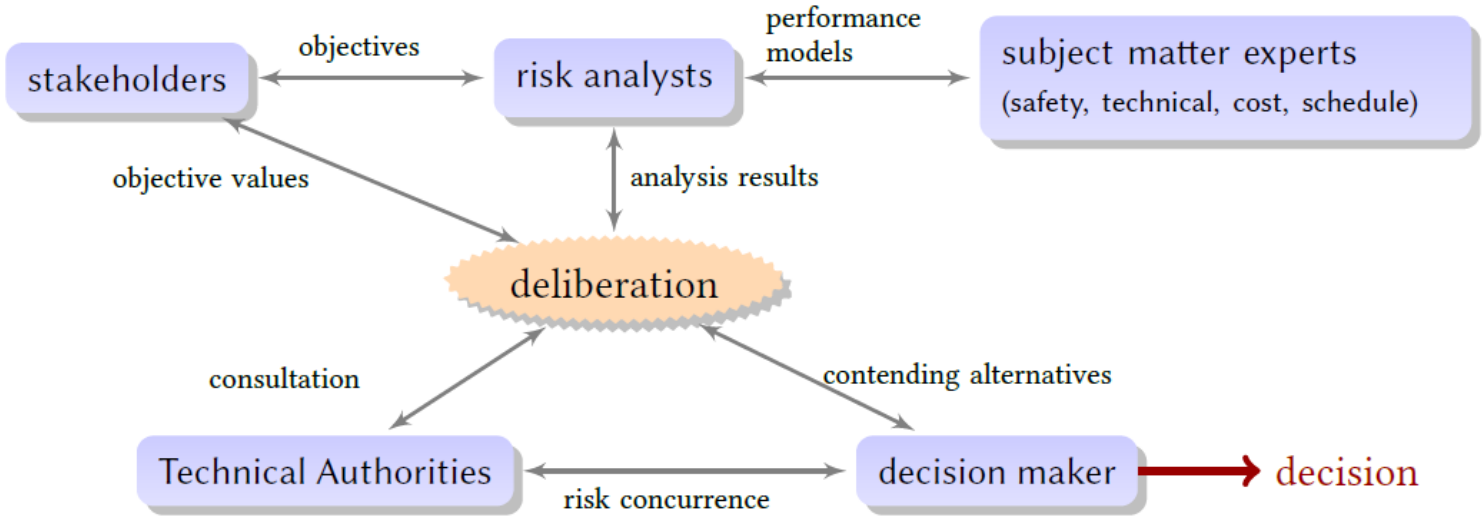
Risk Informed Decision Making – NASA (2010)



Complex risk problems with deep uncertainty

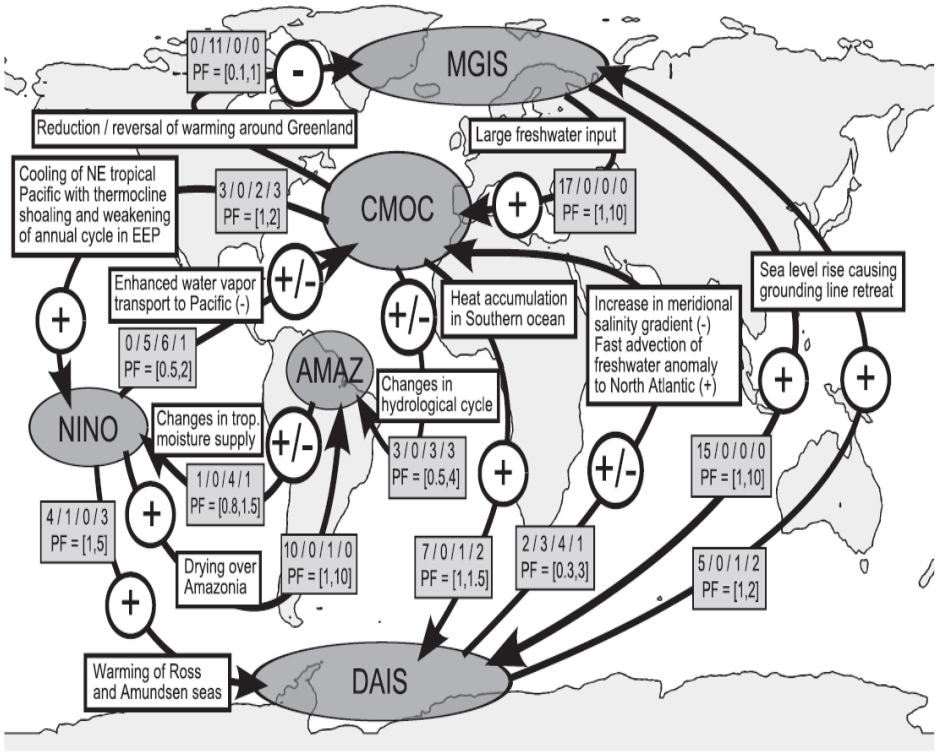
- New technologies / activities
- Activities in understudied environments
- Cumulative and indirect effects
  - Surprises ('black swan' events)
  - Tipping points
- Adaptive / changing threats (e.g., terrorism, emerging disease resistance, invasive species)

Tools for assessing risks with deep uncertainty

- Probability bounds analysis (PBA) – interval analysis
- Imprecise probabilities
- Graph-based Markov Decision models
- Robust Decision Making
- Resilience Analytics
- Qualitative network models & Quantitative risk analysis

Tools for assessing cumulative and indirect effects

- Loop analysis
  - Qualitative network model of complex systems
  - Use to model indirect & cumulative effects of stressors
- Imprecise probability assessment
  - Used when knowledge is poor
  - Exclude probabilities incommensurate with expert beliefs
  - Use to elicit probability (& uncertainty) of tipping points
- Probability Bounds Analysis
  - Used to combine uncertainty from variation (prob. distributions) with uncertainty from ignorance (intervals)

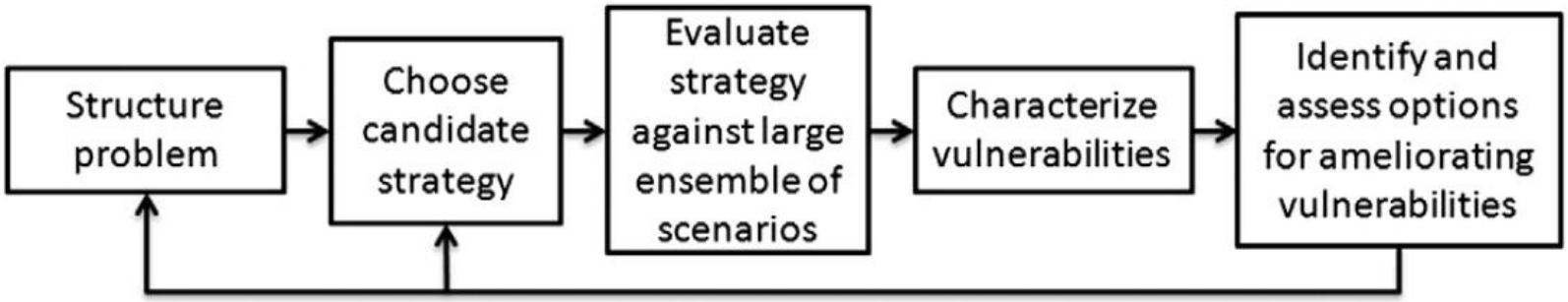


[1]Walley P (1991) Statistical Reasoning with Imprecise Probabilities (Chapman and Hall, London).

[2]Kriegler, E., Hall, J. W., Held, H., Dawson, R. & Schellnhuber, H. J. (2009) Imprecise probability assessment of tipping points in the climate system. Proceedings of the National Academy of Sciences, 106, 5041-5046.

Tools for generating and evaluating possible future outcomes

- Robust Decision Making (Lempert et al. 2006)
- Computational decision analysis framework to compare robustness / vulnerability of strategies when:
  - There are many potential future states
  - Decision challenge is complex
- Iterative evaluation of vulnerability and response options



Lempert, R.J., Groves, D.G., Popper, S.W., Bankes, S.C. (2006) A general, analytic method for generating robust strategies and narrative scenarios. *Management Science*, 52(4): 514-528. 10.1287/mnsc.1050.0472

Project activities

- Phase 1 (July 2017 – March 2019)
  - Review and evaluate methods to:
    - assess risks from multiple stressors
    - estimate the likelihood of highly uncertain transitions (“tipping points”),
    - quantify bounds in uncertainty
- Phase 2
  - Apply developed methodologies to a problem in the case study area

Thank you


WE'LL NEED A RISK ANALYSIS ON THIS PROJECT BEFORE I CAN APPROVE IT.
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S. Adams
RISK 1: INDECISIVENESS
RISK 2: OVERANALYSIS
RISK 3: CLUELESSNESS
RISK 4: MICROMANAGE-MENT...
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I DON'T UNDERSTAND THESE RISKS.
THAT'S NUMBER THIRTY-SIX.