Limitations of Ecological Risk Assessment In Decision Making

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Ecological Risk Assessment: An Evaluation of the State-of-the-Practice

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some of my biases

- ecology, as other sciences, is value neutral
- ecological resources are given value by humans

  Specific values are assigned differently by different humans (cultural, ethnic, class, age, gender,… differences)
- emergent properties of ecological systems are key if the aim is to manage populations, communities, and system functions
- ecological systems:
  - can<u>not</u> be restored; they can only be emulated
  - change is inevitable
  - predictions of future conditions are tenuous at best

Kapustka, L. A., and W. G. Landis. 1998. Ecology: the science versus the myth. *Human and Ecol. Risk Assessment* 4: 829-838.

Presentation Outline

- Limitations
  - Inherent
  - Contrived
- Near-term solutions (<3 yr)
- Long-range solutions (3^+ yr)

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Inherent 1. Stochasticity

- Stochastic nature of ecological systems
  - certain uncertainty is certain

- Risk statements easily interpreted as lack of understanding

  - Population A exposed to Stress X is predicted as having 80% chance of extirpation over 10 years
    - After 20 yr, Population A is thriving
  - Population B exposed to Stress Y is predicted as having 10% chance of extirpation over 10 years
    - Within 1 yr, Population B is extirpated
  - Stress Z is predicted to have no adverse effect on Population C
    - Population C declines 20% per year over four years

Inherent Limitations

1. Stochasticity
2. Scale [space, time]
3. Baseline ecological information
4. Toxicity profiles
5. Exposure conditions
6. Multiple stressors
7. Complex Stressors

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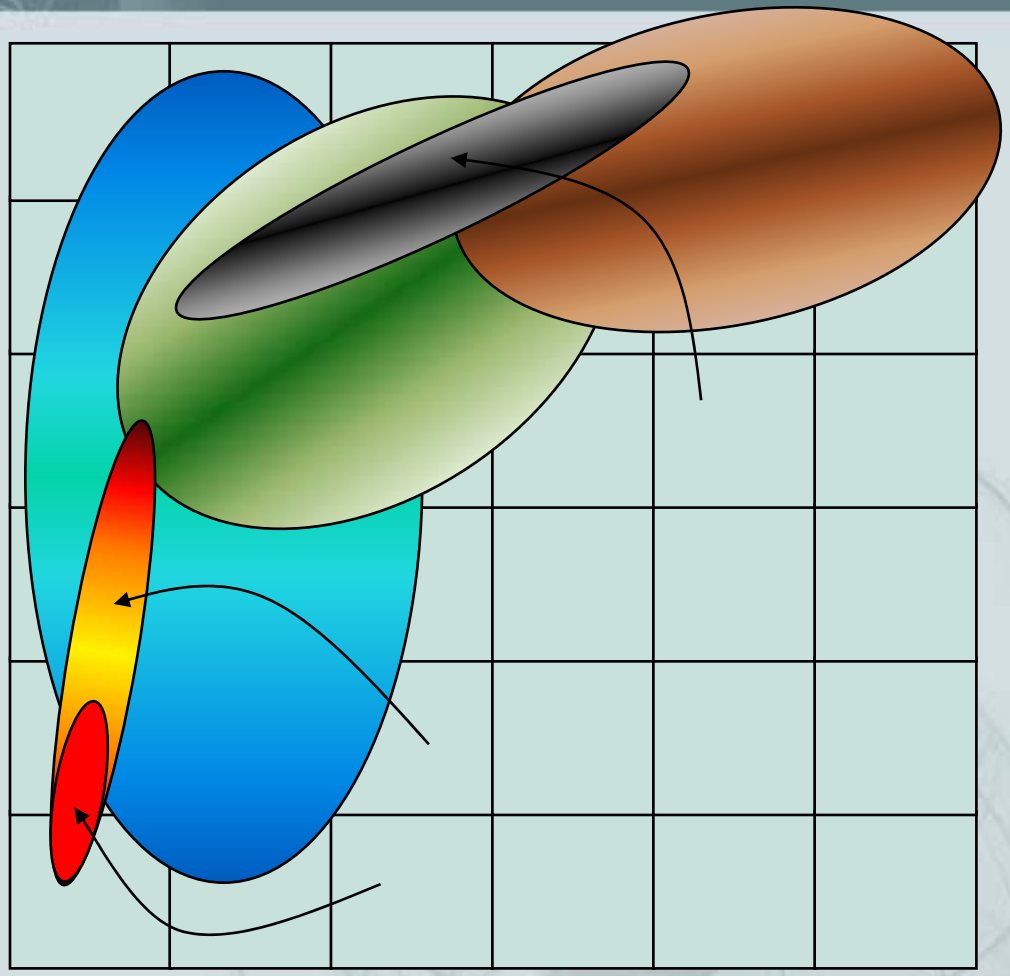

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Inherent 2b.

Scale

Mammal	Number per 25-ha site	Home range (%)
Black-tailed jackrabbit	2.5	?
Coyote	<1	0.25
Long-tail weasel	1.5	6
Mule deer	2	18
Raccoon	<1	25
Red fox	<1	5
White-tailed deer	2	10

From Tannenbaum (2005) IEAM 1:66-72

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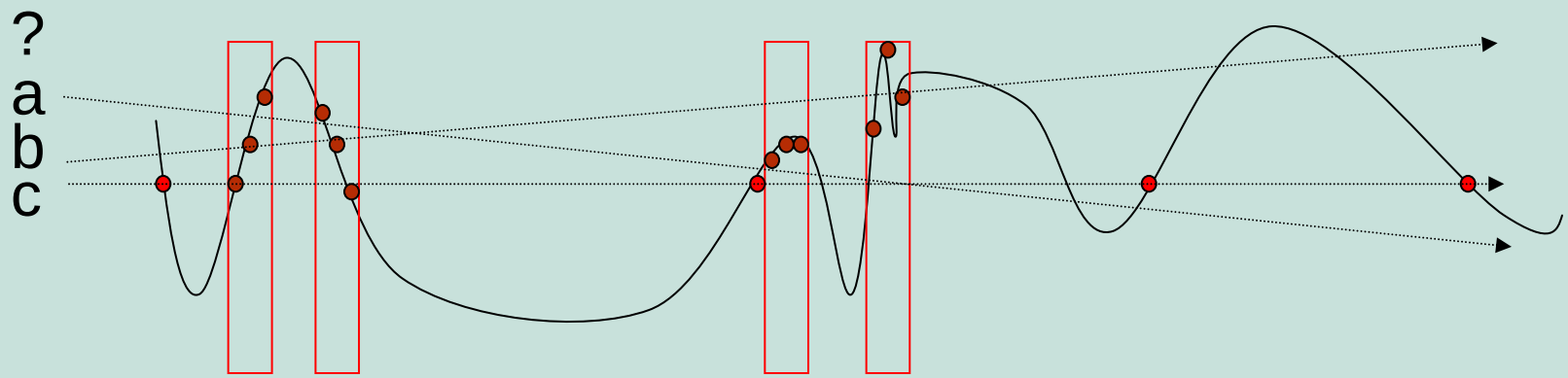
Inherent 3.

Elusive Ecological Baseline

- time of observations
  - ecological processes play out over decades, even centuries
  - short-term trajectory may give false indication of long-term trend
  - “fortuitous change” that coincides with one hypothesis can be misleading



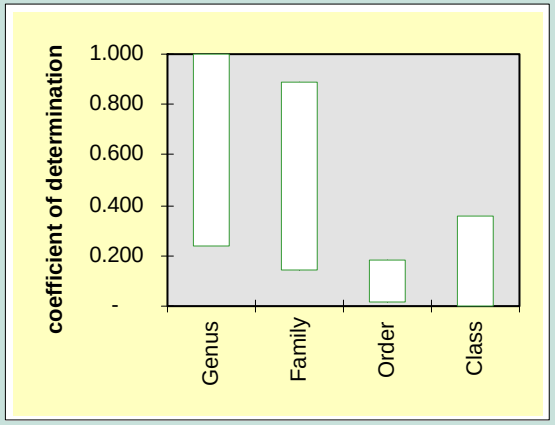
Inherent 4.

Toxicity Profiles

Biodiversity

Mammals	~ 4,000
Birds	~ 8,600
Fish	~ 40,000
Invertebrates	~10,000,000
Conifers	~550
Ferns	~13,000
Algae	~27,700
Bryophytes	~31,600
Fungi	~100,000
Angiosperms	~235,000
Bacteria	1,000s?

- Surrogate species
- Indicator Species



Range of variation expressed as coefficient of determination of EC50 values within various taxonomic levels.

Inherent 5. Exposure Conditions

- Dietary preferences
- Dietary availability
- Metabolic (caloric) demand
- Incidental ingestion (soil, sediment)
- Bioavailable fraction
- Behavioural dynamics
  - Seasonal patterns
  - Eco-regional patterns

What we don't know exceeds what we do know!

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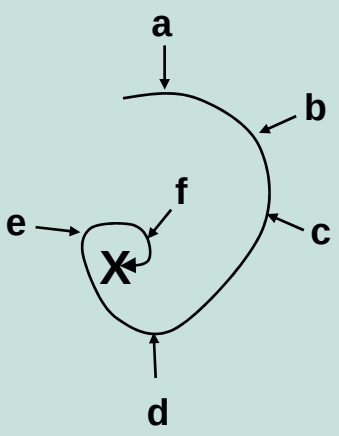
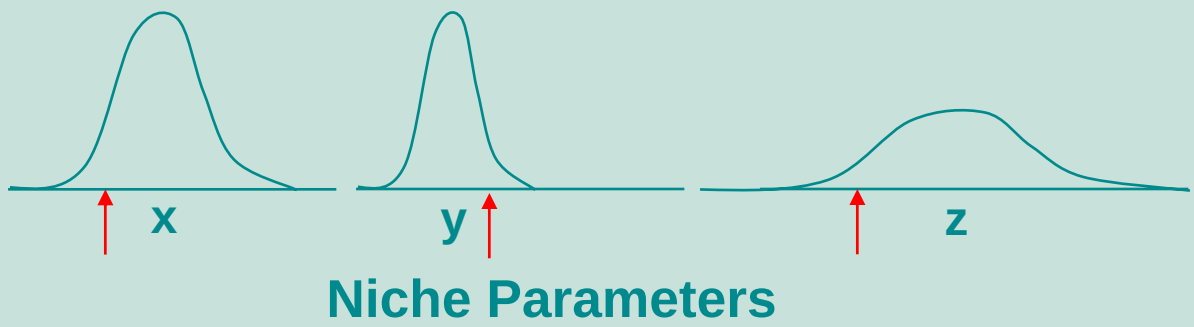
Inherent 6. Multiple Stressors

- Arguably no organism resides at the optimum position for all of its niche parameters (i.e., “stress” is a constant).
- Acclimation is an important survival mechanism for organisms – a means of finessing the effects of specific stressors.
- Adaptation is an important evolutionary mechanism that adjusts population fitness to changing environments.
- Cumulative effects of stressors confound predictive capacity regarding particular stressor effects.

Death Spiral





Inherent 7. Complex Stressors

- Certain stressors have different effects under different conditions
  - Essential nutrients
  - Acclimation regimes
  - Co-occurrence of stressors
  - Sequence of exposure

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Contrived Limitations

1. Legal/Regulatory
2. Policy/Precedent
3. Ecotheocracy
4. Point Estimates
5. Data Quality
6. Perceived Value/Perceived Cost
7. Trustworthiness

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Contrived 1.

Legal/Regulatory

- Practices specified by law
- Established regulations

Unintended consequences – potential liability promotes avoidance

Ignorance becomes a defense.

Prescriptive measures can stifle innovation or at least provide justification for minimalistic approaches.

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Contrived 2a.

Policy/Precedent

- NOAEC, LOAEC, MATC
- Hazard (Risk) Quotients
- Non-empirical Extrapolation Factors
  (a.k.a. Safety Factors, a.k.a. Assessment Factors)
- Area Use Factors
- Bioavailability
- Bioaccumulation; Bioconcentration Factors (Constants)

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Contrived 2b.

Policy/Precedent

Terrestrial Species Having Exposure Data or Habitat Models

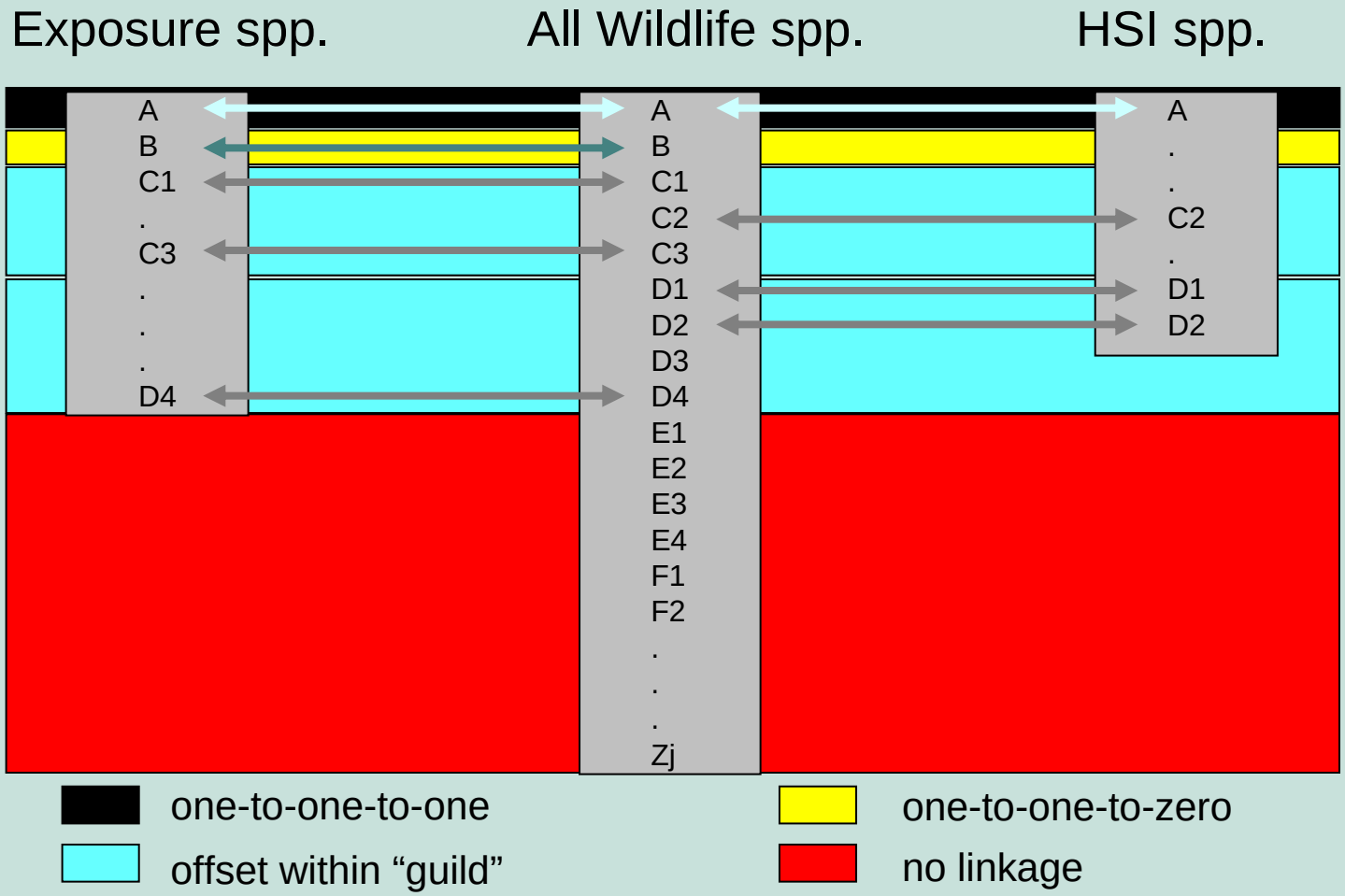
- *Exposure Handbook* species without HSI models
  (total of 198 species)
- birds – 78%
- mammals – 94%
- herpetofauna – 96%

- HSI model species without exposure parameters
  (total of 89 species)
- birds – 71%
- mammals – 79%
- herpetofauna – 67%

Contrived 2c.

Policy/Precedent

Terrestrial Correspondence Matrix
North American Taxa ~1,200



Contrived 3.

Ecotheocracy

- Derived from Clementsian views (1916)
  - Grand Design
  - Goodness of nature
  - Evil of humans
- Effectively Refuted by Gleason (1926)
- Resurrected in many circles – the catechism of Ecotheocracy:
  - Ecosystem Health
  - Integrity
  - Stability
  - Balance of Nature
  - Recovery
  - Restoration

Unacceptable as science-based assessment endpoints; inappropriate measurement endpoints!

Indefensible as a science-based effort.

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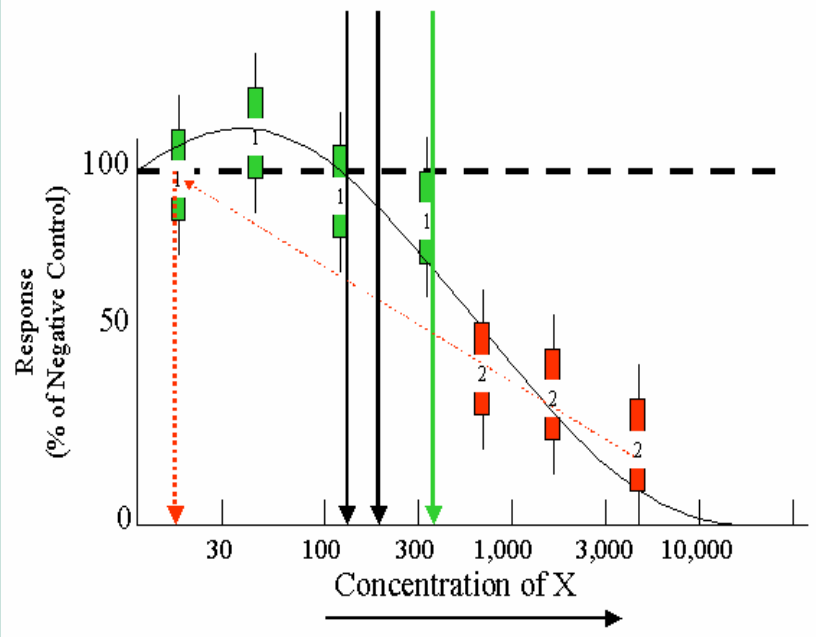
Contrived 4.

Point Estimates

- NOAEC, LOAEC, MATC
  - validity widely refuted over the past 20+ years
  - Indefensible to continue use and claim a science-based process
- Alternative point estimates are available (e.g., EC_x)
  - Even so, only appropriate for screening-level efforts; limited value in higher tiered assessments
- But, why not use all the data?



Environment Canada Standards for Plant, Microbe, and Statistics detail use of experimental designs to generate full response.

Contrived 5a. Data Quality

- Literature review experience (Eco-SSL and other)
  - Peer-reviewed literature generally unusable
    - Poor study design (Usually meant for some other purpose)
    - Poor reporting standards
  - Taxonomic diversity of terrestrial toxicity test species highly restrictive
    - Costs and animal rights pressures make it unlikely that substantially more species are added
  - Limited ability to place species accurately along species sensitivity gradient relative to test species
  - Too much data reported as point estimates
  - Unfortunately, conflicts stemming from animal rights concerns effectively preclude gathering new data.

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Contrived 5b. Data Quality

Tally of references examined pertaining to PAHs for five receptor groups.

Receptor Group	ProCite® Hits	Surviving Screen and Ordered	Acquired [a]	Passed Acceptance Criteria
plants	496	162	91	1
invertebrates	182	81	68	3
birds	509	76	40 (35)	1
mammals	4,122	283	178(139) [b]	9
herpetofauna	197	28	27 (21) [c]	0
Retention Rate		11.4%	3.2%	

[a] The number in parentheses are the number actually reviewed if fewer than acquisition number.
[b] Distributed as: rats, 71; mice, 46; other (guinea pigs, rabbits, hamsters, etc.), 22.
[c] Distributed as: amphibians, 18; reptiles, 3.

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Contrived 5c. Data Quality

Tally of references examined pertaining to CoC for plants and invertebrates					
Receptor Group	ProCite ® Hits	Surviving Initial Screen	Papers Scored	Experiments Scored	Useful Data
Antimony-Plant	300	58	0	0	0
Barium-Plant	622	60	1	2	1
Chromium (VI)-Invertebrate	1,485	121	1	1	0
Chromium (VI)-Plant	2,679	366	3	12	2
HMX-Invertebrate	40	22	3	9	2
HMX-Plant	43	9	0	0	0
Nickel-Invertebrate	1,534	94	2	7	4
Perchlorate-Invertebrate	145	6	0	0	0
Perchlorate-Plant	91	9	0	0	0
Silver-Invertebrate	749	50	0	0	0
Silver-Plant	1,350	291	1	12	4
Totals	9,038	1,086	11	43	13
Retention Rate (% of Hits)		12%	0.12%		

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Contrived 6. Perceived Value/Cost

- EcoRAs often seen as make-work effort to check a box
- Connection to management decision often obscure or lacking
  - Not seen as identifying real problems that could then be addressed through meaningful management strategies
  - Commonly there is failure to match the level of effort to the magnitude of problems being addressed

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Contrived 6. Trustworthiness

- Pre-ordained actions (decisions made in advance of EcoRA)
- Easy to game the system
- Manipulate data to “risk away” problems
- Shortage of follow-up to evaluate risk predictions
  - Monitor
  - Calibrate
  - Corroborate

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Near Term (<3 yr)

Align policies/practices with the state-of-the-science

- Use ECx for screening; complete response profile for higher tiered assessments
- Restrict HQ to screening-level assessments; use effects response relationships for higher tiered assessments
- Adopt contemporary ecological theory and practices in:
  - defining assessment endpoints
  - conducting analysis steps
  - interpreting consequences
  - proposing risk mitigation/reduction actions
- Establish focused follow-up activities to evaluate risk predictions
  - Monitoring
  - Calibration
  - Corroboration
- Promote Integration of EcoRA with Environmental Management Decision Process
- Initiate long-range research programs

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Long-range (3+ yr)

Filling Data Gaps and Moving Onward

- Wildlife Species Sensitivity Analysis
- Expand scope of EcoRAs to include biological and physical stressors explicitly (i.e., put chemical stressors in ecological context)
- Expand focus from a limited number of indicator species to larger suite of receptors
- Focus explicitly on functional ecological processes at population and community levels
- Adopt landscape-level assessments (and configure necessary regulations and policies) to approach meaningful ecological scales
  - Aggregate effects at eco-regional levels
  - Evaluate risk predictions with analyses contained in State of Environment Reports

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