# The ghost of adaptive management


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# What is Adaptive Management?

Learning by doing

- Walters, C., and C. S. Holling. 1990. Large-scale management experiments and learning by doing. Ecology **71**:2060-2068.
- Walters, C. J. 1986. Adaptive management of renewable resources. MacMillan, New York, New York, USA.

1. Management with a plan for learning
2. Trial and Error?
3. A coherent strategy for management in the face of uncertainty
4. Why so few good examples?

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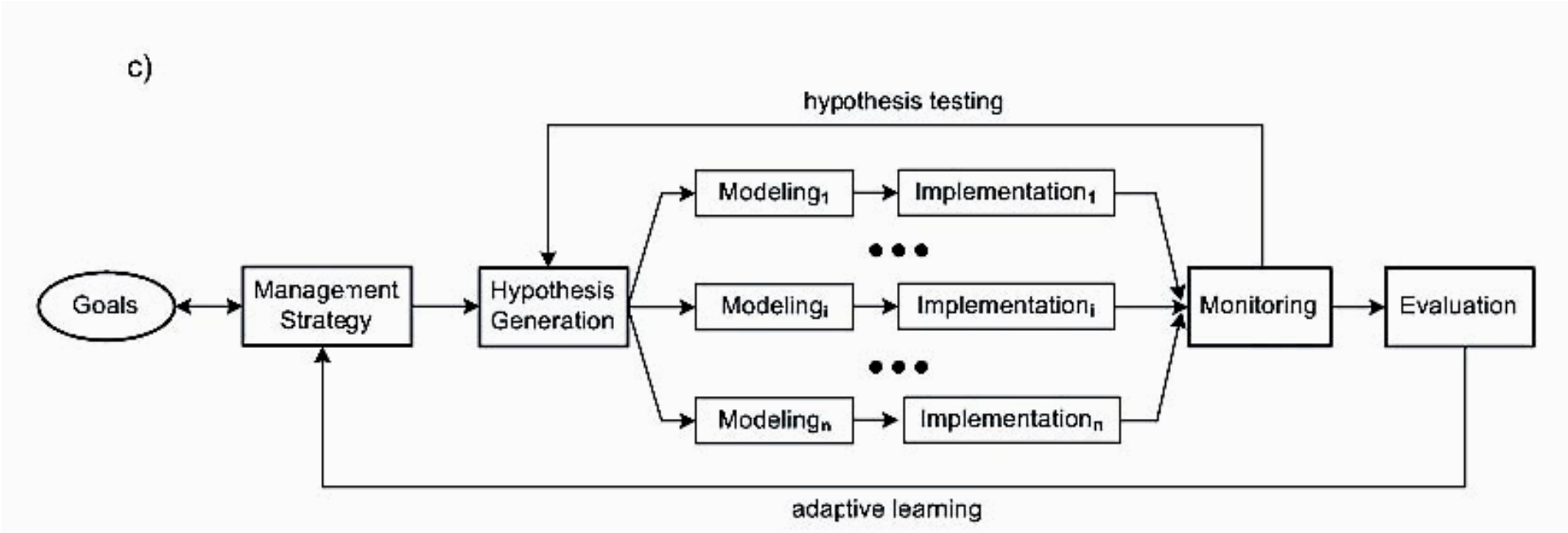
# Adaptive management

Linkov *et al.* 2006 Integ. Env. Ass. Manag't

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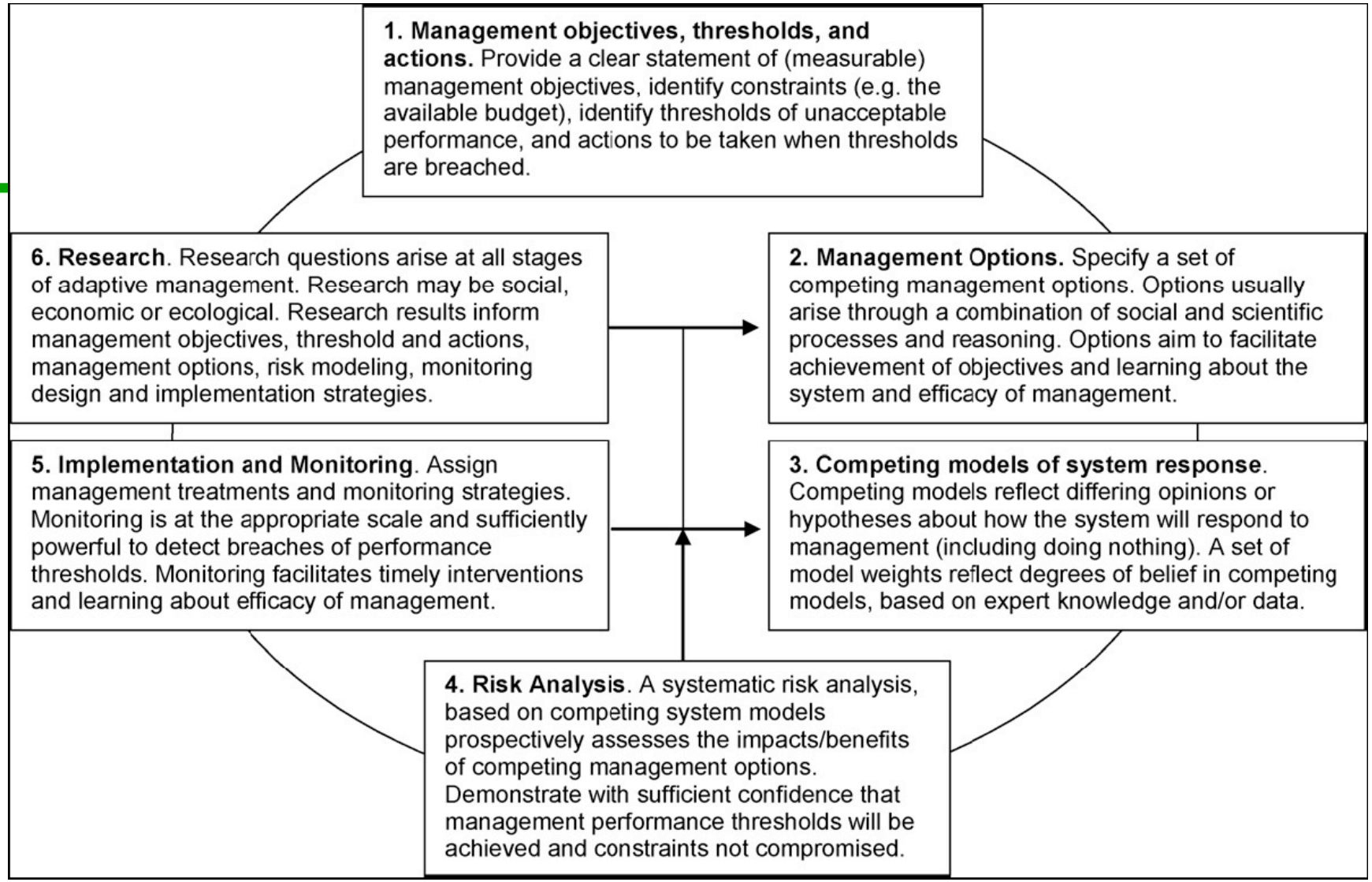


Wintle, B.A. & Lindenmayer, D. B. (2008) Adaptive risk management for sustainable forestry. For. Ecol. Man

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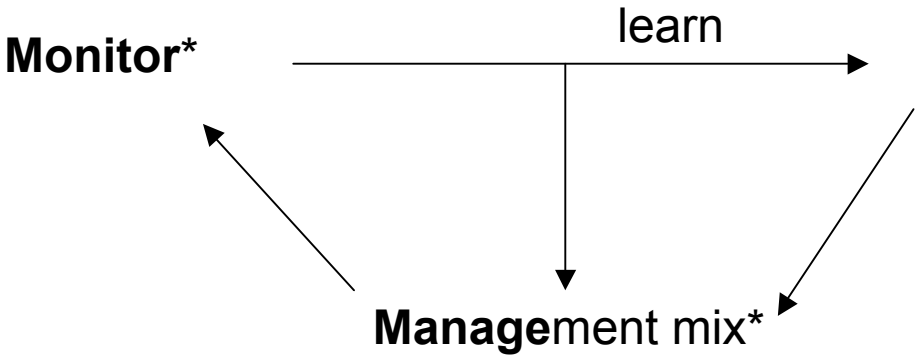
# Adaptive management

**Goal**: 90% confidence in a 15% *increase in redgum woodland cover* by 2020 → **Management options** Weed,Graze,Fence,Plant...

**Model** of the system response
*Outcome ~ f(management, nature)*

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# The working examples

. . .


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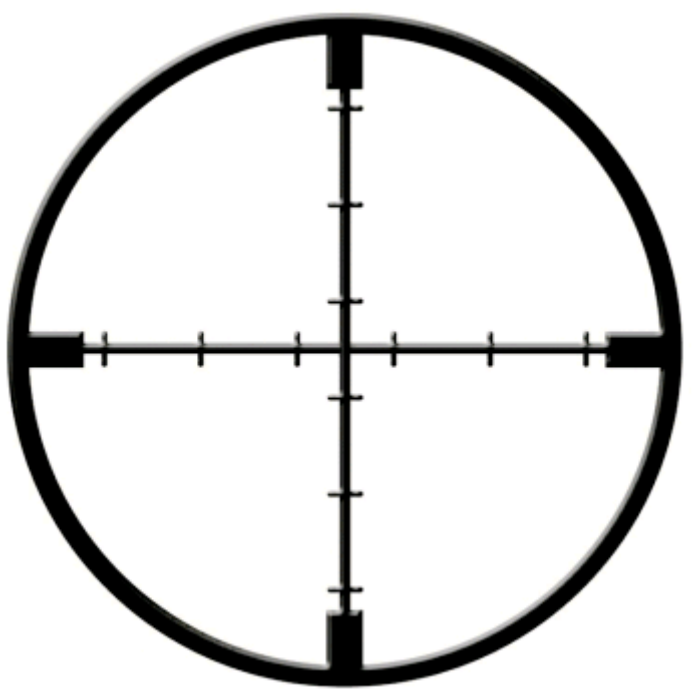
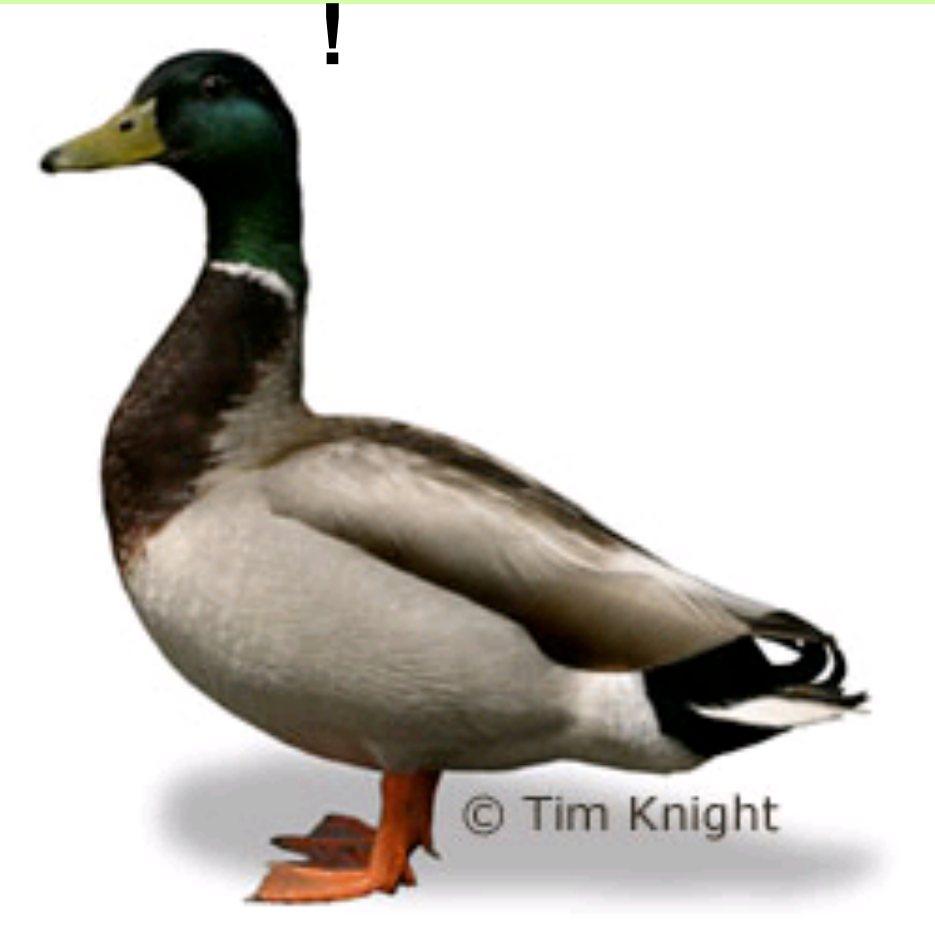
# One example of Adaptive management in the World!





# The American Mallard (Johnson et al 1997)

Management goal: Max hunting while maintaining 8 million birds → Management options (C, R, M, L)

Competing models of the system response

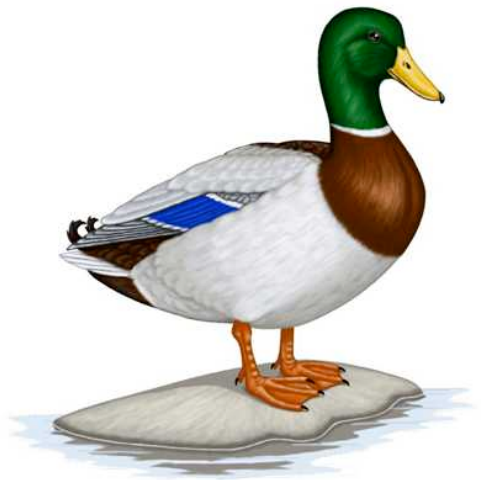
M1… M4

w1…. w4 Model weights

Monitoring* → learning

state-based management

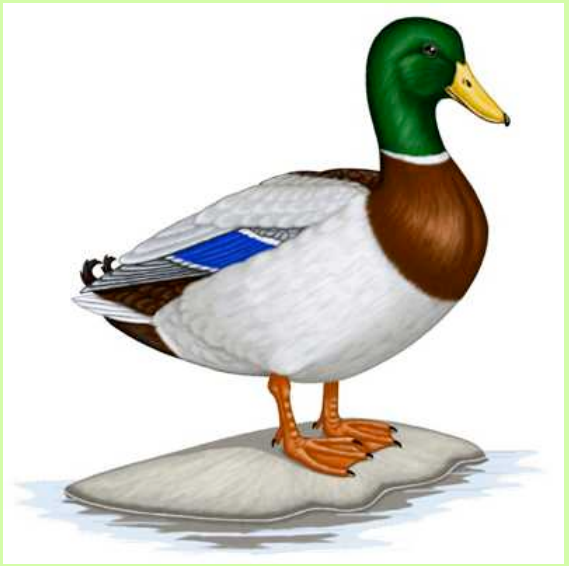
Management mix*



# adaptive management - example

- Alternative models
  - Additive hunting mortality; weak density-dependent recruitment
  - Additive hunting mortality; strong density-dependent recruitment
  - Compensatory hunting mortality; weak density-dependent recruitment
  - Compensatory hunting mortality; strong density-dependent recruitment

- Management options
  - Closed hunting (C)
  - Restrictive hunting (R)
  - Moderate hunting (M)
  - Liberal hunting (L)



## Additive hunting mortality; weak density-dependent recruitment

| | $X2^b$ | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $X1^c$ | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 |
| 2.0 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 2.5 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 3.0 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 3.5 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 4.0 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 4.5 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 5.0 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 5.5 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 6.0 | C | C | C | C | C | C | C | C | C | C | C | R | R |
| 6.5 | C | C | C | C | C | C | C | C | R | R | R | R | M |
| 7.0 | C | C | C | C | C | C | R | R | R | M | M | M | L |
| 7.5 | C | C | C | R | R | R | R | M | M | L | L | L | L |
| 8.0 | C | R | R | R | R | M | M | L | L | L | L | L | L |
| 8.5 | R | R | R | M | M | L | L | L | L | L | L | L | L |
| 9.0 | R | R | M | L | L | L | L | L | L | L | L | L | L |
| 9.5 | M | M | L | L | L | L | L | L | L | L | L | L | L |
| 10.0 | M | L | L | L | L | L | L | L | L | L | L | L | L |
| 10.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 11.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 11.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 12.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |

Number of mallards (millions)

Number of ponds in May in Prairie Canada (millions)

## Additive hunting mortality; strong density-dependent recruitment

| | $X2^b$ | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $X1^c$ | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 |
| 2.0 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 2.5 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 3.0 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 3.5 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 4.0 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 4.5 | C | C | C | C | C | C | C | C | C | C | C | C | C |
| 5.0 | C | C | C | C | C | C | C | C | C | C | R | R | R |
| 5.5 | C | C | C | C | C | C | R | R | R | R | R | R | M |
| 6.0 | C | C | C | C | R | R | R | R | R | M | M | M | L |
| 6.5 | C | R | R | R | R | R | R | M | M | M | L | L | L |
| 7.0 | R | R | R | R | R | M | M | M | L | L | L | L | L |
| 7.5 | R | R | R | R | M | M | L | L | L | L | L | L | L |
| 8.0 | R | R | M | M | M | L | L | L | L | L | L | L | L |
| 8.5 | R | M | M | M | L | L | L | L | L | L | L | L | L |
| 9.0 | R | M | M | L | L | L | L | L | L | L | L | L | L |
| 9.5 | M | M | L | L | L | L | L | L | L | L | L | L | L |
| 10.0 | M | M | L | L | L | L | L | L | L | L | L | L | L |
| 10.5 | M | L | L | L | L | L | L | L | L | L | L | L | L |
| 11.0 | M | L | L | L | L | L | L | L | L | L | L | L | L |
| 11.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 12.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |

## Compensatory hunting mortality; weak density-dependent recruitment

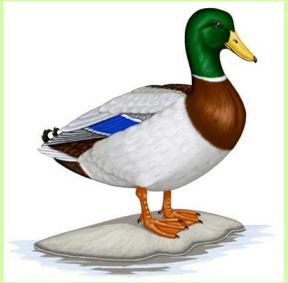
| | $X2^b$ | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $X1^c$ | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 |
| 2.0 | R | R | R | R | R | R | R | R | R | R | R | R | R |
| 2.5 | R | R | R | R | R | R | R | R | R | R | R | R | R |
| 3.0 | R | R | R | R | R | R | R | R | R | R | R | R | R |
| 3.5 | R | R | R | R | R | R | R | R | R | M | M | M | M |
| 4.0 | R | R | R | M | M | M | M | M | M | M | M | M | M |
| 4.5 | M | M | M | M | M | M | M | M | M | M | M | L | L |
| 5.0 | M | M | M | M | M | M | M | L | L | L | L | L | L |
| 5.5 | M | M | M | M | L | L | L | L | L | L | L | L | L |
| 6.0 | M | L | L | L | L | L | L | L | L | L | L | L | L |
| 6.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 7.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 7.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 8.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 8.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 9.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 9.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 10.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 10.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 11.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 11.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 12.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |

## Compensatory hunting mortality; strong density-dependent recruitment

| | $X2^b$ | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $X1^c$ | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 |
| 2.0 | R | R | R | R | R | R | R | R | R | R | R | R | R |
| 2.5 | R | R | R | R | R | R | R | R | R | R | R | R | R |
| 3.0 | R | R | R | R | R | R | R | R | M | M | M | M | M |
| 3.5 | R | R | R | M | M | M | M | M | M | M | M | L | L |
| 4.0 | M | M | M | M | M | M | M | L | L | L | L | L | L |
| 4.5 | M | M | M | M | L | L | L | L | L | L | L | L | L |
| 5.0 | M | L | L | L | L | L | L | L | L | L | L | L | L |
| 5.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 6.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 6.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 7.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 7.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 8.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 8.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 9.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 9.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 10.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 10.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 11.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 11.5 | L | L | L | L | L | L | L | L | L | L | L | L | L |
| 12.0 | L | L | L | L | L | L | L | L | L | L | L | L | L |

# Adaptive management

| Mortality hypothesis | Reproductive hypothesis | Model weights | | |
|---|---|---|---|---|
| | | **1995** | **1997** | **1999** |
| Additive | Strong density-dependence | 0.25 | 0.53 | **0.61** |
| Additive | Weak density-dependence | 0.25 | 0.46 | 0.38 |
| Compensatory | Strong density-dependence | 0.25 | 0.00 | 0.00 |
| Compensatory | Weak density-dependence | 0.25 | 0.00 | 0.00 |



# An Australian Example?

Adaptive biodiversity investment in the GBCMA

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# Demonstrating Returns on Investment: Australian National Audit Office (ANAO)

| ***What they were saying in 1997*** | ***What they said in 2008*** |
|---|---|
| It is difficult to determine the extent to which programs are achieving their intended outcomes. | **Overall, the ANAO considers the information reported in the DAFF and NHT Annual Reports has been insufficient to make an informed judgement as to the progress of the programs towards … outcomes** |
| **Performance information is not adequate for program managers in DPIE or Environment Australia to determine the quality or the nature of outcomes being achieved.** | There is little evidence … that the programs are … achieving the anticipated national outcomes |
| **Monitoring, review and performance reporting has not been adequate** to manage potential risks. | **Priority should be given to improving the Joint Team's ability to monitor, evaluate and report reliably..** |

(Thanks to Stefan Hajkowicz for paraphrasing)

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# The NHT problem - summary

1. Failed to clearly define [measurable] objectives
2. Lack of an explicit model to describe how competing investments options would contribute to outcomes
3. Opaque allocation/prioritization strategies
4. Failure to demonstrate value for $ due to lack of monitoring
5. No plan for learning (Adaptive Management)

**These problems exist at all levels**

# …But we're not alone

ABC reporter: *"Are we winning the war on terror..?"*

Adam Dolnik (Centre for transnational crime prevention): *"Well, we have **not defined our objectives** and we have no metrics for **measuring success**…"* In short, I don't know.

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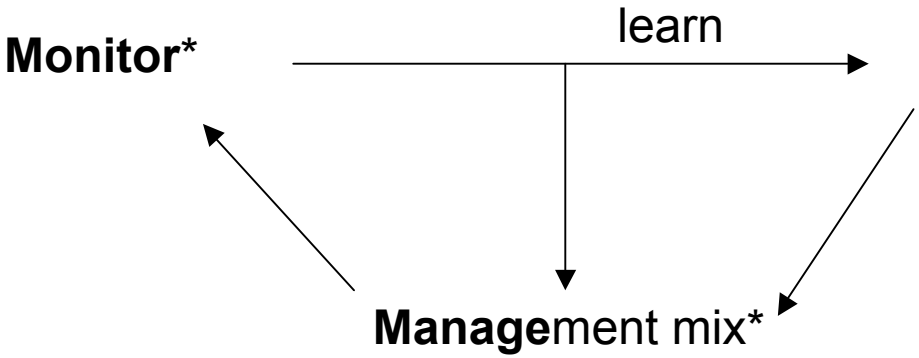
HERE'S THE PLAN....

# Adaptive management - GBCMA

**Goal**: 90% confidence in a 15% *increase in redgum woodland cover* by 2020 → **Management options** Weed,Graze,Fence,Plant...

**Model** of the system response

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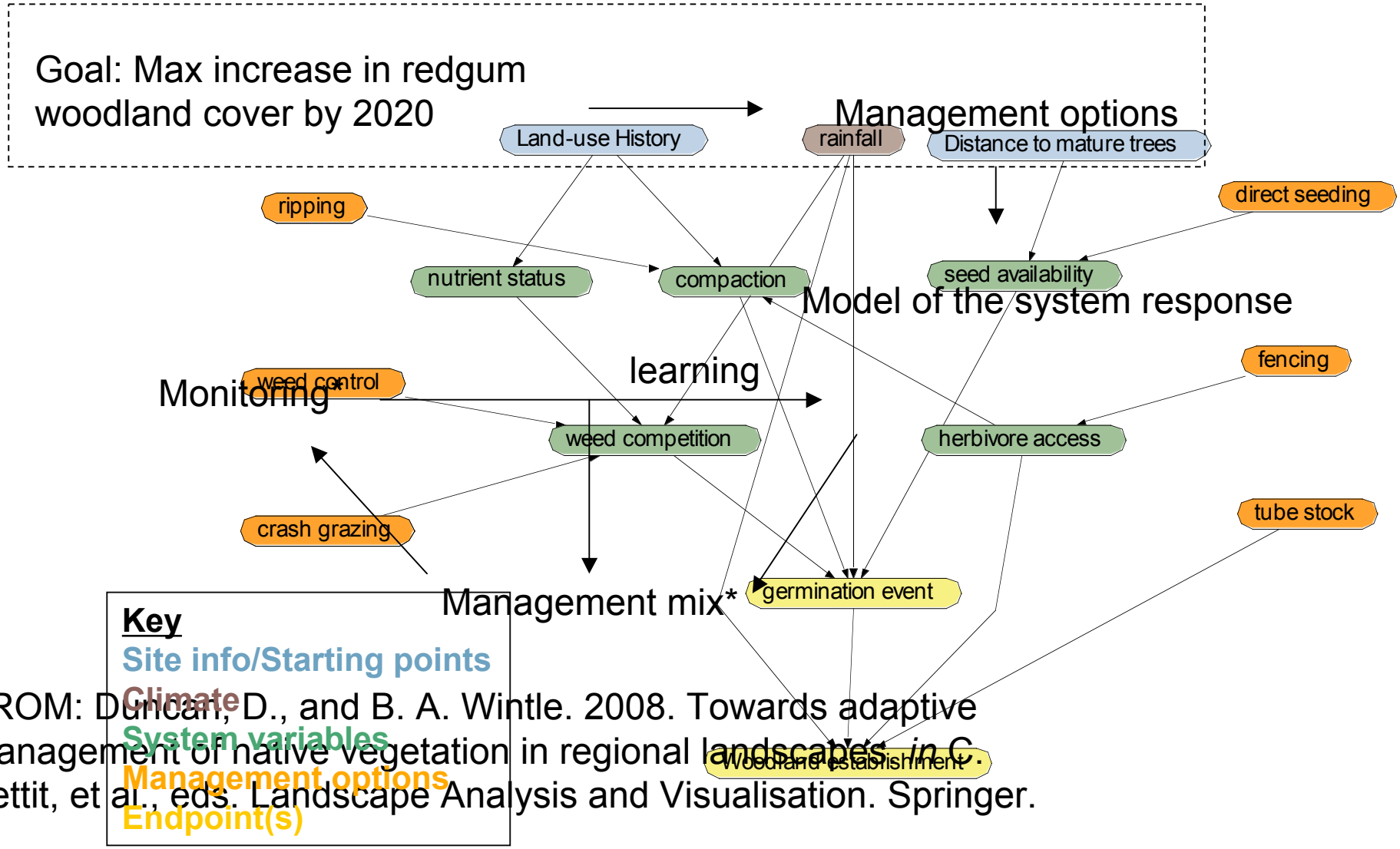
# Adaptive management

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# Which projects will we fund this year?

Project Prioritization Protocol: V = P*B/C

| Project | Success **P**robability | **B**enefit (Ha) | **C**ost $NPV_{50}$ | Value (W*P*B)/C |
|---|---|---|---|---|
| Fence Farm A | 0.8 | 50 | 300K | 0.13 |
| Buy Farm B | 0.8 | 50 | 1.0M | 0.04 |
| Weed Farm C | 0.4 | 20 | 700K | 0.01 |
| etc… | | | | |

Joseph, L. N., R. F. Maloney, S. M. O'Conner, P. Cromarty, P. Jansen, T. Stephens, and H. P. Possingham. 2008: In press. Improving methods for allocating resources among threatened species: the case for a new national approach in New Zealand. *Pacific conservation biology*.

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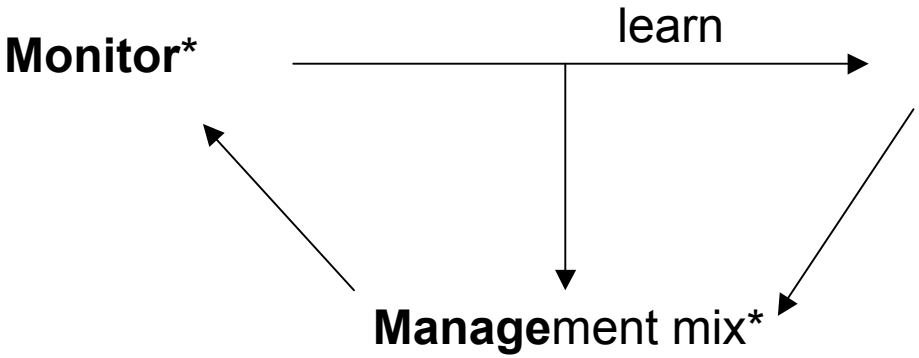


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# Monitoring: two components

**Reporting:**

The performance measure implicit in the goal statements should be monitored in order to report on the success of the management.

**Learning:**

1. What should be monitored becomes apparent by analysing the most uncertain nodes in the Bayes' nets.

2. The monitoring information feeds directly back into the Bayes' net to update the conditional probabilities that link each of the nodes in the net. Natural integration of monitoring and models.

# The NHT problem - summary

1. Failed to clearly define [measurable] objectives
2. Lack of an explicit model to describe how competing investments options would contribute to outcomes
3. Opaque allocation/prioritization strategies
4. Failure to demonstrate value for $ due to lack of monitoring

… No basis for institutional learning (Adaptive Management)

**These problems exist at all levels**

# Conclusions/General Comments

1. Adaptive management is still a highly credible strategy for managing under uncertainty (esp. must act now)
2. AM is NOT TRIAL AND ERROR
3. Clearly stated, measurable goals are everything [failure to do so is death]
4. The Future:

*Theory*

- Active adaptive management
- Optimal Monitoring

*Practice*

- Where have all the models gone?
- The sociology of AM, uncertainty and best practice…

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# Adaptive management

## Passive adaptive management

- management strategies evolve over time in response to evidence gathered through monitoring
- competing models are confronted with the evidence and their relative plausibility iteratively updated
- management implemented consistent with the relative merit of competing models.

## Active adaptive management

- places a premium on learning.
- management strategies may be nominally suboptimal in a deliberate attempt to identify the best model sooner (learn faster).
- foregoes optimality in the short term in anticipation of longer term gains secured through accelerated learning.

# Active adaptive management

## Only really one tangible, theoretical contribution:

McCarthy, M. A., and H. P. Possingham. 2007. Active adaptive management for conservation. Conservation Biology **21**:956–963.

- *What action should be taken now to maximise long-run revegetation success, taking into account the gains that can be made through learning?*

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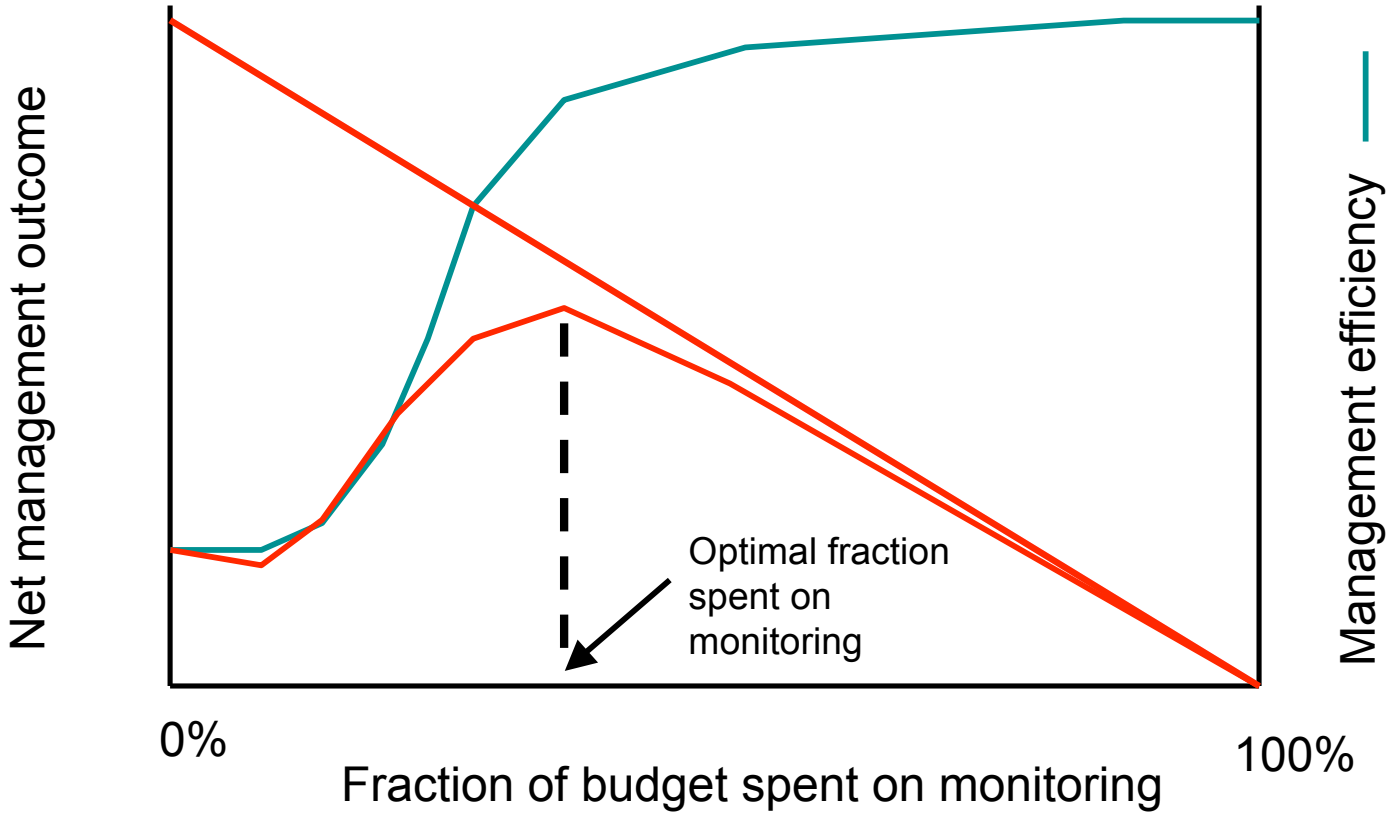
# What proportion of a budget should I allocate to monitoring?

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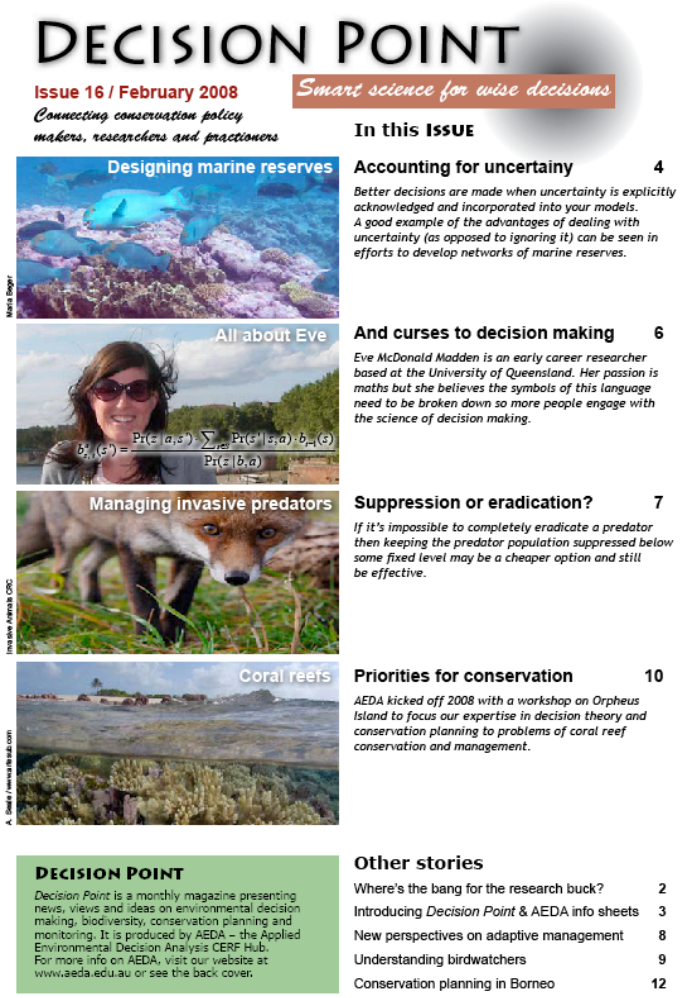
# Reading



DECISION POINT

Issue 16 / February 2008

*Connecting conservation policy makers, researchers and practioners*

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In this ISSUE

Designing marine reserves

**Accounting for uncertainty** 4

*Better decisions are made when uncertainty is explicitly acknowledged and incorporated into your models. A good example of the advantages of dealing with uncertainty (as opposed to ignoring it) can be seen in efforts to develop networks of marine reserves.*

All about Eve

**And curses to decision making** 6

*Eve McDonald Madden is an early career researcher based at the University of Queensland. Her passion is maths but she believes the symbols of this language need to be broken down so more people engage with the science of decision making.*

Managing invasive predators

**Suppression or eradication?** 7

*If it's impossible to completely eradicate a predator then keeping the predator population suppressed below some fixed level may be a cheaper option and still be effective.*

Coral reefs

**Priorities for conservation** 10

*AEDA kicked off 2008 with a workshop on Orpheus Island to focus our expertise in decision theory and conservation planning to problems of coral reef conservation and management.*

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**Other stories**



Adaptive management – Cindy Hauser (University of Melbourne)

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