Planning for persistence in marine reserves

- conservation planning with probabilities

Eddie Game

The Ecology Centre,

University of Queensland

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Australian Government

AUSTRALIAN INSTITUTE OF MARINE SCIENCE

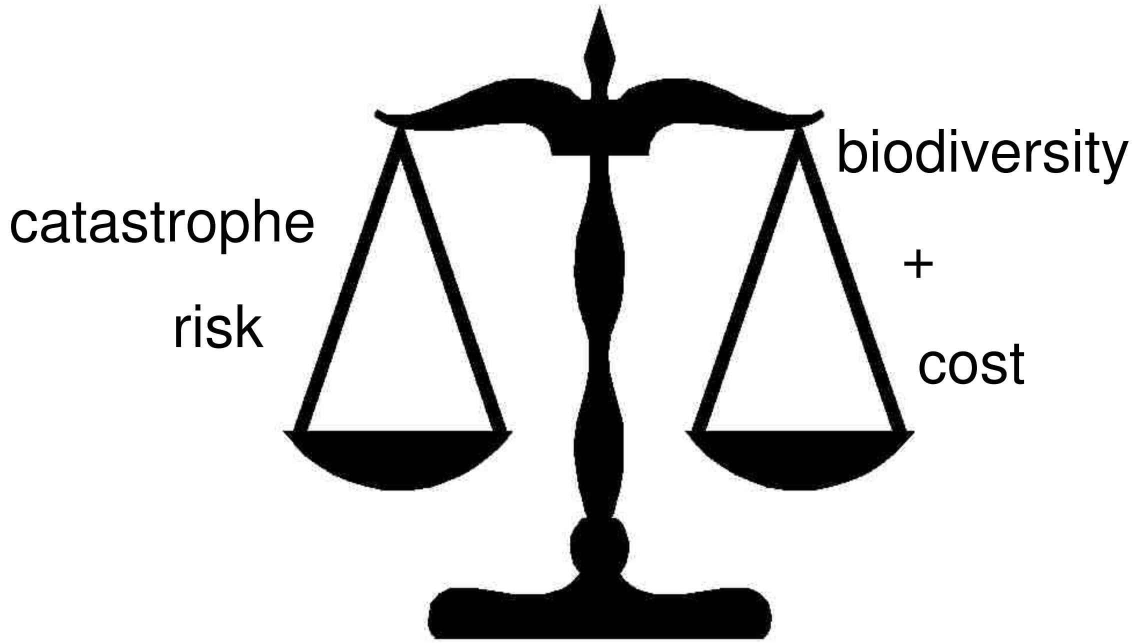
CSIRO

"catastrophes may be more important in determining persistence time than any other factor usually considered" - Mangel and Tier (*Ecology* 1994)

In 1998 and 2002 roughly 30% of GBR reefs suffered lethal bleaching

Catastrophes must be considered….

…BUT AT WHAT COST?

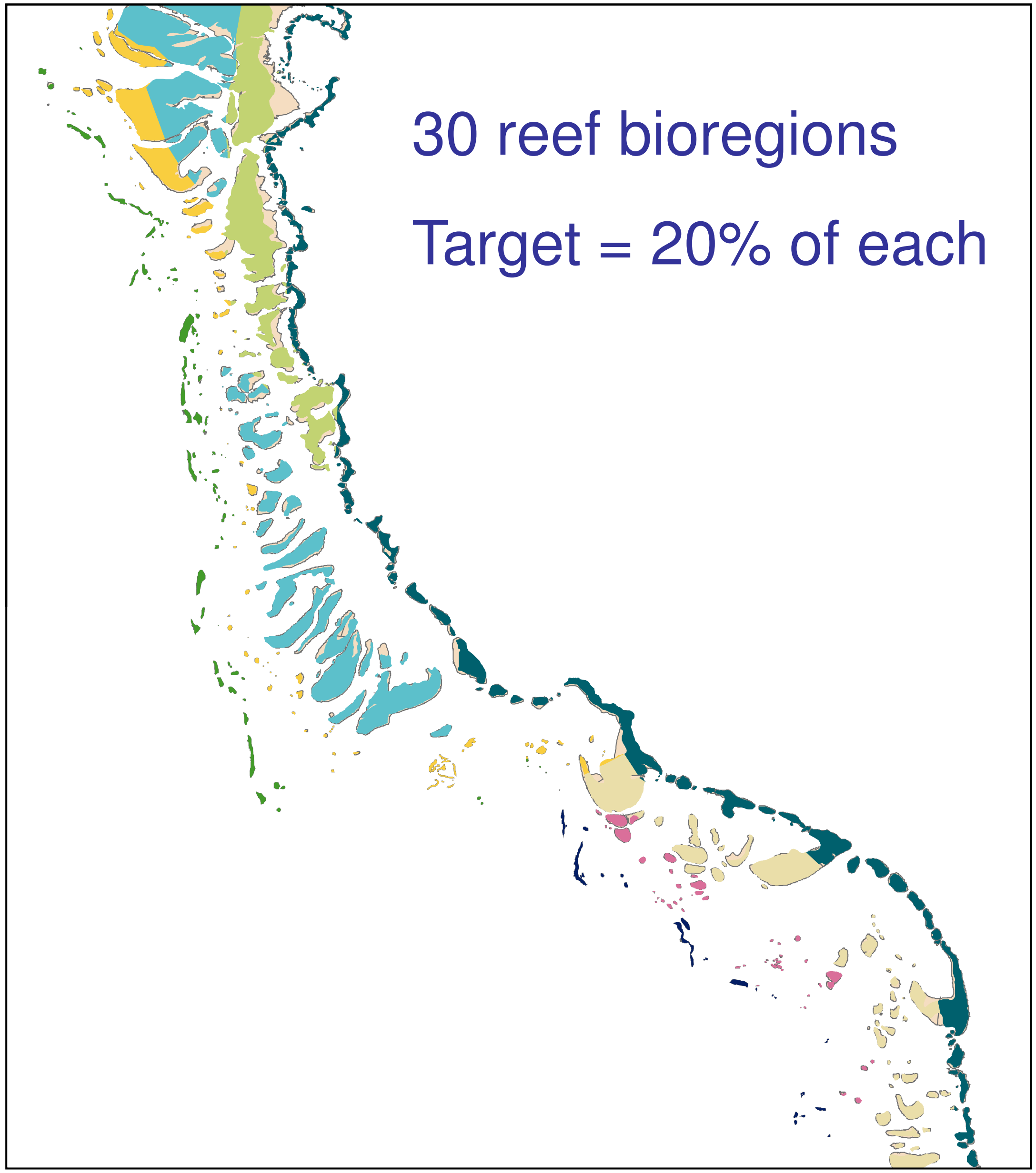


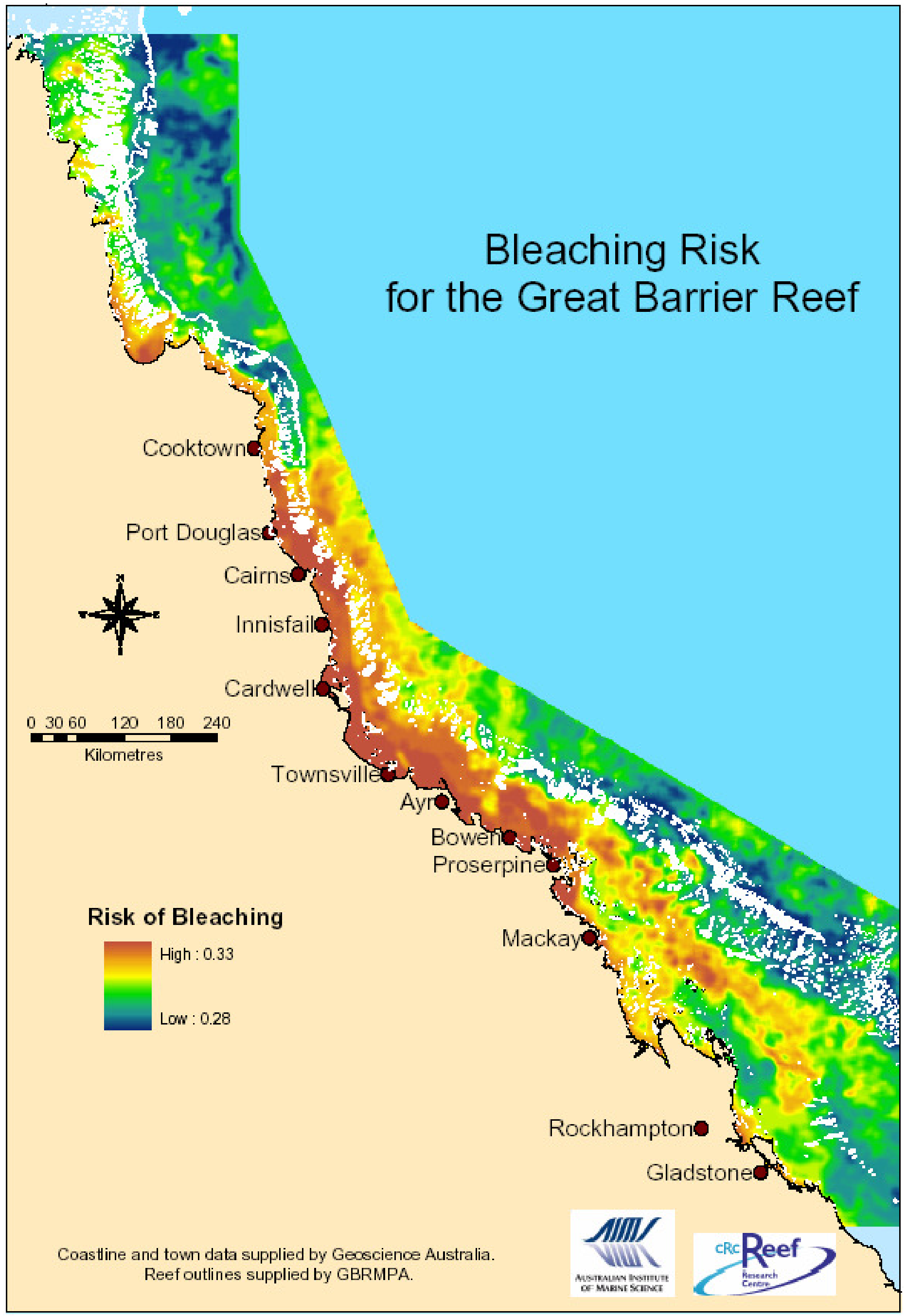
Key Point: Risk must be incorporated into the problem in a way that allows the correct trade-offs to be made!

…..enter **MarProb** (yes – creative names are our real strength)

The Problem: minimise the extent to which our conservation objectives are compromised due to uncontrollable catastrophes

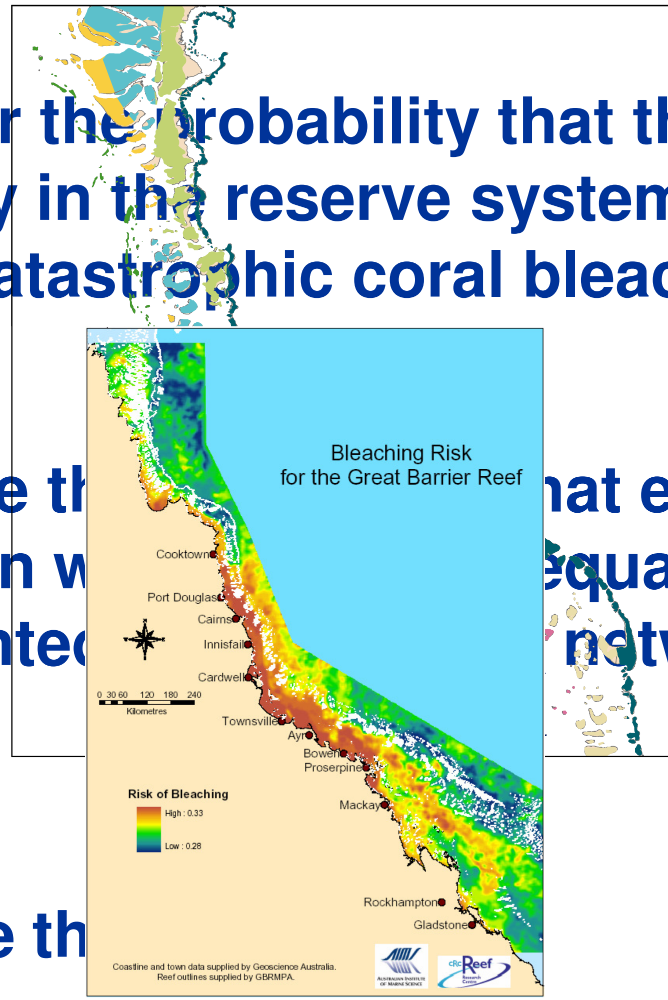
The Constraints: protect enough biodiversity and don't spend too much money


30 reef bioregions
Target = 20% of each



Bleaching Risk
for the Great Barrier Reef
Cooktown
Port Douglas
Cairns
Innisfail
Cardwell
0 30 60 120 180 240
Kilometres
Townsville
Ayr
Bowen
Proserpine
Risk of Bleaching
High : 0.33
Low : 0.28
Mackay
Rockhampton
Gladstone
Coastline and town data supplied by Geoscience Australia.
Reef outlines supplied by GBRMPA.
Australian Institute of Marine Science
CRC Reef

First calculate how much of each bioregion is represented in the reserve network



Consider the probability that the reefs currently in the reserve system will be lost due to catastrophic coral bleaching

Calculate th … hat each bioregion w … equately represente … network as a result

Minimize th

How do we solve this problem?

Old problem

min. $\sum_{i=1}^{n} c_i y_i$ s.t. $\sum_{i=1}^{n} a_{ij} y_i > t_j$

New problem = minimize risk of missing conservation targets at the end of the planning horizon due to catastrophes

min. $\sum_{j=1}^{n} \Pr(A_j < t_j)$ s.t. $\sum_{i=1}^{n} a_{ij} y_i > t_j$

s.t. $\sum_{i=1}^{n} c_i y_i \leq$ budget

SLOW!!

$E(A_j)$ the expected area of feature j conserved at the end of T

$$E(A_j) = \sum_{i=1}^{n} a_{ij} y_i E(X_i)$$

$$= \sum_{i=1}^{n} a_{ij} y_i p_i$$

The variance in the expected area of feature j conserved is given by

$$Var\left(\sum_{i=1}^{n} a_{ij} y_i E(X_i)\right) = \sum_{i=1}^{n} a_{ij}^{\ 2} y_i^{\ 2} Var(X_i)$$

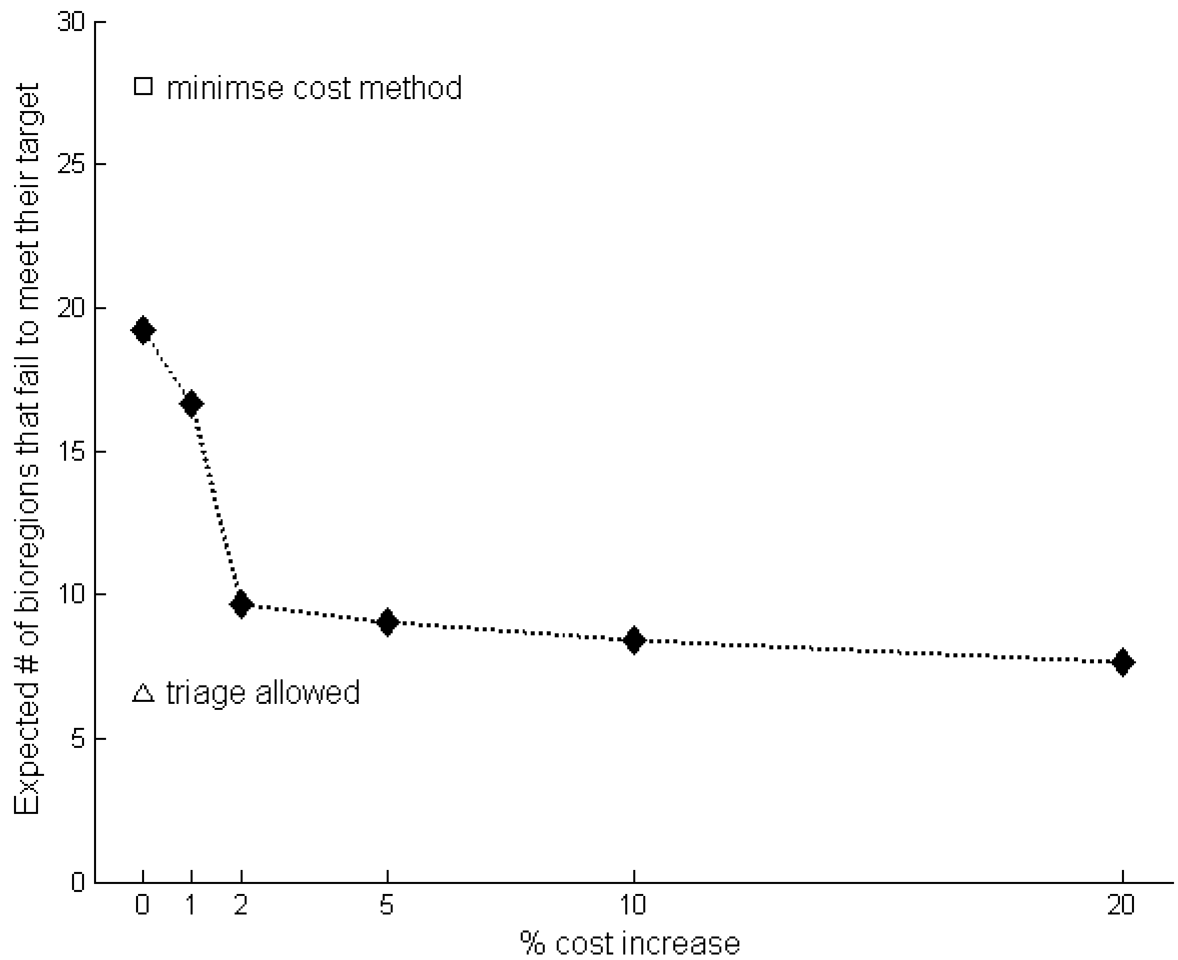
$$= \sum_{i=1}^{n} a_{ij}^{\ 2} y_i \ p_i (1 - p_i)$$

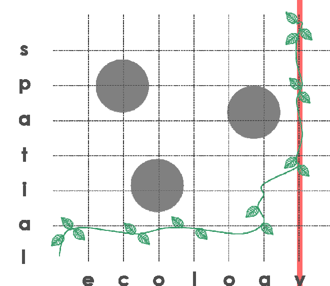
input - Notepad

File Edit Format View Help

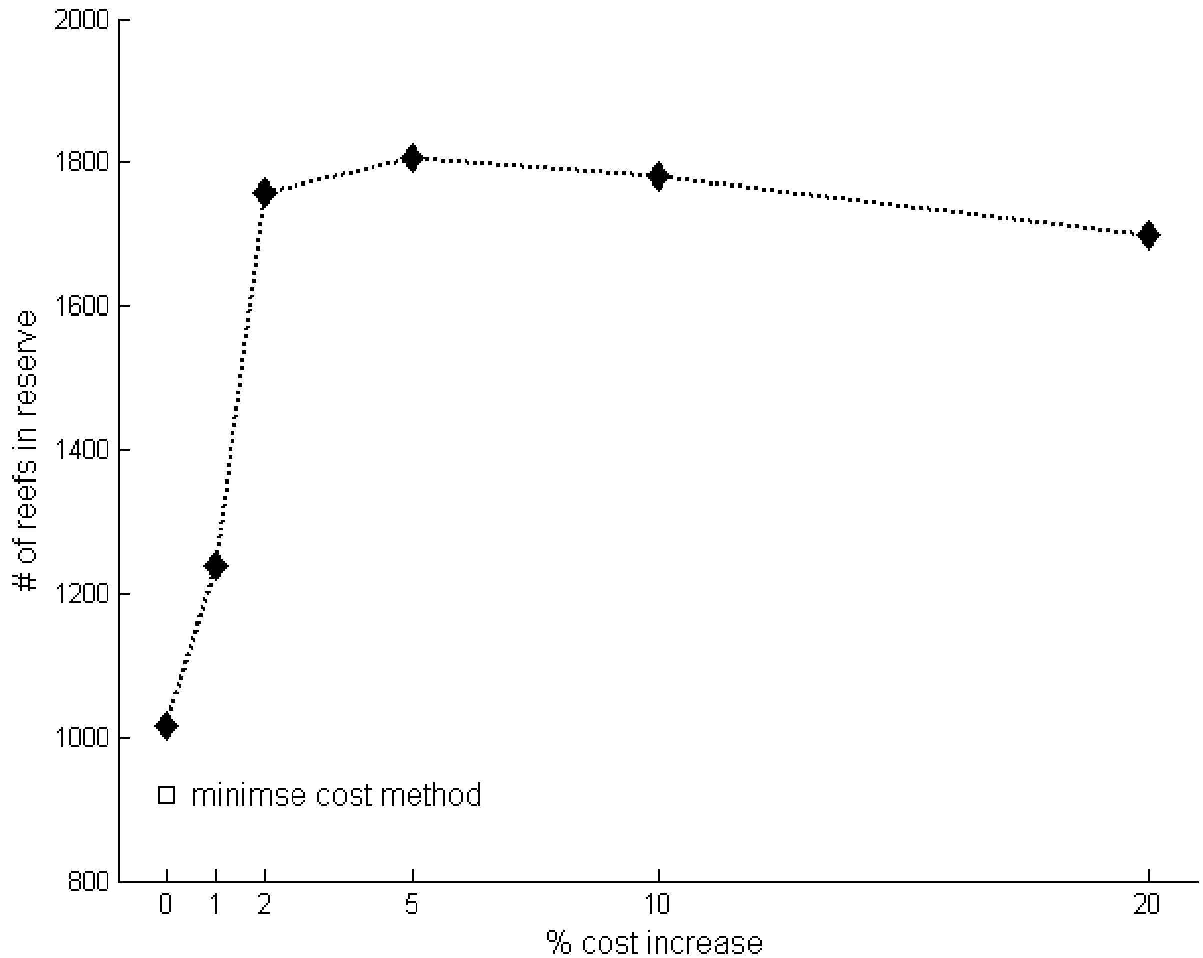
```
Input file for Annealing program.

This file generated by Inedit.exe.
written by Ian Ball and Hugh Possingham.
iball@maths.adelaide.edu.au
hpossing@maths.adelaide.edu.au

General Parameters
VERSION 0.1
BLM  0.00000000000000E+0000
PROP  0
RANDSEED -1
BESTSCORE  1.00000000000000E+0001
NUMREPS 100

Annealing Parameters
NUMITNS 10000
STARTTEMP -1.00000000000000E+0000
COOLFAC  6.00000000000000E+0000
NUMTEMP 10000

Cost Threshold
COSTTHRESH  40000
THRESHPEN1  100
THRESHPEN2  0.001
STARTDECTHRESH .1
ENDDECTHRESH 0.0001
STARTDECMULT 5
ENDDECMULT 1

Input Files
INPUTDIR input
SPECNAME spec.dat
PUNAME pu.dat
PUVSPRNAME matrix.dat

Save Files
SCENNAME output
SAVERUN 1
SAVEBEST 1
SAVESUMMARY 1
SAVESCEN 1
SAVETARGMET 1
SAVESUMSOLN 2
SAVELOG 1
SAVESNAPSTEPS 0
SAVESNAPCHANGES 0
SAVESNAPFREQUENCY 23
OUTPUTDIR output

Program control.
RUNMODE 1
MISSLEVEL 1
ITIMPTYPE 0
HEURTYPE -1
CLUMPTYPE 0
VERBOSITY 2
PROBABILITYWEIGHTING 100
```

good solutions are not necessarily expensive



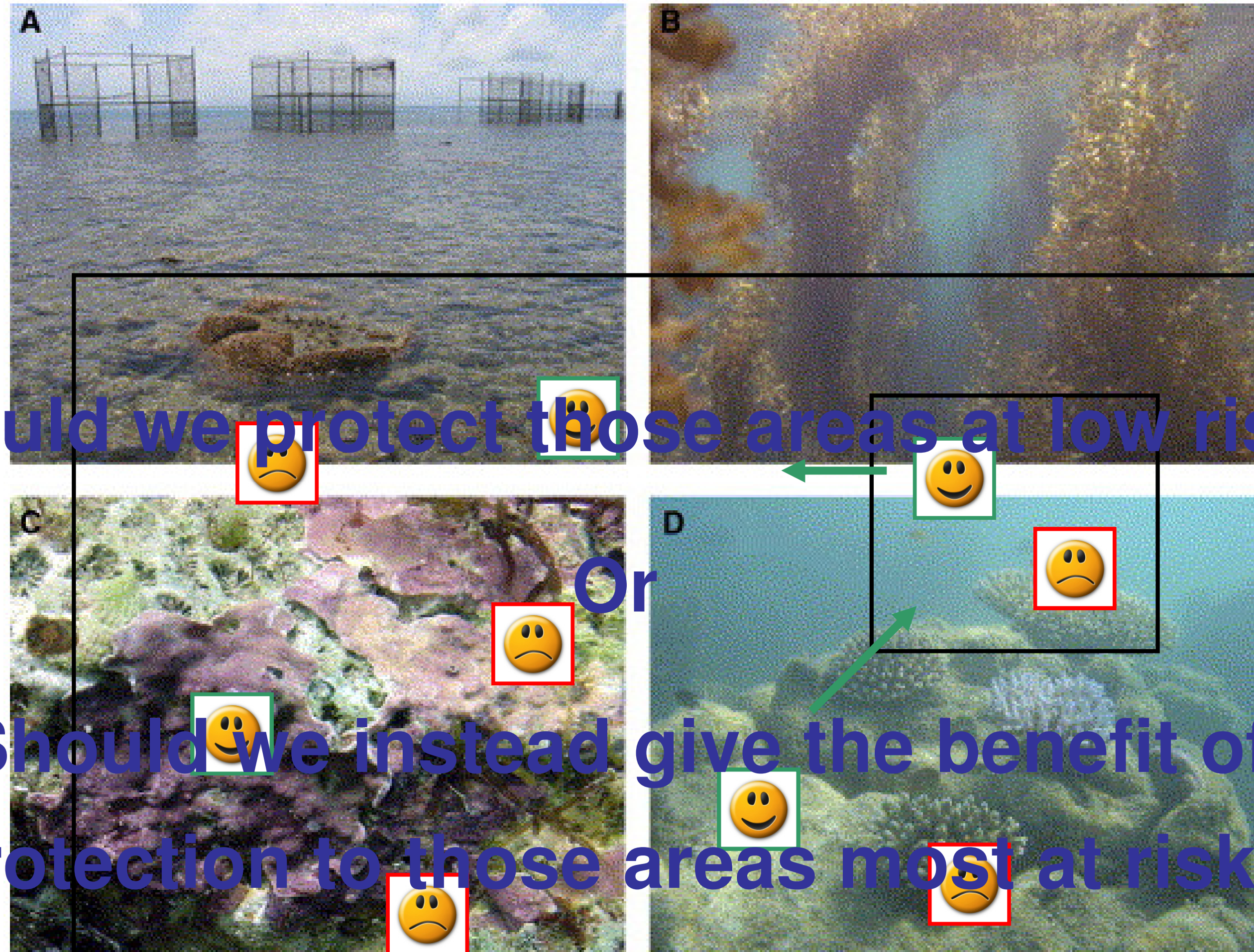


low risk sites are not necessarily the best



Can be used for any problem where we have data on relative risk of threats or future changes

- Changes in Pantanal flood regime with climate change (Brazil)
- Patchy pelagic resources (Namibia + Australia)
- Risk of land degradation through salinity and invasive weeds (Australia)



Should we protect those areas at low risk?

Or

Should we instead give the benefit of protection to those areas most at risk?

Figure 1. Hughes et al. 2007