Ecological Risk Assessment: Overview of Development and Application of Science

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Risk Assessment: Historical Background

- 17th Century insurance of merchant ships
  - Most RA is still financial
- Engineering RA 1970s
  - Fault and event trees: WASH-1400
- Health Risk Assessment in the EPA
  - Clean air 1970
  - Pesticides 1972
  - Drinking water 1974
  - Industrial chemicals 1976
- Red Book 1983

Ecological Assessment: Pre-ERA

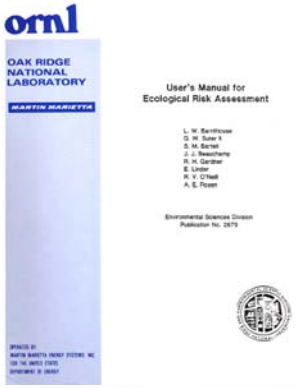
- NEPA 1969
  - EIAs and EISs – EPA exempted
  - Largely descriptive and compliance oriented
- Pesticides and Toxic Substances
  - Hazard Assessment
    - Pellston workshops – Cairns, Dickson and Maki 1978
  - Comparison of exposure & response
  - Tiered testing
  - Still important – emphasis of testing rules
  - Clearest EPA implementation:
    - Urban & Cook 1986

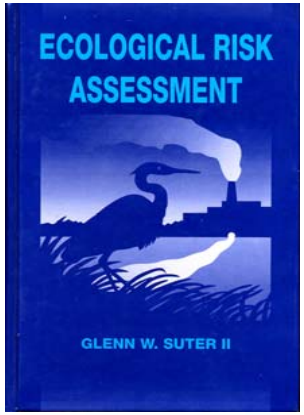
Ecological Assessment: Other

- Clean Water Act 1977
  - Strong Eco Mandate
  - But implementation not risk oriented
    - Ambient Water Quality Criteria
    - Effluent toxicity testing
    - Bioassessment and biocriteria

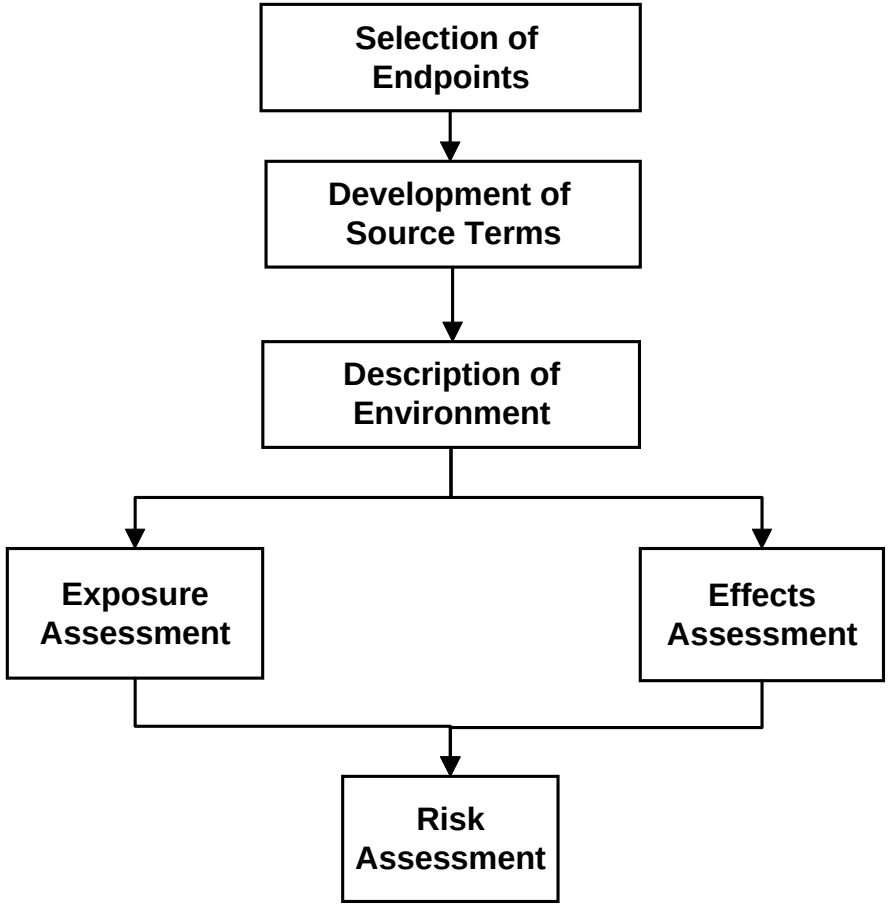
First ERA Program: Synfuels Ecological Risk Assessment

- EPA-funded 1981, Environmental Sciences Division, ORNL
- Probabilistic methods
- Organism, Population and Ecosystem Levels
- Methods report 1982
- Methods manual 1986
- Two books 1992

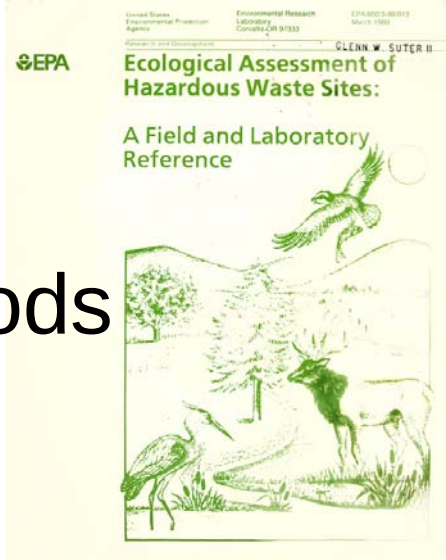




Framework for Ecological Risk Assessment



Superfund ERA



- 1989 Field and Laboratory Methods
- 1989 RAGS Vol. II
  - 1997 interim final revision
- 1994-97 Env. Resp. Team guidance docs.
- 2000 ERA for Contaminated Sites
- Since 1990,

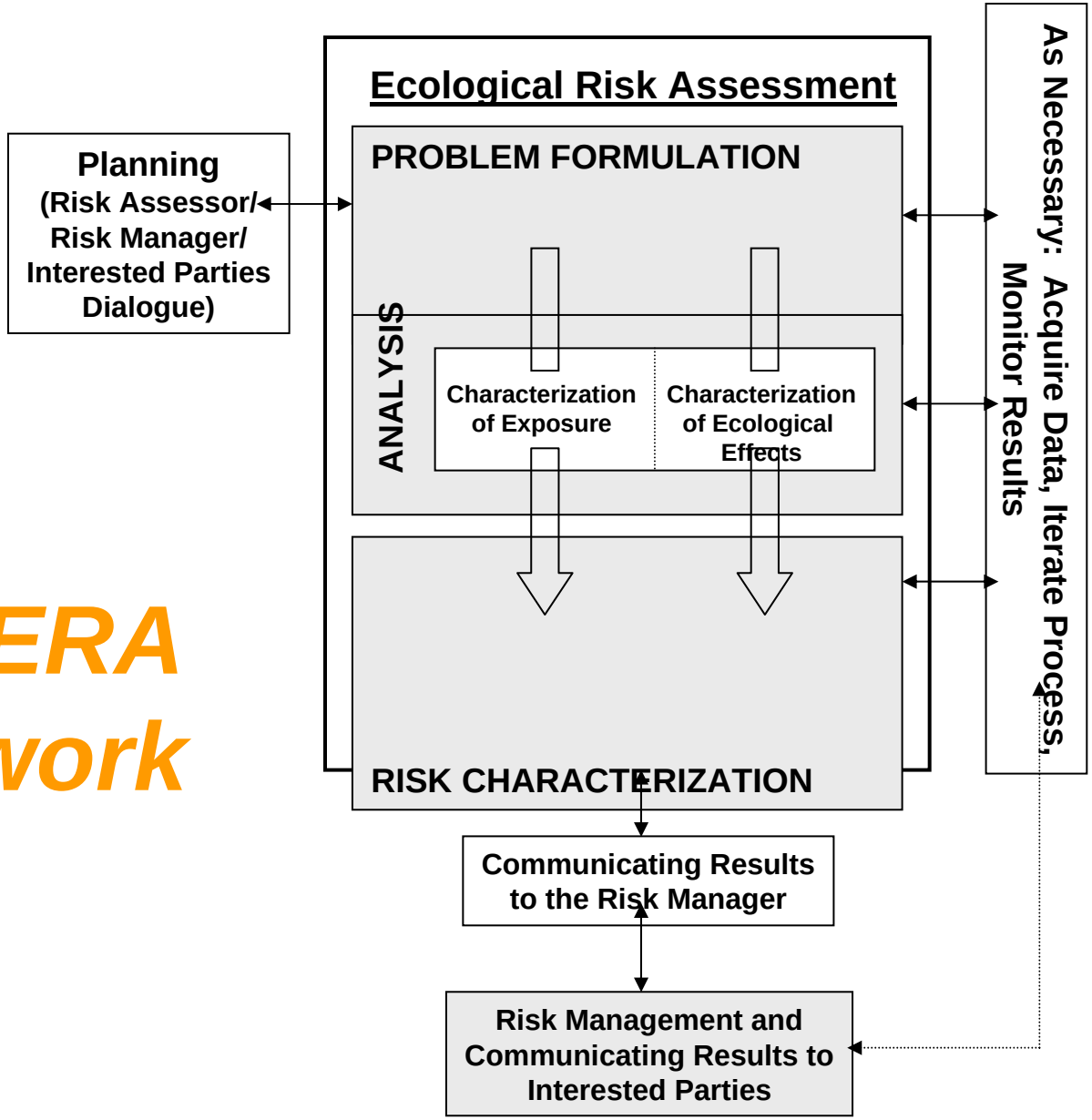
  the major arena

  for ERA

EPA Framework Development

- 1987-91 colloquia, reviews & meetings
- 1992 Framework for ERA
  - Planning and problem formulation
  - Assessment Endpoints
  - Conceptual Model
  - Analysis plan
  - Inclusion of non-chemical stressors

EPA's ERA Framework



Success of the ERA Framework

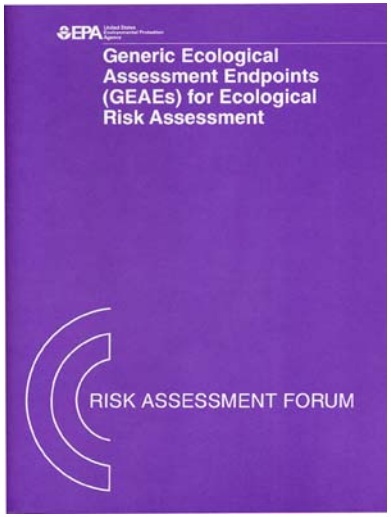
- Recognized as an advance over the NRC Framework
- Adapted for use by:
  - several national frameworks
  - WHO Integrated Risk Framework
  - IlSI Microbial Risk Framework
  - RAF Cumulative Risk
  - others

ERA Guidelines Development

- 1993-94 Case Studies
- 1994 Issue Papers
- 1998 Guidelines for ERA
  - Kept framework
  - Expanded guidance
  - Continued emphasis on planning and problem formulation

Guidelines Follow-On

- 1998 RAF colloquium on ERA Guidance
  - Bookshelf of specific guidance documents
  - Prioritized topics
- One completed
  - Generic Assessment Endpoints
- One shot down in review
- Others planned

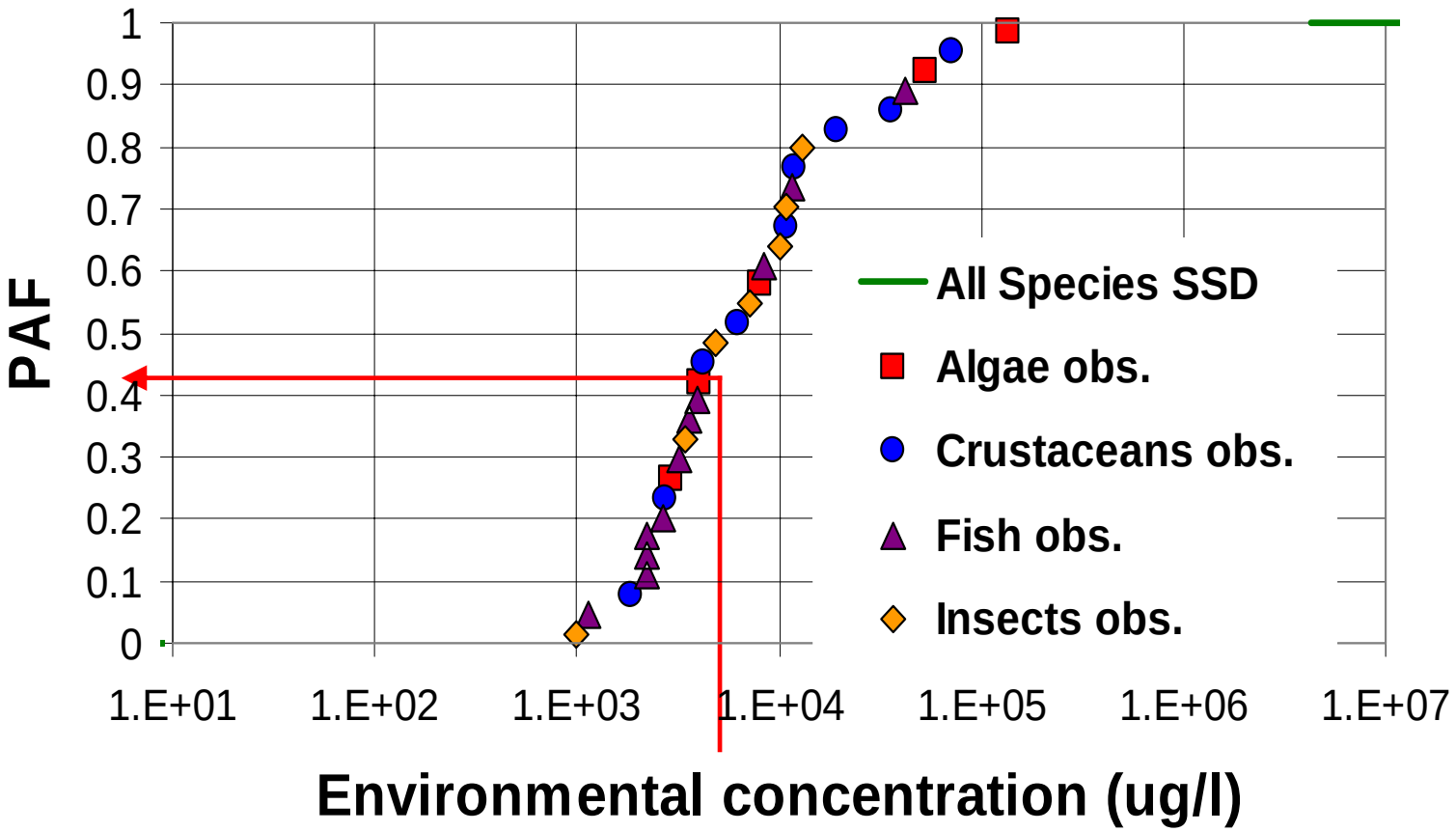


ERA Issues: Probability and Uncertainty

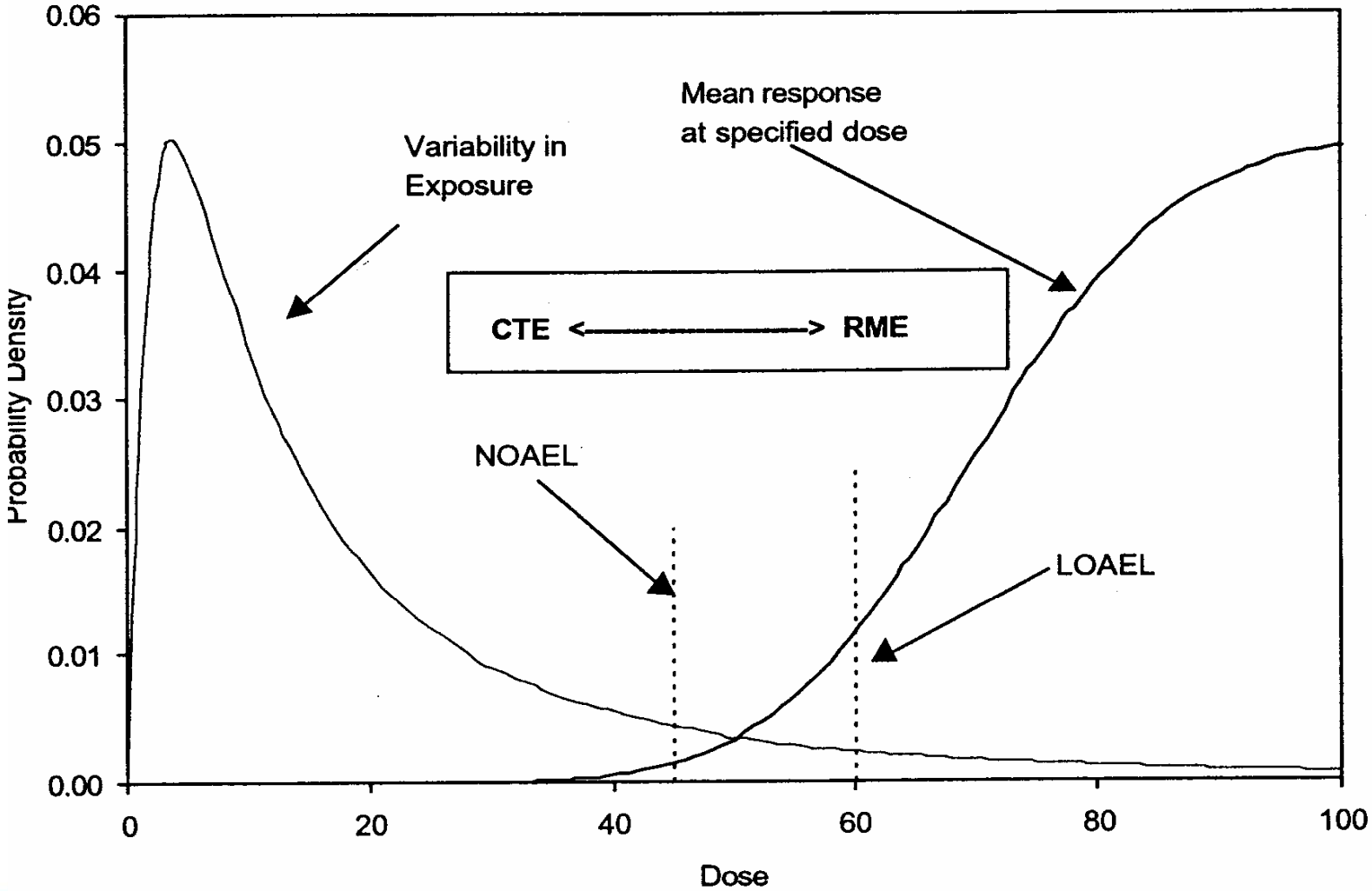
- First ERA methods were probabilistic
- Hazard Assessment methods were not
  - Used factors – still common
- 1996 FIFRA SAP demanded PRA
  - 1998 ECOFRAM, terrestrial and aquatic
    - Numerous tiered approaches
    - Developing Level II Models (Version 2.0)

Species Sensitivity Distributions

Benzene, *all data lumped in 1 SSD*



ERA includes Integration of Exposure and Exposure-Response Distributions



ERA Issues: Levels of Organization

- Regulated parties and many ecologists prefer ERAs at higher levels of organization
  - More ecological
  - Incorporates functional redundancy and compensation
- EPA ERAs mostly use organismal attributes
  - Easier given available methods
  - Understandable by decision-makers and public
  - Accused of protecting individuals

Levels of What?

- Endpoint = Entity and Attribute
- They may not be at the same level of organization
- Often the entity is defined at a higher level than the attributes

Comparing HH & Eco Endpoints: Organism Attributes

Entities	**HHRA**	**ERA**
an Individual Organism	Probability of death or injury	Seldom used (T&E species)
a Population of Organisms	Frequency of death or injury or Numbers dying or injured	Frequency of mortality or anomalies; Average reduction in growth or fecundity

Comparing HH & Eco Endpoints: Population Attributes

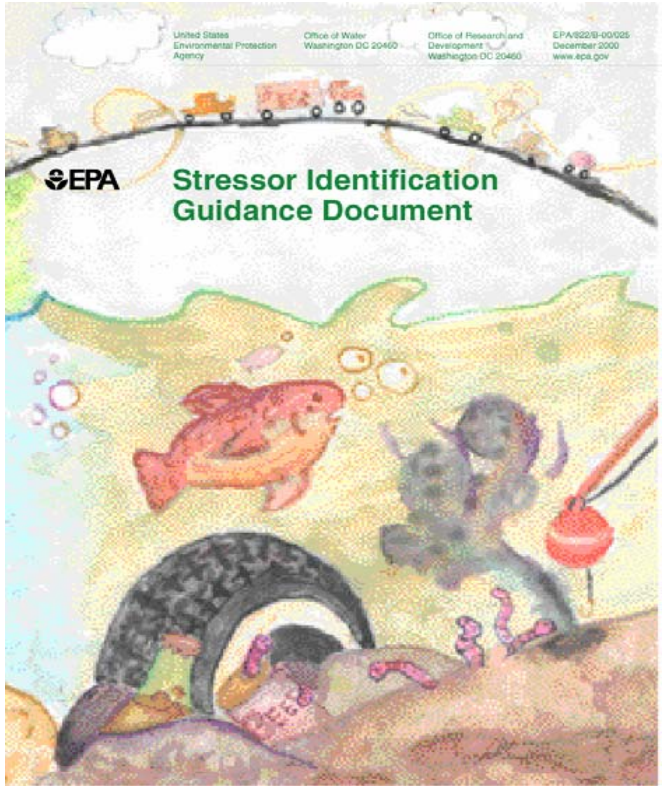
Entities	**HHRA**	**ERA**
an Individual Population	Not used	Extirpation, Production, or Abundance
a Set of Populations	Not used	Seldom used (e.g., extinction rate)

ERA Issues:
ERA and Ecological Epidemiology

- Bioassessment is integral to CWA
- Superfund assessments often include observed effects.
  - sometimes documented
- Pesticide reregistrations include incident reports.
- Not risk assessment per se, but closely related.

EcoEpidemiology

- Bioassessment reveals all effects
- But not clearly
- Causality is difficult
- Formal methods and guidance



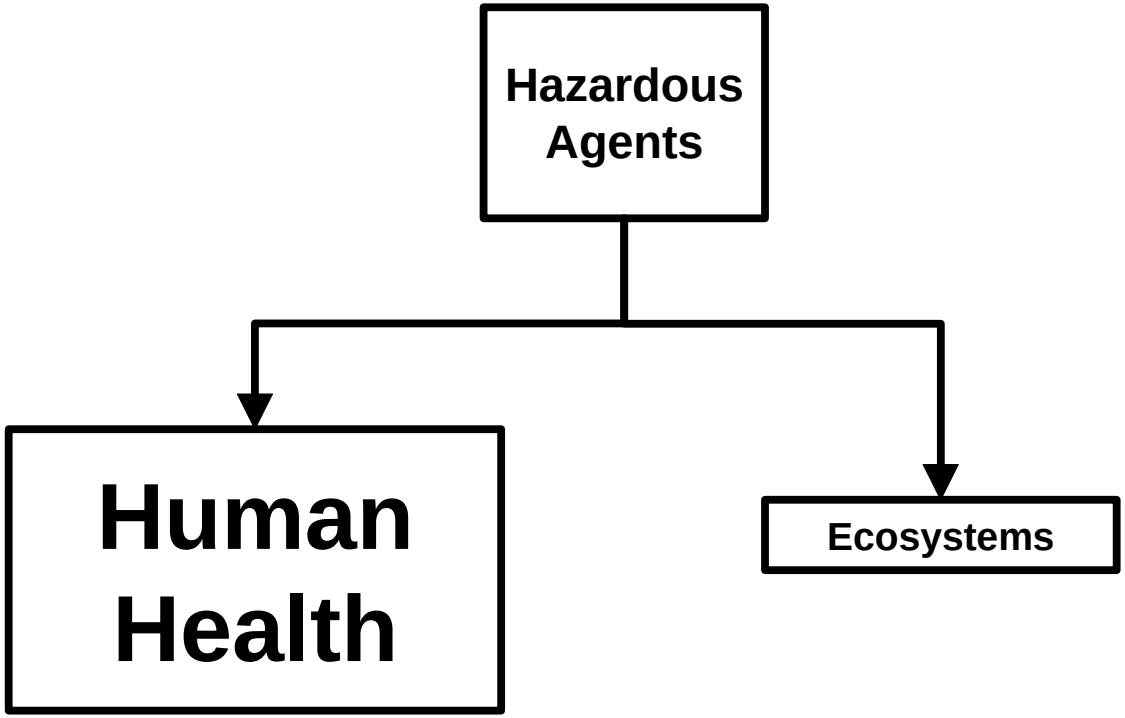
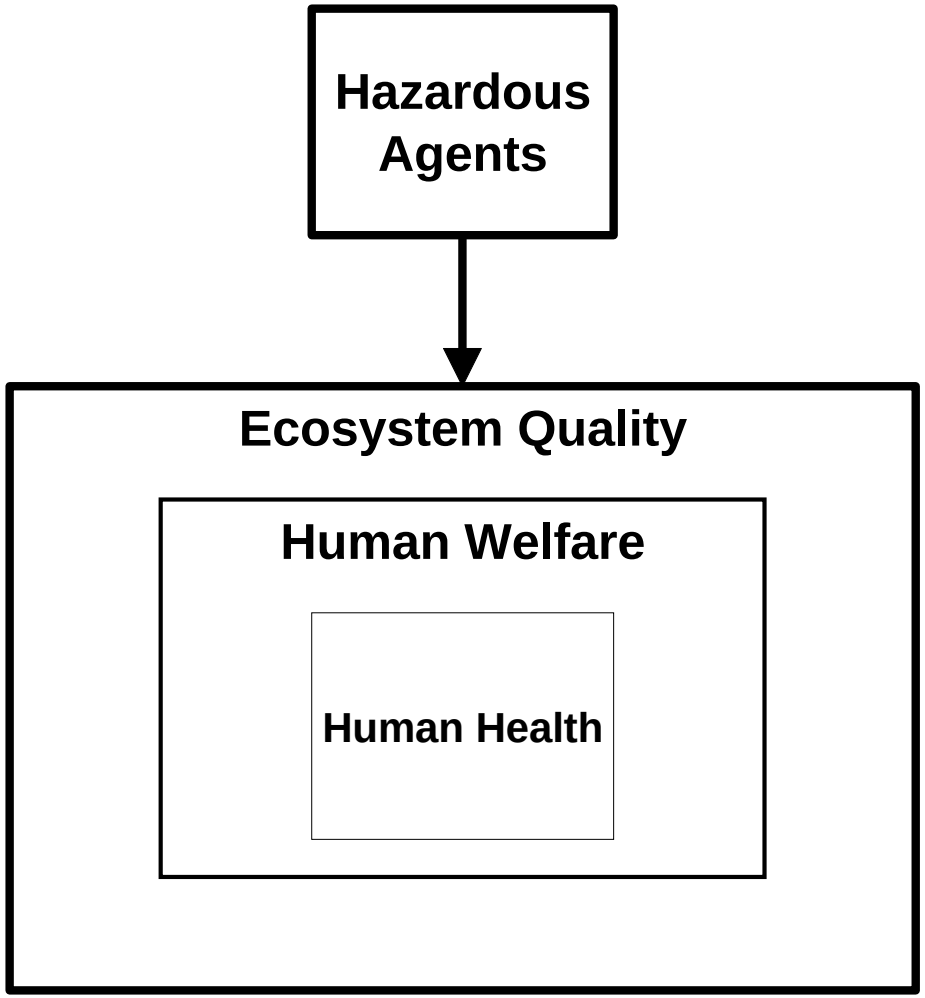
ERA Issues: Weight of Evidence

- Ecologists often have multiple types of evidence and multiple lines of evidence within a type
- Most practitioners prefer to consider all available relevant evidence
- Some consider weighing evidence to be too subjective

ERA and Cost-Benefit Analysis

- ERA is aimed at protecting endpoints
  - Representative species/ecosystems
  - Sensitive species/ecosystems
- Benefits accounting requires estimating all ecological effects that are welfare effects
  - Surrogates not acceptable
    - Proposed construction runoff standard
- SAB attention to problem of monetizing benefits but not estimating them

ERA Issues: How do we increase the influence of ecological concerns?



Change our World View?