Carbon Sequestration Risks and Risk Management

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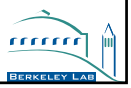
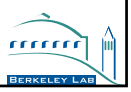


Overview

- **Some background on risk assessment and risk management**
- **Carbon sequestration hazards/risks**
- **The problem of uncertainty**
- **Key issues**



What is Risk Assessment?

RISK ASSESSMENT =

THE APPLICATION OF SCIENCE, MODELING, AND POLICY TO UNCERTAIN AND ADVERSE CONSEQUENCES.

"Most predictions are uncertain, especially those about the future"

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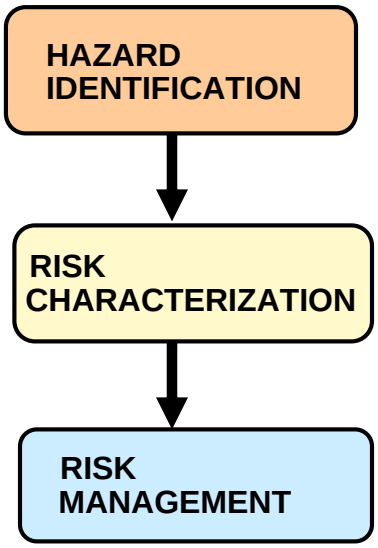
Risk Assessment in a Regulatory Environment



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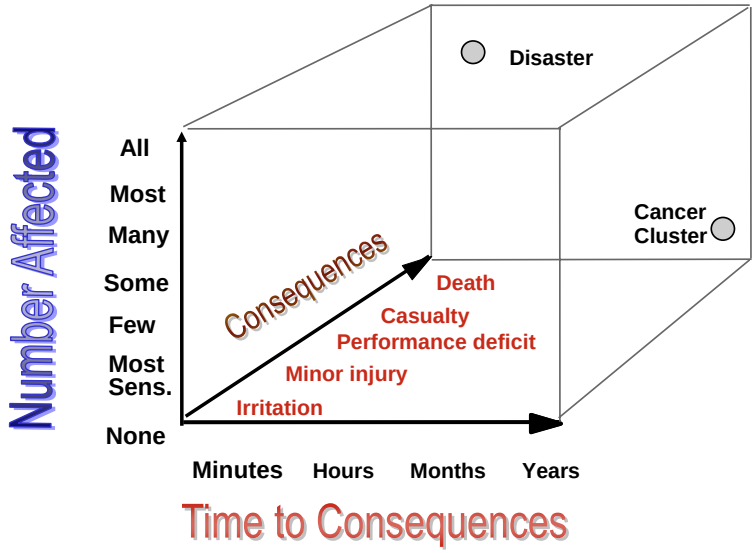
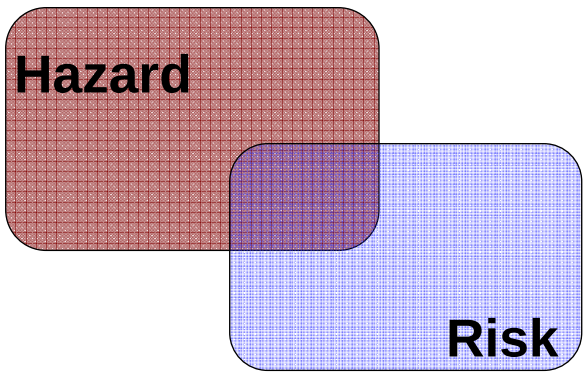
Dimensions of Harm



Hazard and Risk

The possibility of harm



The likelihood of harm

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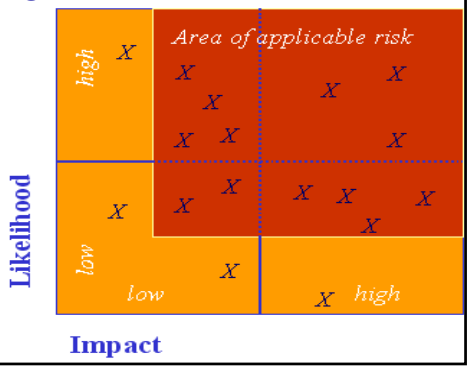
Hazard

A condition or physical situation with a potential for an undesirable consequence, such as harm to life or limb

http://www.sra.org/resources_glossary.php

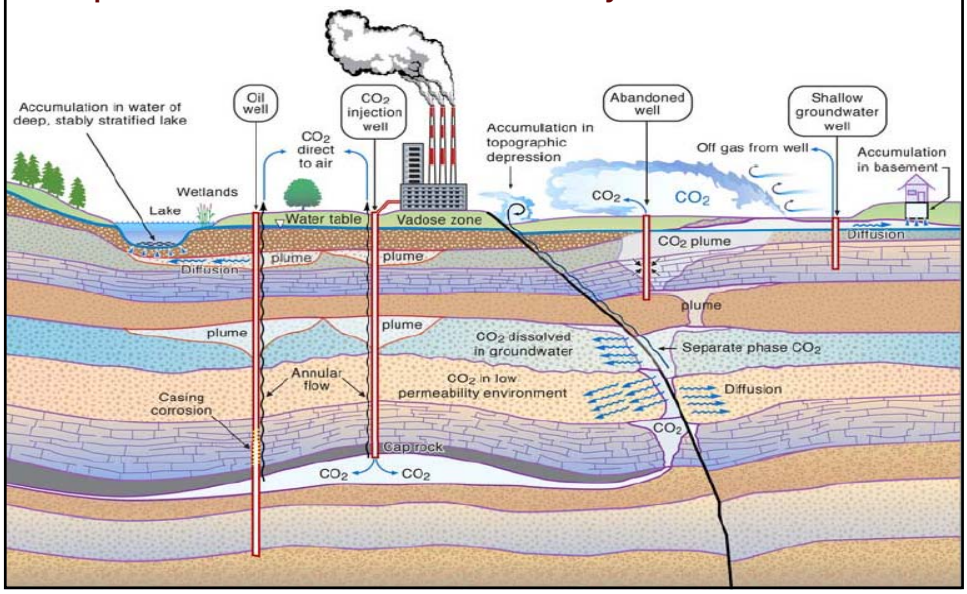
Risk

The potential for realization of unwanted, adverse consequences to human life, health, property, or the environment; estimation of risk is usually based on the expected value of the conditional probability of the event occurring times the consequence of the event given that it has occurred



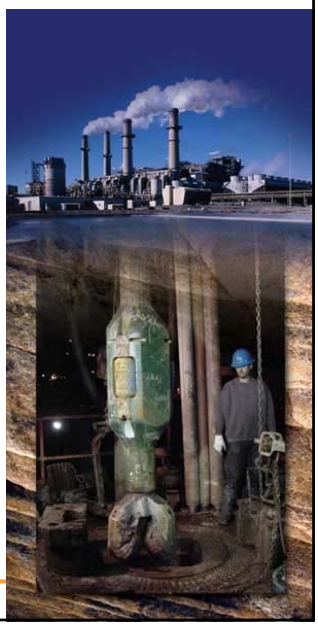
Carbon Sequestration Concepts

Risks to economic, ecological, and human health from carbon sequestration have been studied extensively.



Carbon Sequestration Risks

- **Human health**
  - **Worker exposure**
  - **Exposures from CO2 transport**
  - **Exposures from leaking geological structures**
- **Environment**
- **Resources**



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Representing Risk

The triplet definition of risk:

- **Risk involves three elements**
  - **1) Scenarios of what can go wrong**
  - **2) Likelihood of each scenario**
  - **3) A measure of damage for each scenario**

For carbon sequestration

Risk = *f* (failure type, failure probability, impact)

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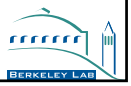

Scenarios of What Can Go Wrong

Leakage of CO_2 from pipelines or geologic formations:

- **To the surface or shallow subsurface could harm or kill people**
- **Into groundwater could degrade water quality, either directly or by acidifying the water so that it leaches toxic compounds out of rock or soil**
- **To the surface or shallow subsurface could lead to damaging or lethal effects on plants and sub-soil animals**
- **Into natural gas or oil deposits could increase the costs of recovering those assets or make them infeasible for use**

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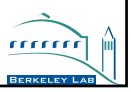
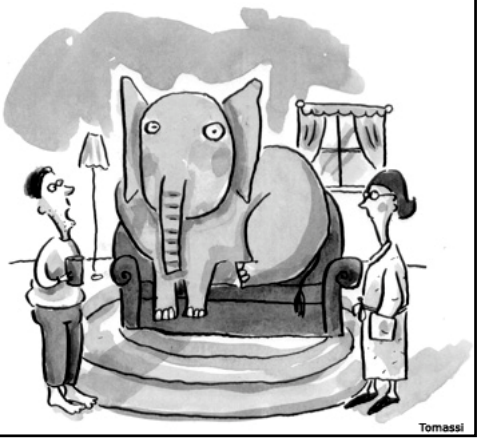


Uncertainty!!!



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Confronting Uncertainty

- **Tier 0: Default assumptions--single value of result**
- **Tier 1: Qualitative--systematic identification and characterization of uncertainties**
- **Tier 2: Quantitative--bounding values, interval analysis, sensitivity analysis**
- **Tier 3: Probabilistic assessments**

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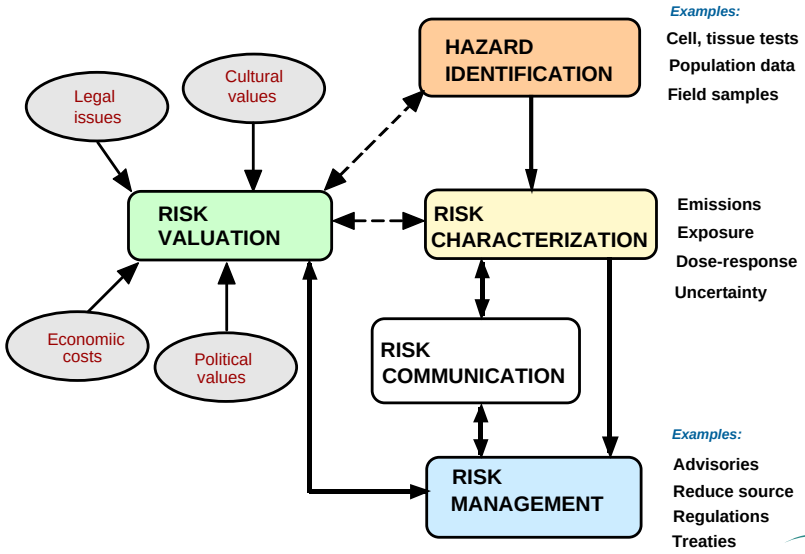
Managing Uncertainty

In any system or operation, uncertainty decreases in time. So

- **So start with sites, technologies, and actions that are well characterized**
- **Engage in limited deployment to allow learning and adjustment**
- **Expect to expand your portfolio of options as new information accrues**

Risk Assessment & Risk Management



Risk Perception/Risk Valuation

Individuals

How do individuals deal with incomplete information?

- Heuristics or simple models based on recall
- Preference for reducing one risk to zero rather than reduce multiple risks slightly
- Gains and losses are not valued the same
- People do not like risk/risk tradeoffs

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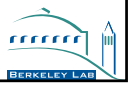

Risk Perception/Risk Valuation

Experts

How do experts deal with incomplete information?

- Physicians who are 95% confident are correct about 80% of the time
- Most "experts" overestimate confidence in their predictions
- Weather forecasters and odds makers have the best correlation between their estimated and actual confidence

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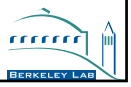

Decision-Driven Assessments

- **A transparent & deliberative evaluation builds confidence among all participants**
- **Hazard characterization lacks information on severity and likelihood of consequences**
- **Risk assessments do not need to be complicated or confusing**
- **A <u>useful</u> risk assessment helps to inform decisions**

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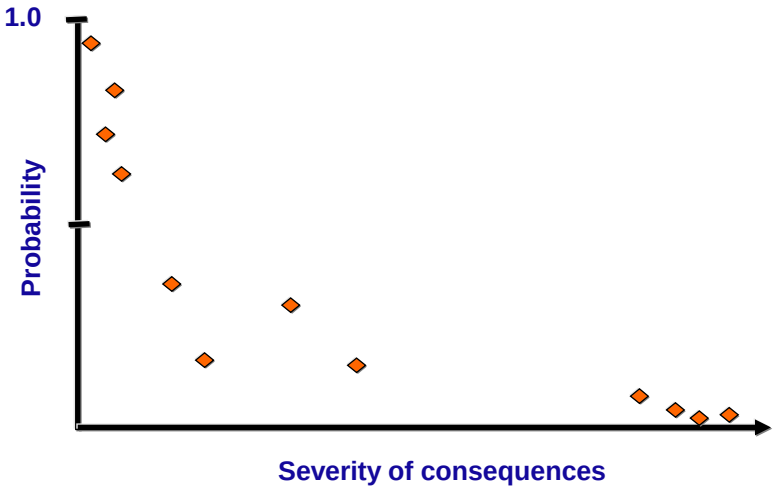
How to allocate resources



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Concluding Points

- **We have to address the uncertainty inherent in subsurface systems**
  - **Default assumptions**
  - **Bounding assessments with sensitivity analysis**
  - **Probabilistic assessments**
- **The largest risks from carbon capture and sequestration could arise during capture, transportation, and injection**
- **Create incentives for sufficient, accurate, and precise information**
- **Public education to increase confidence and acceptance**

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