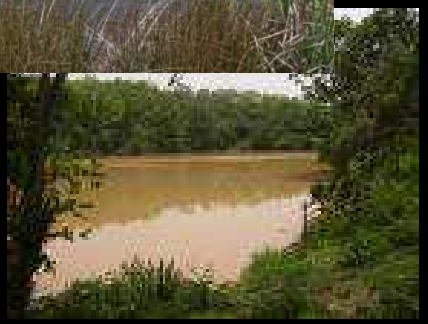
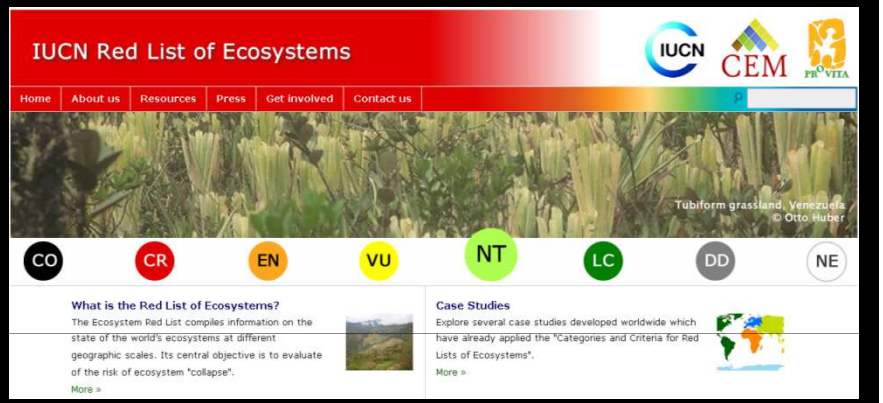
Assessing risks to ecosystems

- a new global standard

IUCN Ecosystem Red List Working Group

David Keith et al.





Major scientific challenges

I. What is an ecosystem?

II. When is an ecosystem “extinct”?
- disappearance or transformation?

III. How to assess ecosystem change?
- distribution
- function

Conservation Biology

Review

Assessing the Threat Status of Ecological Communities

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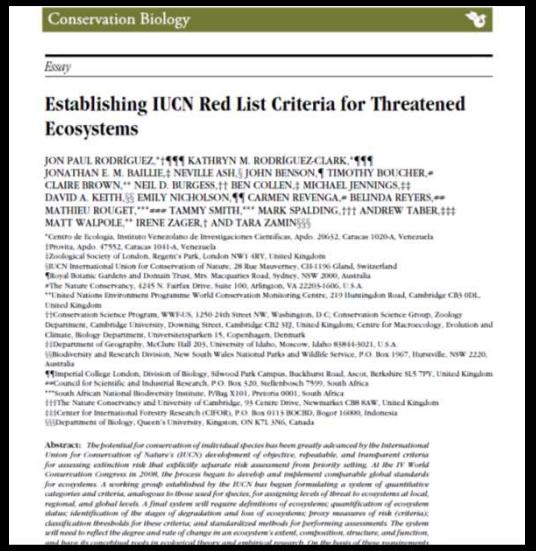
Abstract: *Conservationists are increasingly interested in determining the threat status of ecological communities as a key part of their planning efforts. Such assessments are difficult because of conceptual challenges and a lack of generally accepted criteria. We reviewed 12 protocols for assessing the threat status of communities and identified conceptual and operational issues associated with developing a rigorous, transparent, and universal set of criteria for assessing communities, analogous to the International Union for Conservation of Nature (IUCN) Red List standards for species. We examined how each protocol defines a community and its extinction and how each applies 3 overarching criteria: decline in geographic distribution, restricted geographic distribution, and changes to ecological function. The protocols vary widely in threshold values used to assess declines and distribution size and the time frames used to assess declines, leading to inconsistent assessments of threat status. Few of the protocols specify a scale for measuring distribution size, although assessment outcomes are highly sensitive to scale. Protocols that apply different thresholds for species versus communities tend to require greater declines and more restricted distributions for communities than species to be listed in equivalent threat categories. Eleven of the protocols include a reduction in ecological function as a criterion, but almost all assess it qualitatively rather than quantitatively. We argue that criteria should be explicit and repeatable in their concepts, parameters, and scale, applicable to a broad range of communities, and address synergies between types of threats. Such criteria should focus on distribution size, declines in distribution, and changes to key ecological functions, with the latter based on workable proxies for assessing the severity, scope, and immediacy of degradation. Threat categories should be delimited by thresholds that are assessed at standard scales and are logically consistent with the viability of component species and important ecological functions.*



Conservation Biology

Essay

Establishing IUCN Red List Criteria for Threatened Ecosystems

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Abstract: *The potential for conservation of individual species has been greatly advanced by the International Union for Conservation of Nature's (IUCN) development of objective, repeatable, and transparent criteria for assessing extinction risk that explicitly separate risk assessment from priority setting. At the IV World Conservation Congress in 2008, the process began to develop and implement comparable global standards for ecosystems. A working group established by the IUCN has begun formulating a system of quantitative categories and criteria, analogous to those used for species, for assigning levels of threat to ecosystems at local, regional, and global levels. A final system will require definitions of ecosystems; quantification of ecosystem status; identification of the stages of degradation and loss of ecosystems; proxy measures of risk (criteria); classification thresholds for these criteria; and standardized methods for performing assessments. The system will need to reflect the degree and rate of change in an ecosystem's extent, composition, structure, and function,*

I. Defining ecosystems

No global classification, ecosystems may be defined at various scales (raindrops – oceans)

Approach:

i) Adopt widey accepted conceptual definition (Tansley 1935)

ii) Develop a risk assessment method applicable to any classification

iii) Promote development of a global ecosystem classification

iv) Require documented ecosystem descriptions as part of each risk assessment

Describing ecosystems for assessment

Conceptual definition

(4 key elements, Tansley 1935)

1. characteristic assemblage of biota
2. associated physical environment
3. processes & interactions between components
   - among biota
   - between biota & environment
4. Spatial extent

Description template

Classification (IUCN habitats, etc)

1. List defining biotic features
2. Identify defining abiotic features
3. Describe key ecosystem drivers
4. Maps (time series, projections)
   - past, present, future

Ecosystem description – an example

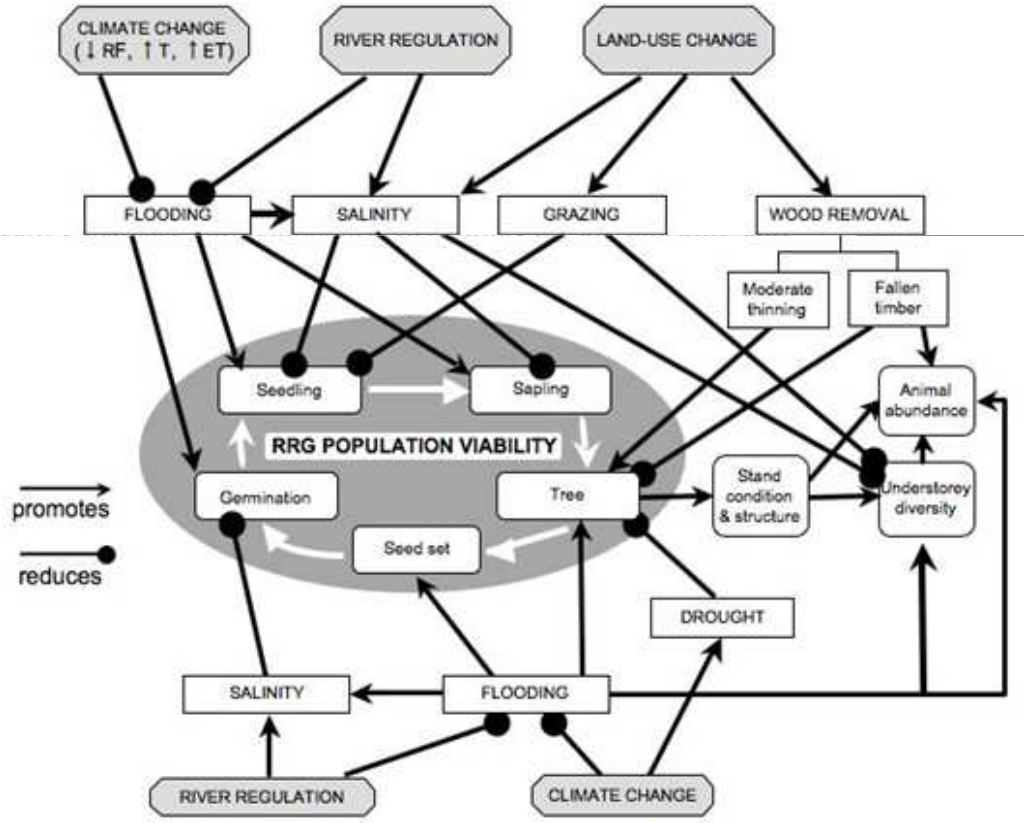
7 COOLIBAH - BLACK BOX WOODLANDS, SOUTH-EASTERN AUSTRALIA

ECOSYSTEM DESCRIPTION

Abiotic environment

Key processes and interactions

Water regimes are a key d
floods may trigger periodi
thin over time, eventually
Extended dry periods are a
process. Different plant sp
magnitude and duration an
(Roberts and Marston 200
overstorey and understorey
local flood regimes (Reid
fauna assemblages, with b
major floods associated wi
Kingsford and Auld 2005)
biota by periodically conne
dry conditions (Humphries



[source: (Mac Nally et al. 2011)].

Threatening processes

Four main processes threat
2008). First, expansion an
with crops and pastures in
for irrigation has altered fl
reducing opportunities for
Thomas 1995; Kingsford a
change may also affect the
2004). Third, invasive plan
and abundance of native bi
diversity of native ground
species has spread rapidly, in response to altered water regimes and persistent heavy livestock grazing

II. The concept of ‘risk’

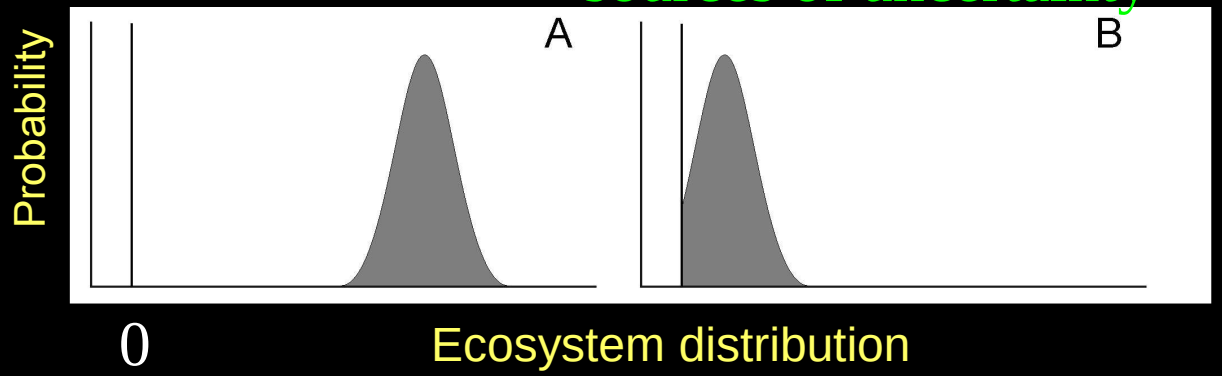
RISK – the probability of a bad outcome over a specified time frame

Define the bad outcome

- An endpoint to ecosystem decline
  - Ecosystems rarely disappear or go “extinct” (cf. species)
  - “Collapse”: transformation of identity, loss of defining features (characteristic biota & function), replacement by a novel ecosystem

Ecosystem collapse

– sources of uncertainty



Species extinction

- When is a species extinct? – when population size = 0 (Precise definition!)
- How many are there now? e.g. population size 0-50 (Uncertain measurement!)

Ecosystem collapse (distribution decline)

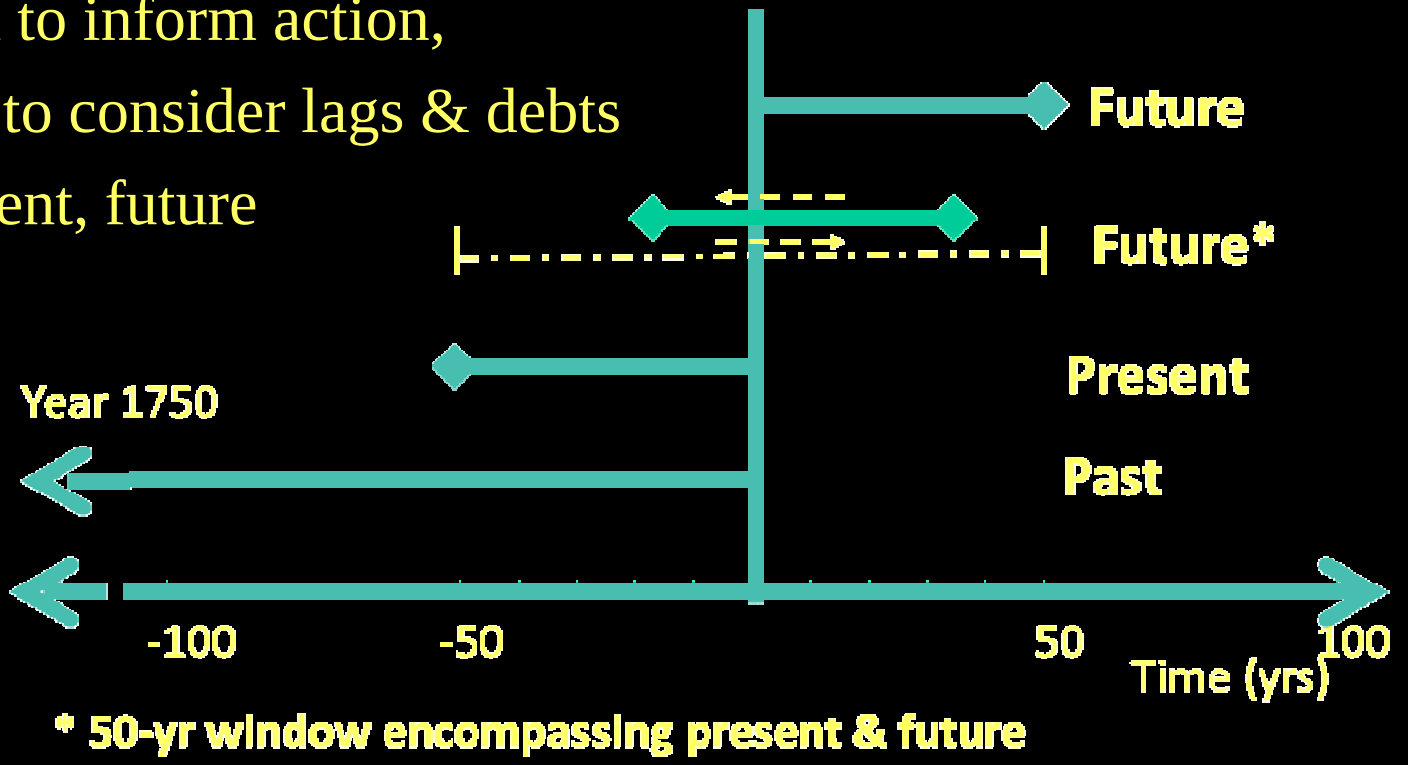
- When has ecosystem collapsed? – when distribution area = 0 (Précise définition)
- How much is there now ? – e.g. mapped area 0-50 (Uncertain measure)

II. The concept of risk

- RISK – the probability of a <u>bad outcome</u> over a specified <u>time frame</u>

<u>Specify the time frame for assessing change</u>

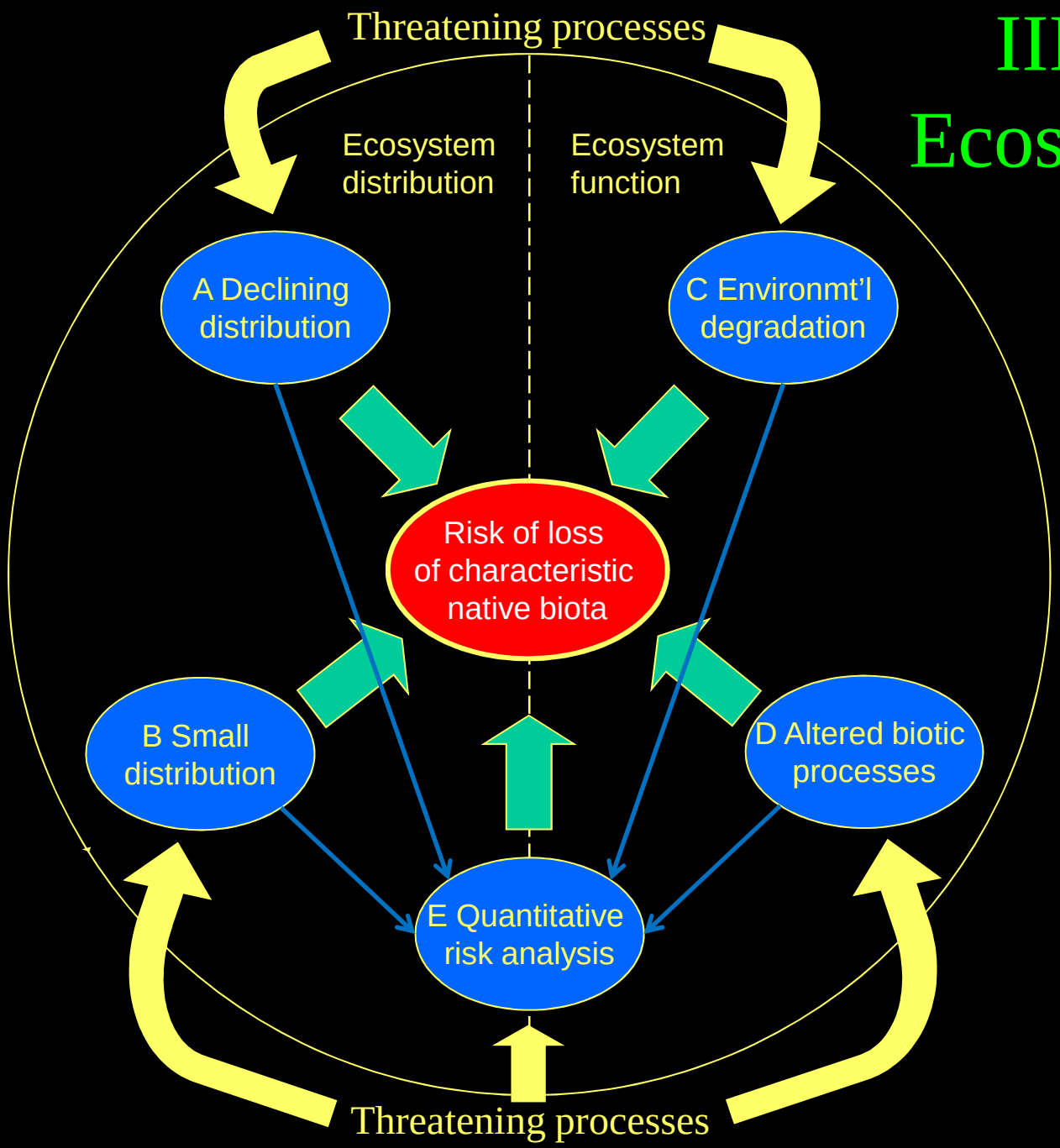
- long enough to detect trends,
- short enough to inform action,
- long enough to consider lags & debts
  - past, present, future



III. Assessing ecosystem change

Guiding principles for design of a protocol

- Evidence-based risk assessment using all available data & information
- Transparent derivation from relevant ecological theories
- Generic concepts and methods adaptable across a range of organisational & spatial scales and all ecological domains
  - terrestrial, freshwater, marine, subterranean
- Logically consistent with IUCN Red List criteria for species



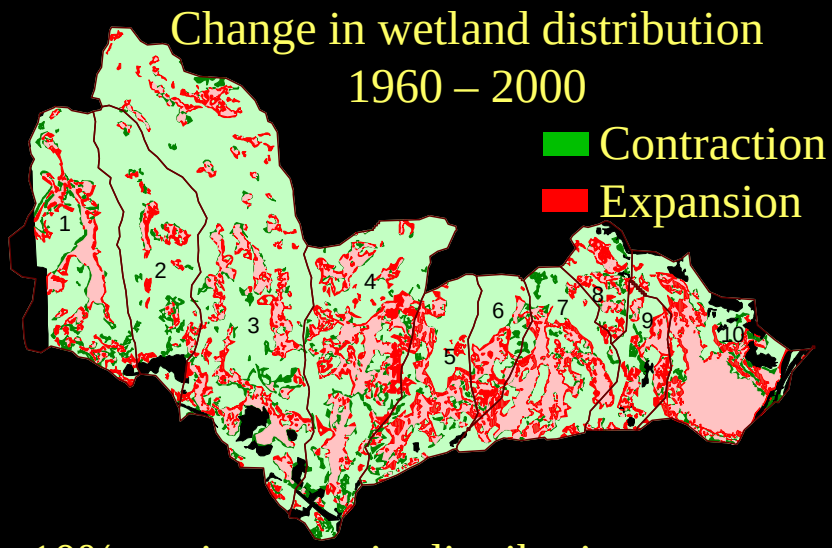
III. Assessing Ecosystem Change

Risk model for ecosystems

- threats to defining features (distribution, biota & function)
- multiple mechanisms (causes of threat)
- 4 symptoms (of decline) = 4 criteria
- plus one overarching criterion (probability of collapse)

A. Decline in distribution

Status	A1 Current (last 50 yrs)	A2 Future (next 50 yrs)	A3 Historic (since c. 1750)
CR	≥80%	≥80%	≥90%
EN	≥50%	≥80%	≥70%
VU	≥30%	≥80%	≥50%
NT	almost 30%	almost 30%	almost 50%
LC	<30%	<30%	<50%



10% net increase in distribution ~~(Keith~~ et al. 2010)

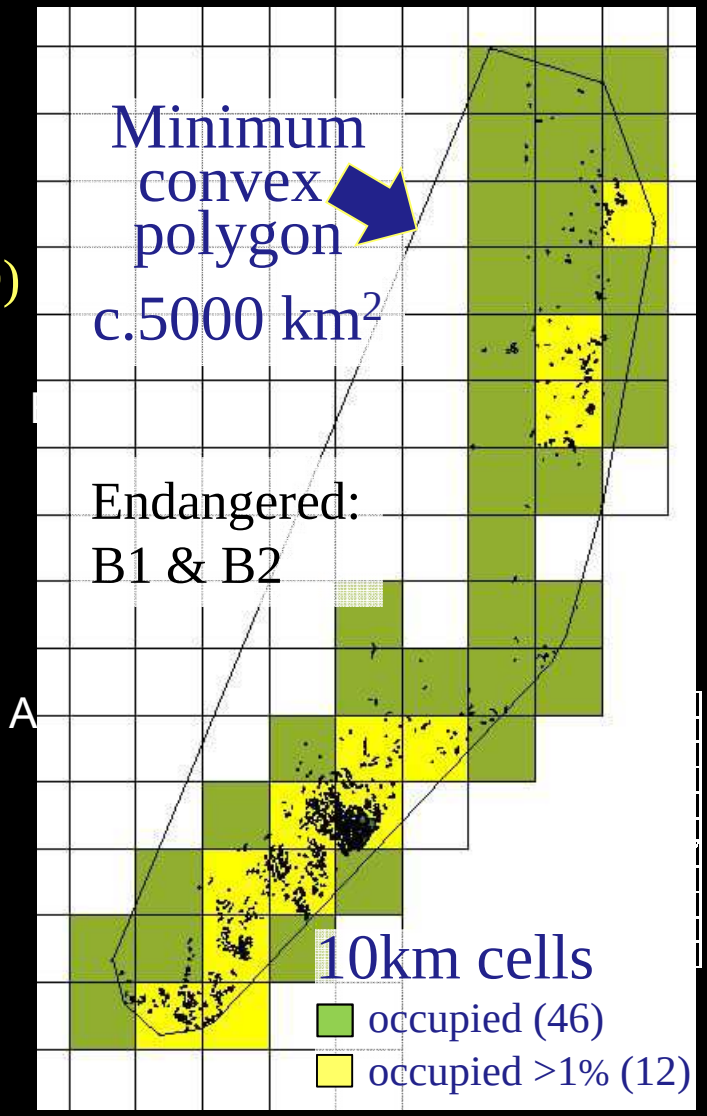
Criterion A = Least Concern

- Time series data (maps, sightings) ≥ 2 observations
- Data quality & interpretation are important
  - "garbage in, garbage out"

B. Restricted distribution

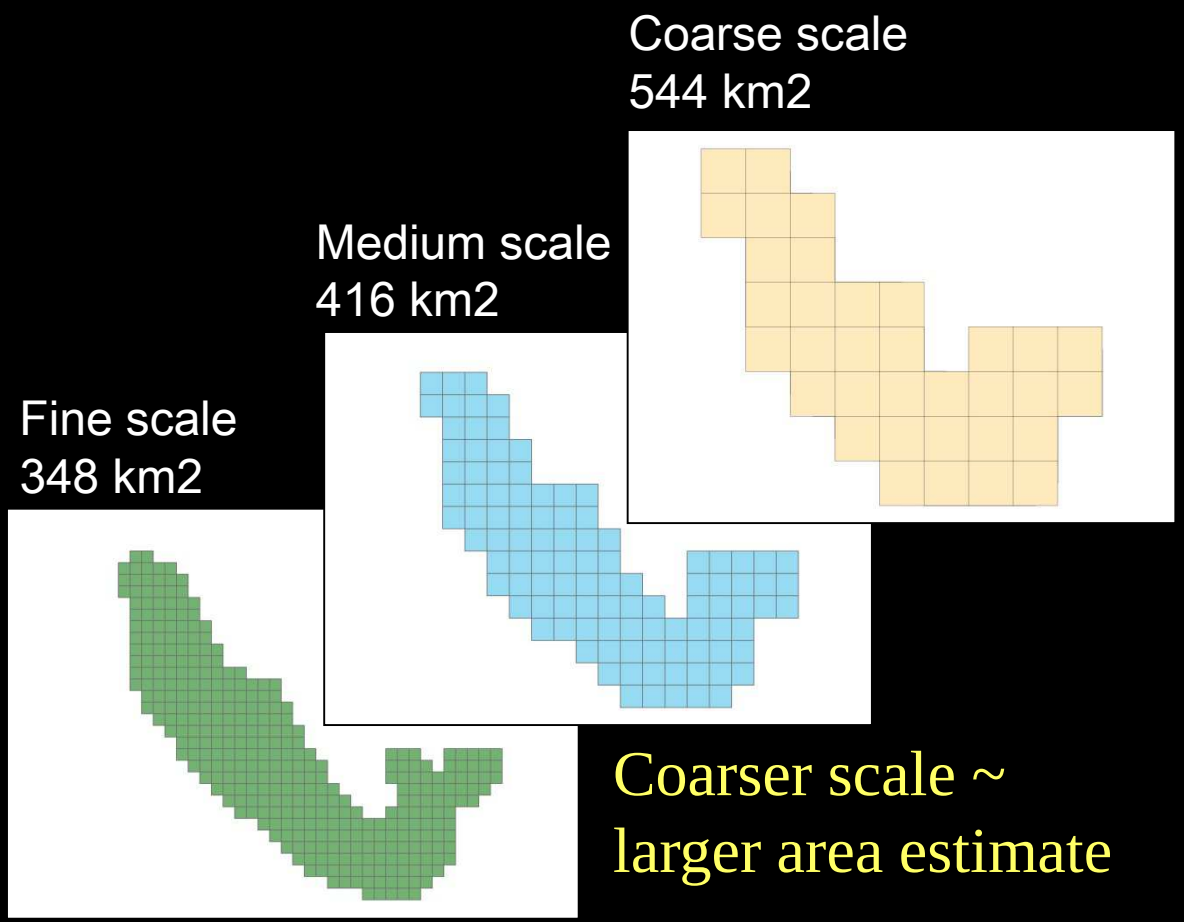
Estimating distribution size

- "risk spreading" against spatially explicit threats
- 2 metrics: polygon(EOO), grids(AOO)
- subcriteria
  - qualitative evidence of decline
- exclude small fragments
  - 1% occupancy rule
- scale-sensitive
  - standardised methods of (spatial) estimation
  - broad/fine ecosystem units



B. Estimating distribution size

Estimates of area depend on map scale
(cf. grid cell size)



Coarser scale ~
larger area estimate

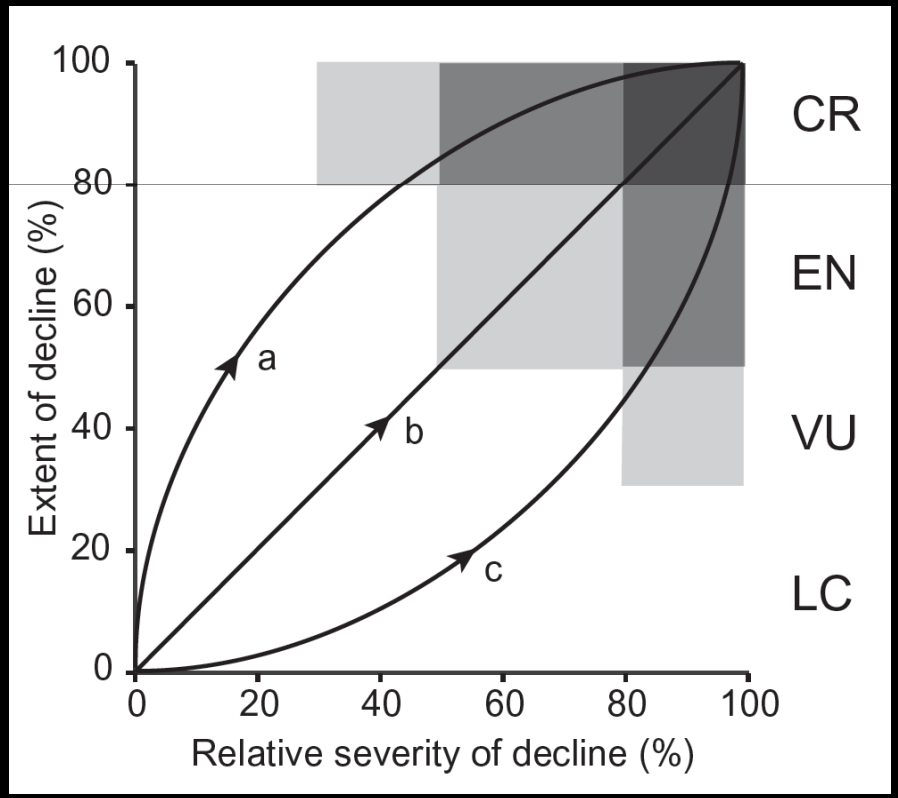
Standard methods of area measurement needed to ensure consistency

- 10 km^2 grid cells

Criteria C & D: functional decline - degradation of abiotic environment (C) - disruption of biotic processes (D)

Varied pathways of functional decline

- Relative severity
- Extent (% of distribution)
- Immediacy
  - Current
  - Future
  - Historic



Steps for assessing functional decline

1. Select one/more variables representing ecosystem function(s)
2. Estimate ‘collapsed state’
   - what value of the functional variable indicates ecosystem collapse?
3. Estimate initial state
   - what is the past value of the variable, e.g. 50 yrs ago?
4. Estimate current state
   - what is the past value of the variable?
5. Calculate range-standardised decline

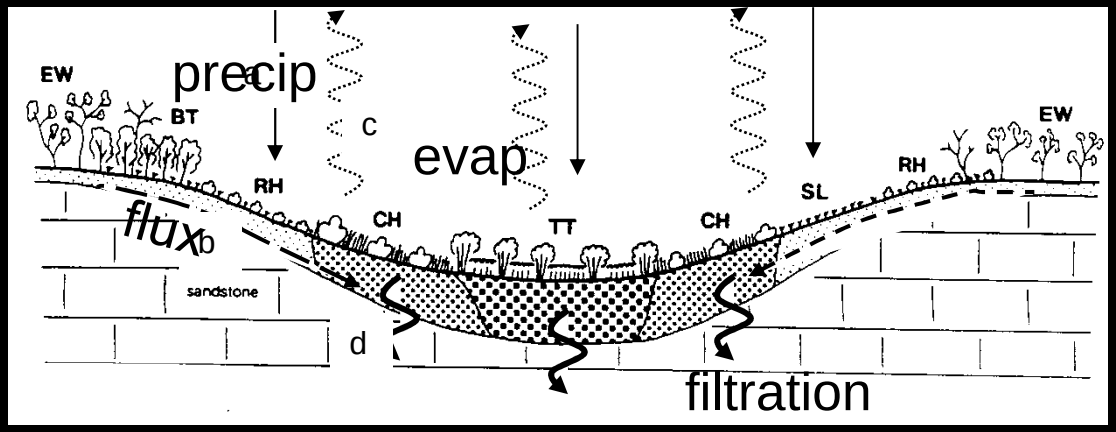
Selecting variables for assessing functional declines (C & D)

Must represent key ecosystem driver or threatening process

- Proximal variables better than indirect ones
- Ecosystem-specific variables better than generic ones
- Sensitive variables better than insensitive ones
- Choice informed by cause/effect process models

Cause – Effect Process Models

- Simple summaries of how an ecosystem works (diagrams)



Upland swamps

- water balance controls vegetation change
- variable selection (criterion C):
  - precipitation
  - evapotransipiration
  - groundwater

Cause-effect process model – Alaskan kelp forests

Killer whales → Dietary shift → Pinipeds, Great whales, Fish, Sea otters

Commercial exploitation ← Humans

Predation ↓

Urchins

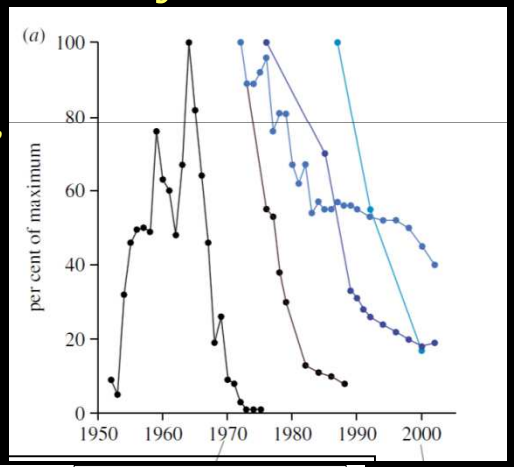
Herbivory ↓

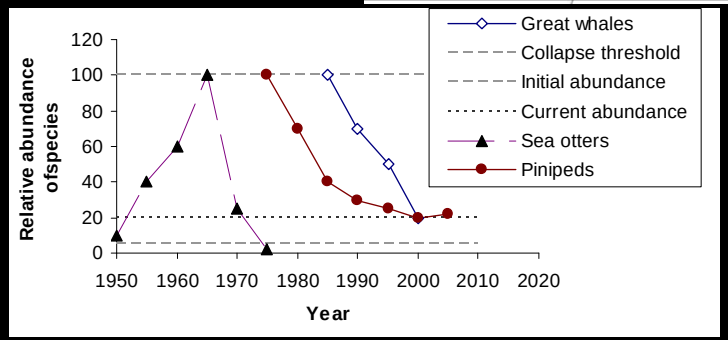
Kelp

Facilitation

Trophic cascade in Nth Pacific coastal marine ecosystem

Source:
Estes et al (1998, 2009),
Springer (2003, 2008)





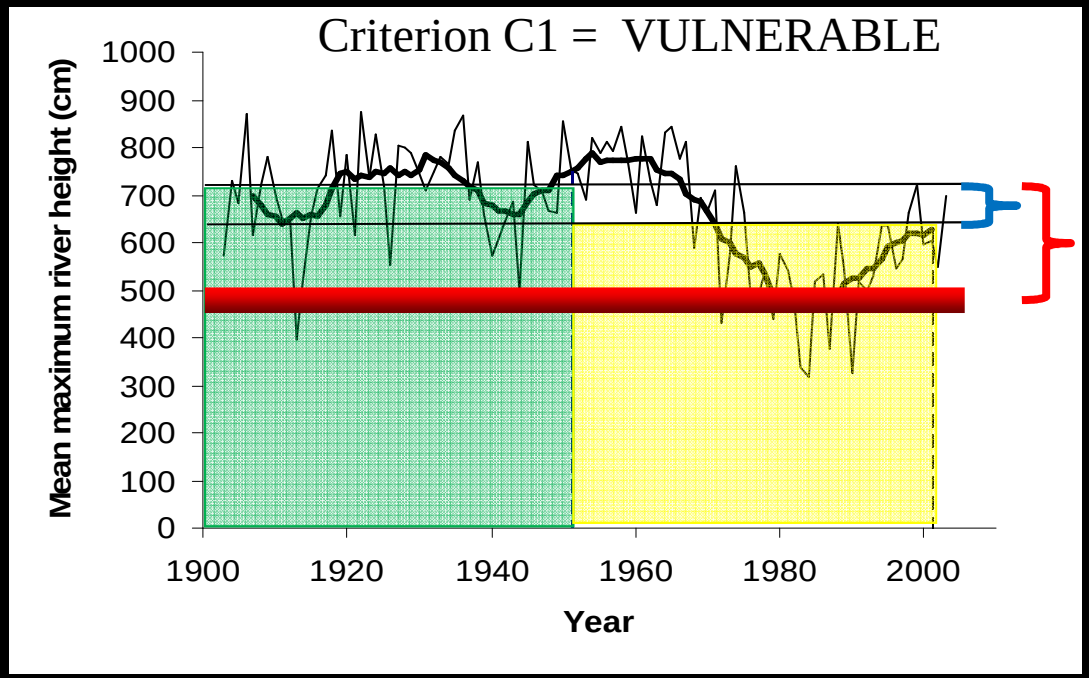
Kelp forest ⇄ Urchin barren

?

Estimating relative severity of functional decline

1. Select functional variable (mean ann max river hgt)
2. Estimate 'collapse state' (450-500 cm)
3. Estimate initial state (712 cm)
4. Estimate current state (619 cm)
5. Calculate range-standardised decline

100*(observed)/(collapsed) = 35-44% (past 50 yrs)

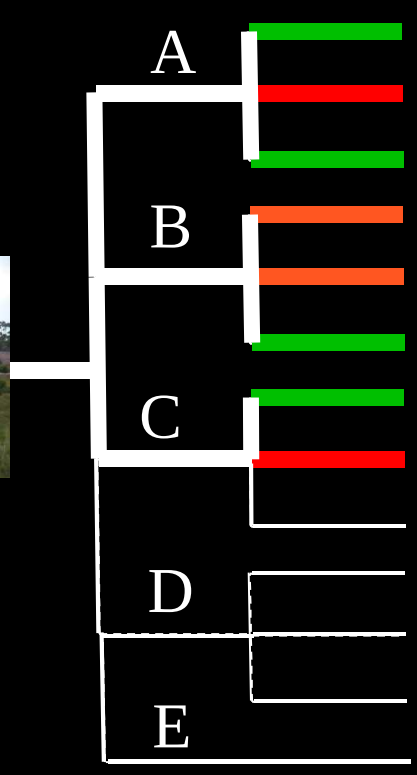


E. Quantitative analysis of risk of collapse

- Enables synthesis across all threats and mechanisms of collapse
- Ecosystem simulation models
  - Simple scalar models
  - State transition models
  - Complex flux models (trophic, energy, matter)
- Varied data requirements
- Progress: one pilot study, research proposal

Risk assessment outcomes

- Coastal upland swamps, SE Australia



LC

EN-CR contracting future distribution

LC

EN

EN

LC

LC

EN-CR declining bioclimatic habitat suitability

DD

DD

DD

DD

DD

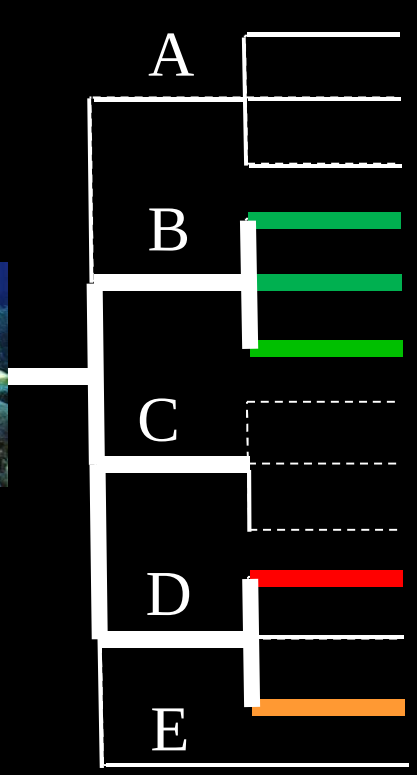
Risk assessment implicates climate change as greatest threat

- adaptation strategies

Risk assessment outcomes

- Caribbean coral reefs, west Atlantic Ocean

Photo: M.Spalding



DD
DD
DD
LC
LC
LC
NE Sea Surface Temps need further interpretation
NE
NE
VU-CR, observed decline in coral cover
DD
EN hindcast decline in coral cover
DD

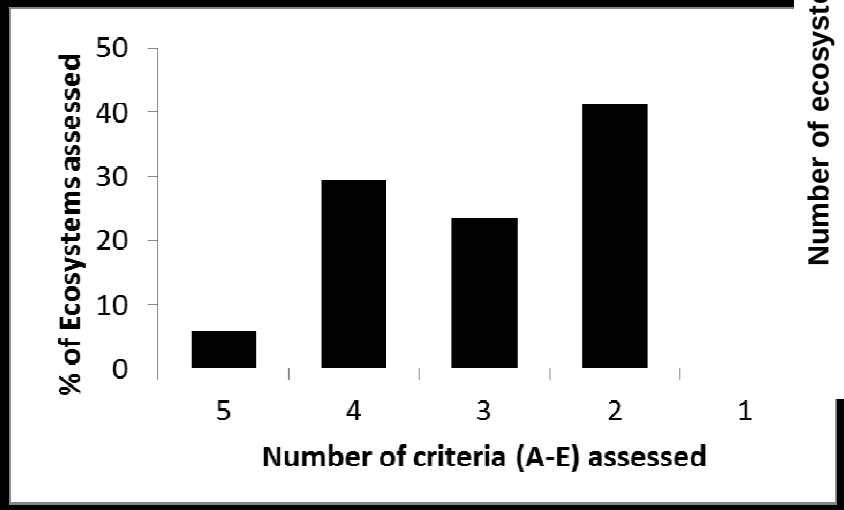
Overall status is EN-CR based on current & historic declines in coral cover

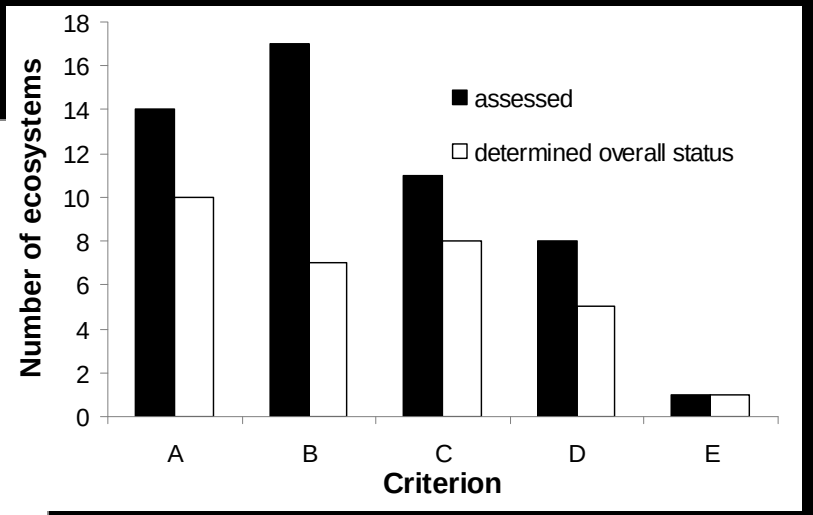
- Disease mgt, climate adaptation

Trial of Red List criteria for Ecosystems

18 detailed case studies

- terrestrial, subterranean, freshwater, marine
- Africa, Australia, Europe, North America, South America
- Data rich, data poor
- All criteria A-E





Outcomes of 8 out of 9 IUCN assessments agreed with assessments done by local authorities

Thank you

- IUCN Commission on Ecosystem Management
- MAVA Foundation
- EcoHealth Alliance
- Fulbright Program
- Smithsonian Institution, Washington DC
- Provita, Caracas
- Tour du Valat, Arles
- Australian Centre of Excellence for Environmental Decisions, Melbourne
- Centre de Suivi Ecologique, Dakar
- Many Collaborators!