ARC Centre of Excellence
Coral Reef Studies

Expert elicitation of a Bayesian Belief Network for the Great Barrier Reef

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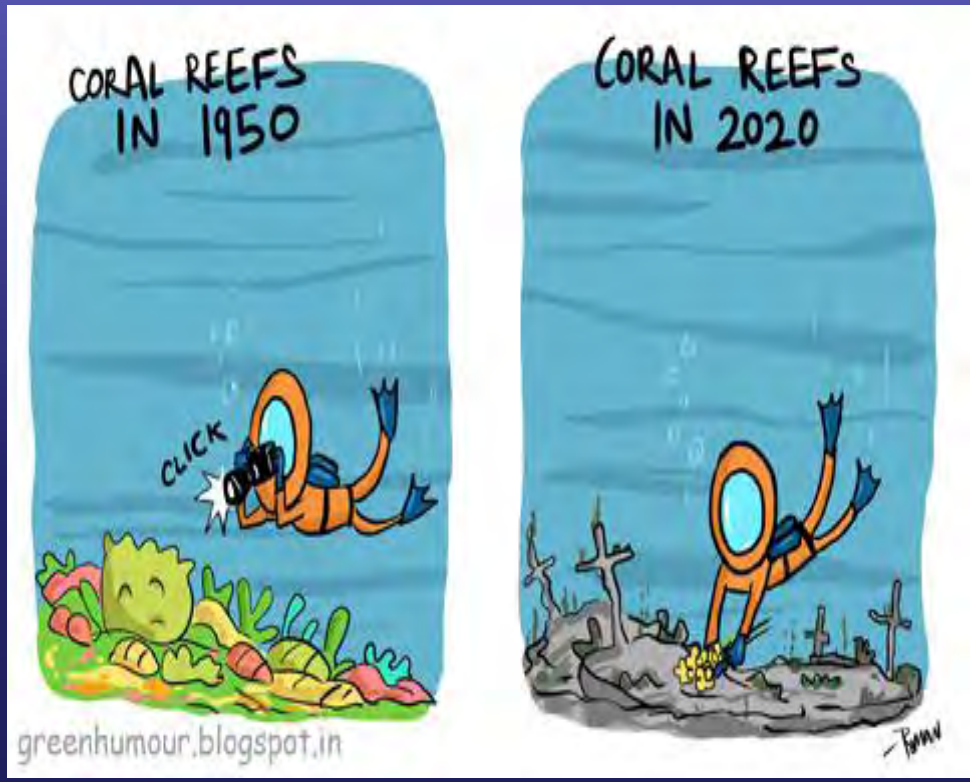
www.coralcoe.org.au

Coral reefs under threat

- Climate change
  - Increased temperatures
  - Severe storm frequency
  - Flood events
  - Disease
- Fishing pressure
- Coastal development/agriculture
  - Eutrophication
  - Sedimentation
  - Chemical pollution



Combined effects of two stressors on Kenyan coral reefs are additive or antagonistic, not synergistic

En

View On

EDITORIAL

PERSPECTIVE

Limnol. Oceanogr.,

STRESSORS

Multiple

Synergy or antagonism—interactions between

T. P.

COMMENT

Depar

XINHAO WANG§

J. H.

Depar

Interactions between stressors on coral reefs: analytical approaches, re-analysis of old data, and different conclusions

ressors

Comment on Dunne (2010)

ord[2]

M. P. Lesser

Relevance to management

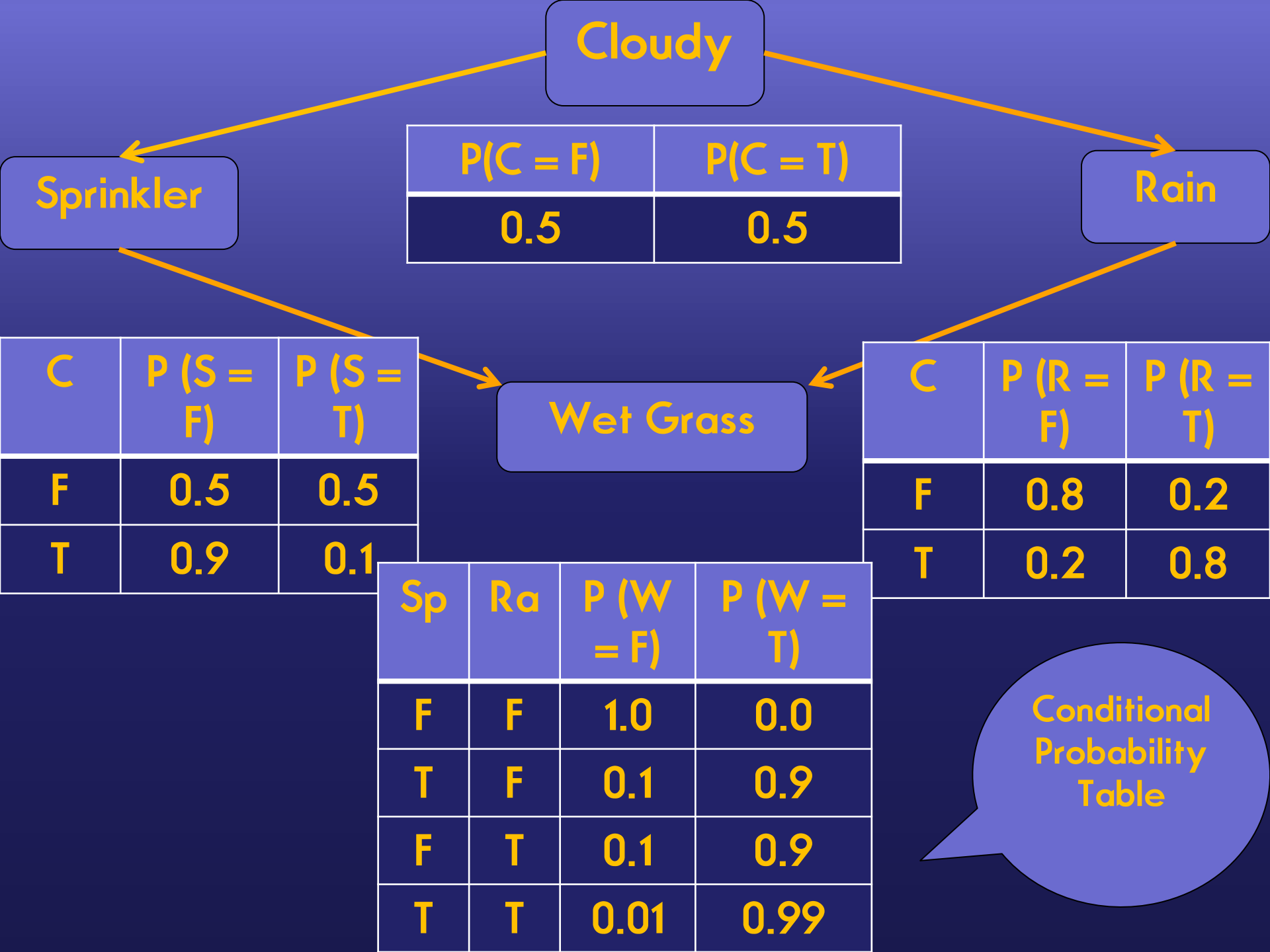
- Regulatory limits set for isolated stressors
- Identification of synergistic effects may allow more efficient mitigation
- Mapping of stressor effects to prioritize areas of concern

What are experts' perceptions about knowledge gap(s), and can they help fill them?

- Complexity increases exponentially with number of stressors
- Amount of data on specific interactions vanishingly small
- If time and resources are limited, is there a rapid way to assess threats and prioritize management actions?

Bayesian Belief Networks

- Bayesian methods:
  - Incorporate prior beliefs/knowledge
  - Make probabilistic predictions about the state of the world
- BBNs are a decision-support tool
  - A BBN is a way of conceptualizing a system
  - Does not require specialist skills; the users are designers
  - Outputs readily interpretable by laypeople
  - Designed to incorporate uncertainty


Cloudy
Sprinkler
Rain
Wet Grass
P(C = F)
P(C = T)
0.5
0.5
C
P (S = F)
P (S = T)
F
0.5
0.5
T
0.9
0.1
C
P (R = F)
P (R = T)
F
0.8
0.2
T
0.2
0.8
Sp
Ra
P (W = F)
P (W = T)
F
F
1.0
0.0
T
F
0.1
0.9
F
T
0.1
0.9
T
T
0.01
0.99
Conditional Probability Table

Why use expert elicitation?

- "We are faced with two options: we can either throw up our hands in despair and wait until we have an adequate theory enabling us to deal with socioeconomic and political problems as confidently as we do with problems in physics and chemistry, or we can make the most of an admittedly unsatisfactory situation and try to obtain the relevant intuitive insights of experts and then use their judgments as systematically as possible" – Helmer, 1967

Methods

- From literature, construct initial model
- Select initial expert pool based on publications, then snowball
- Use four-point elicitation method for probabilities
- Obtain point estimates for scenarios

4-step question format

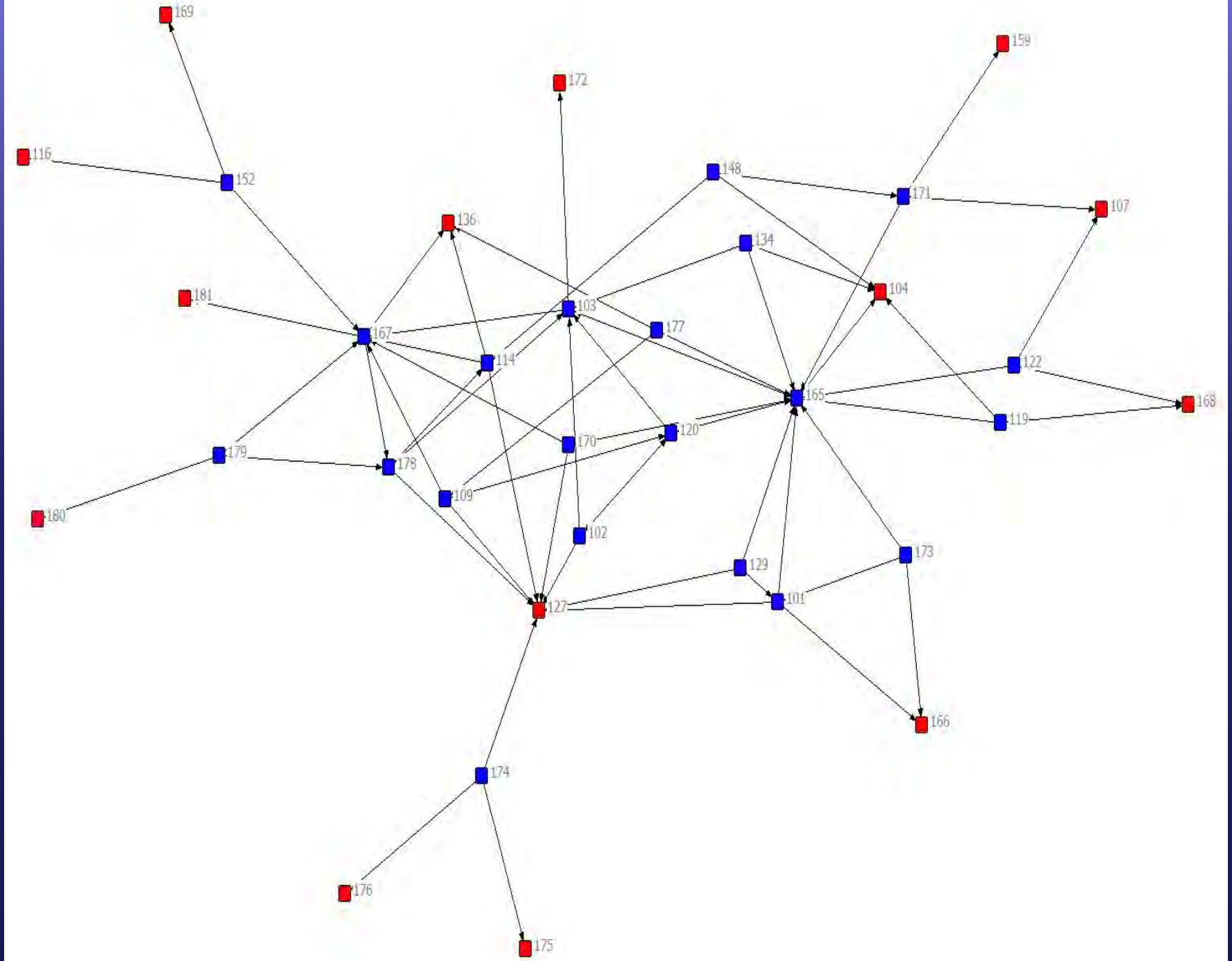
1. Realistically, what do you think the lowest plausible value is?

2. Realistically, what do you think the highest plausible value is?

3. Realistically, what is your best estimate?

4. How confident are you that the interval you created, from lowest to highest, could capture the true value? Select a number between 50 and 100%

Speirs-Bridge et al., 2010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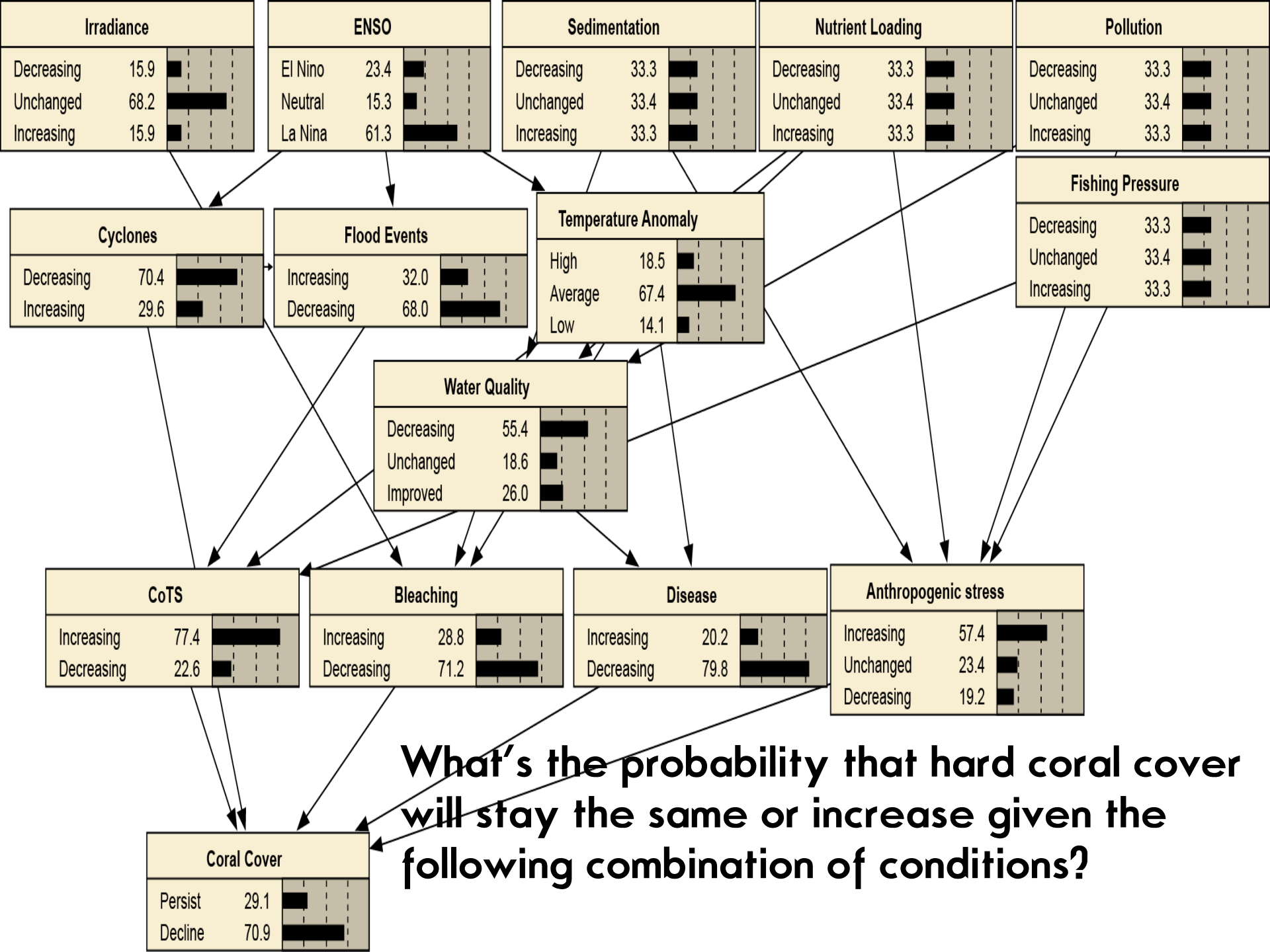
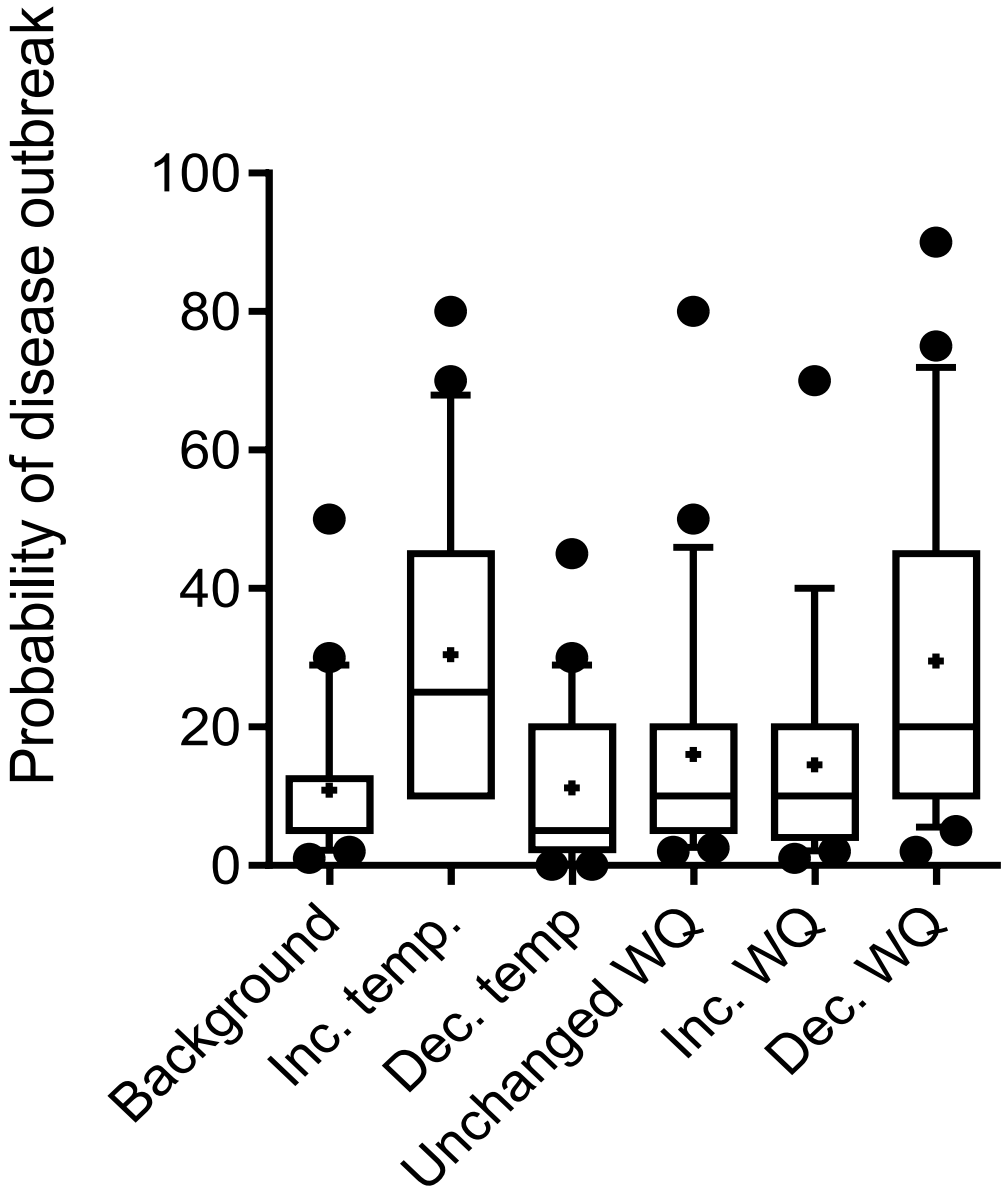
Scenarios

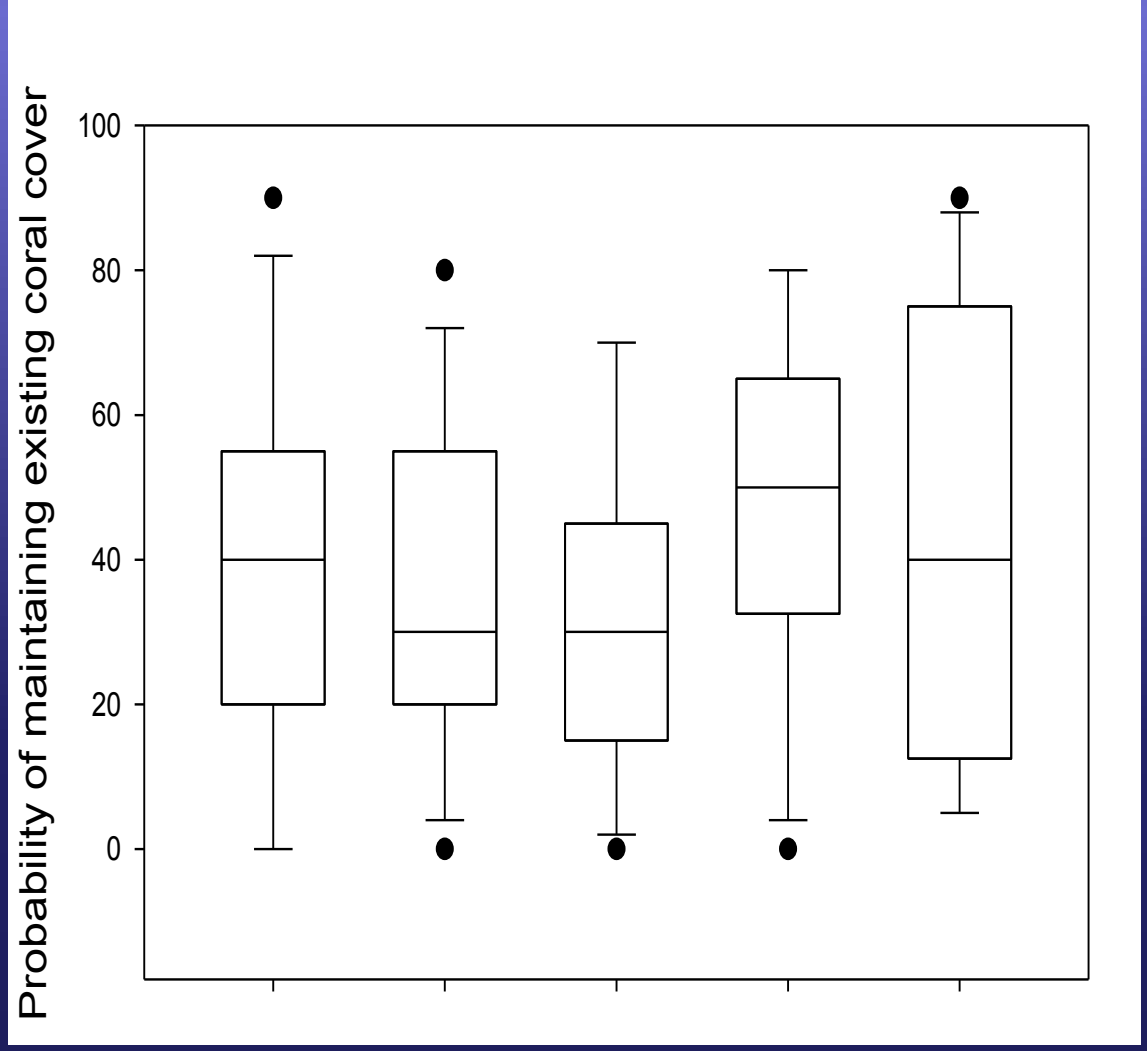
- Baseline
- Climate change
  - Increased flood plume extent
  - Increased temperature
  - Increased cyclone frequency
- Climate change + management
  - Decrease nutrient, sediment, pollution load
  - Decrease fishing pressure outside reserves
- Management only

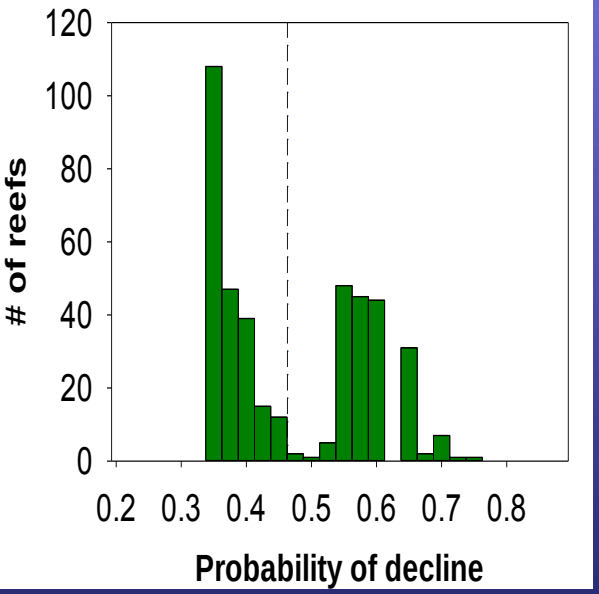


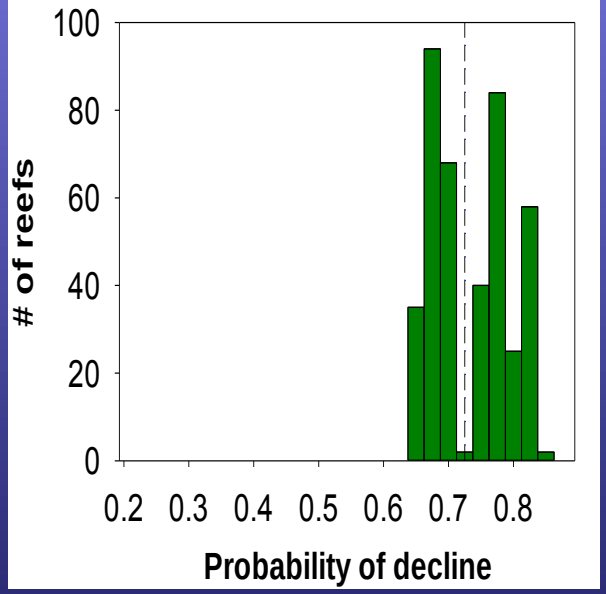
What's the probability that hard coral cover will stay the same or increase given the following combination of conditions?

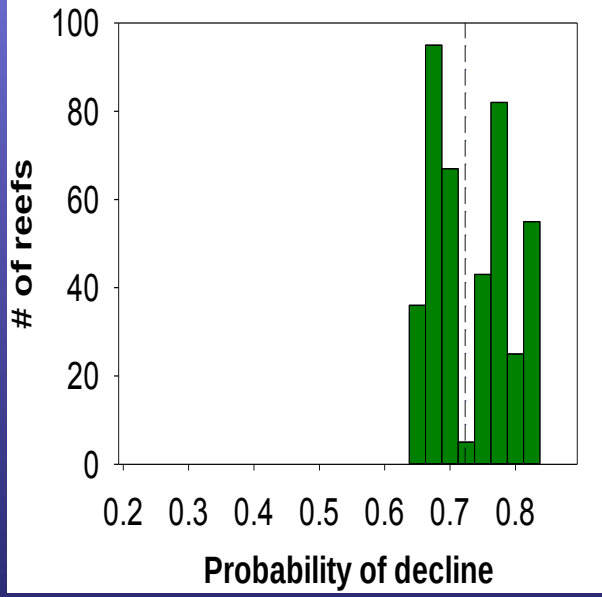
Stressor-disease relationship estimates




Probability of maintaining existing coral cover
100
80
60
40
20
0
Cyclones
CoTS
Bleaching
Disease
Anthropogenic Stress



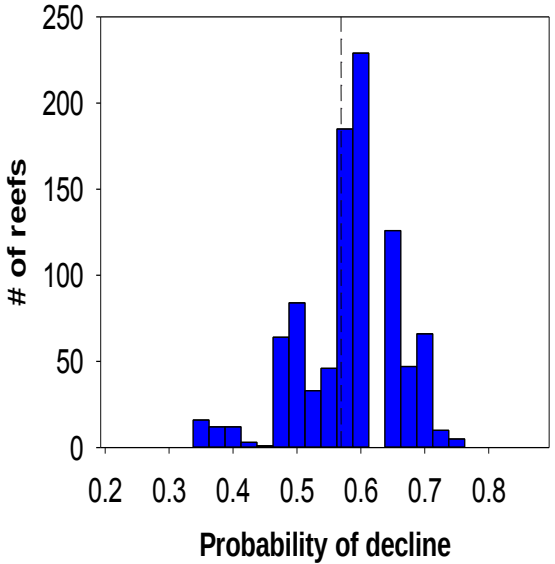


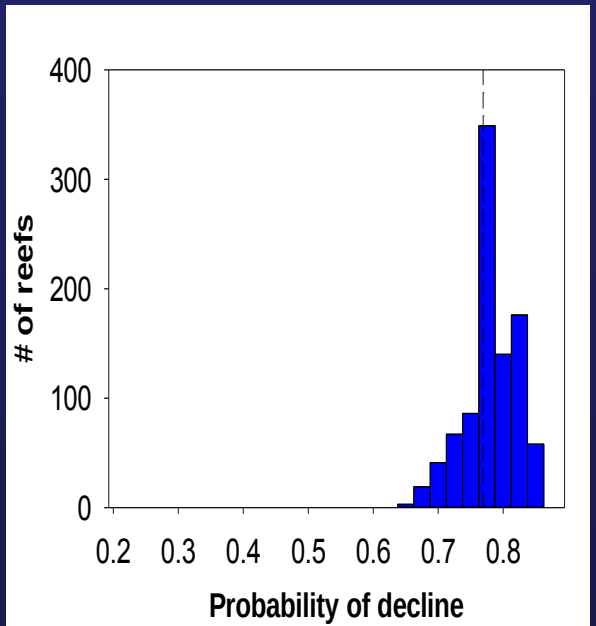


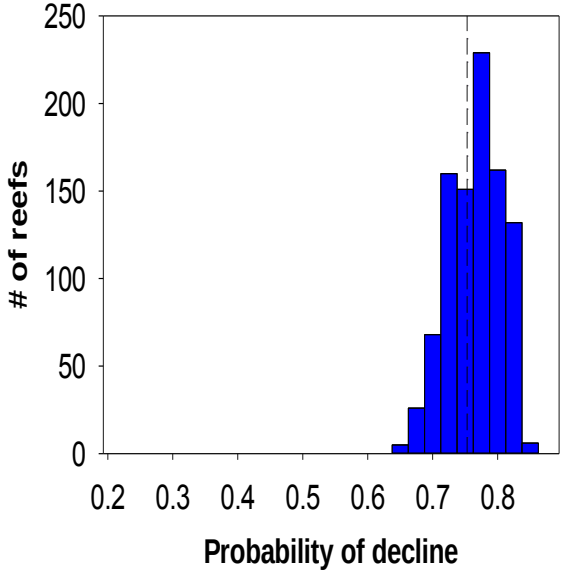
Baseline

Climate change

CC + Management








Teluk Cendrawasih
Port Moresby
Daru Island
Arafura Sea
Coral Sea Islands
Coral Sea
Espiritu Santo
Port Vila
New Caledonia
Van Diemen Gulf
Gulf of Carpentaria
Beagle Gulf
Queensland
Bribie Island
Great Dividing Range
Northern Territory
Great Sandy Desert
Australia
New South Wales
Lake Eyre
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
© 2013 Whereis® Sensis Pty Ltd
Google earth

Conclusions

- Consensus trajectory for the GBR is not optimistic
- Opinion divided over water quality effects on bleaching and disease
- Manageable stressors made little difference to probability of decline
- Challenge is validating the model

What are the implications of multiple stressor interactions for coral reef conservation?

- Broad-scale stresses increasing on Great Barrier Reef
  - Mass bleaching
  - Disease
  - Coastal development
- Climate change adaptation may involve local management

Acknowledgements