The Environment Institute

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THE UNIVERSITY OF ADELAIDE AUSTRALIA

SUB CRUCE LUMEN




Hugh Possingham

‘Why Monitor the Environment? - A Decision Science Approach’

How much and why should we monitor? Monitoring is an optimisation problem first and a statistical problem second

Hugh Possingham, **lab and friends**

The Ecology Centre and Centre for Applied Environmental Decision Analysis – **a CERF**

Read www.aeda.edu.au/news

The University of Queensland

Australia

Applied Environmental Decision Analysis
Commonwealth Environmental Research Facility

spatial ecology

the ecology centre
university of queensland
australia
www.uq.edu.au/spatialecology
h.possingham@uq.edu.au

The University Of Queensland
AUSTRALIA


KOALAS
ARE
KOOL

Who pays for all the work?

- **Australian Research Council grants** (19), UQ, UofA, **Australian Federal Government Environment Department (CERF)**, TNC, PEW, CI, state govts (several), local governments, mining companies, TWS, WWF, BA, CRCs, + innumerable minor grants

Some “straw men” of applied monitoring/data collection

- We need to monitor all conservation interventions with sufficient power to detect significant effects
- I have just monitored frog species Y to extinction
- We need to learn about how the system works = science
- Count first, ask questions later
- Getting more data on biodiversity is always a good investment

  Balmford A. & Gaston K.J. (1999). Why biodiversity surveys are good value. Nature, 398, 204-205

Heretical views

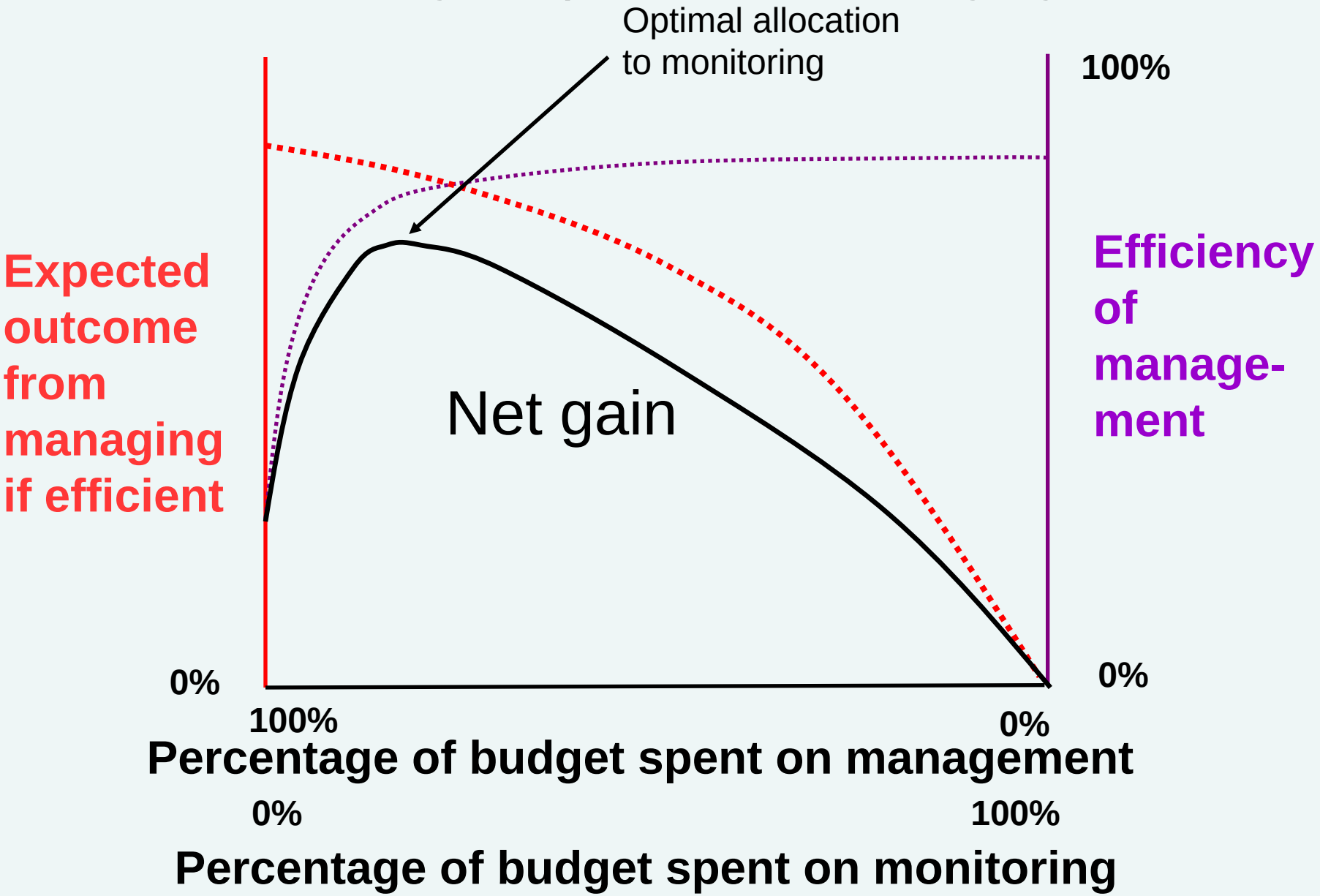
- Most monitoring programs have no clearly stated objectives and hence can't be optimised

  (Joseph et al. 2010, Optimal monitoring for conservation)

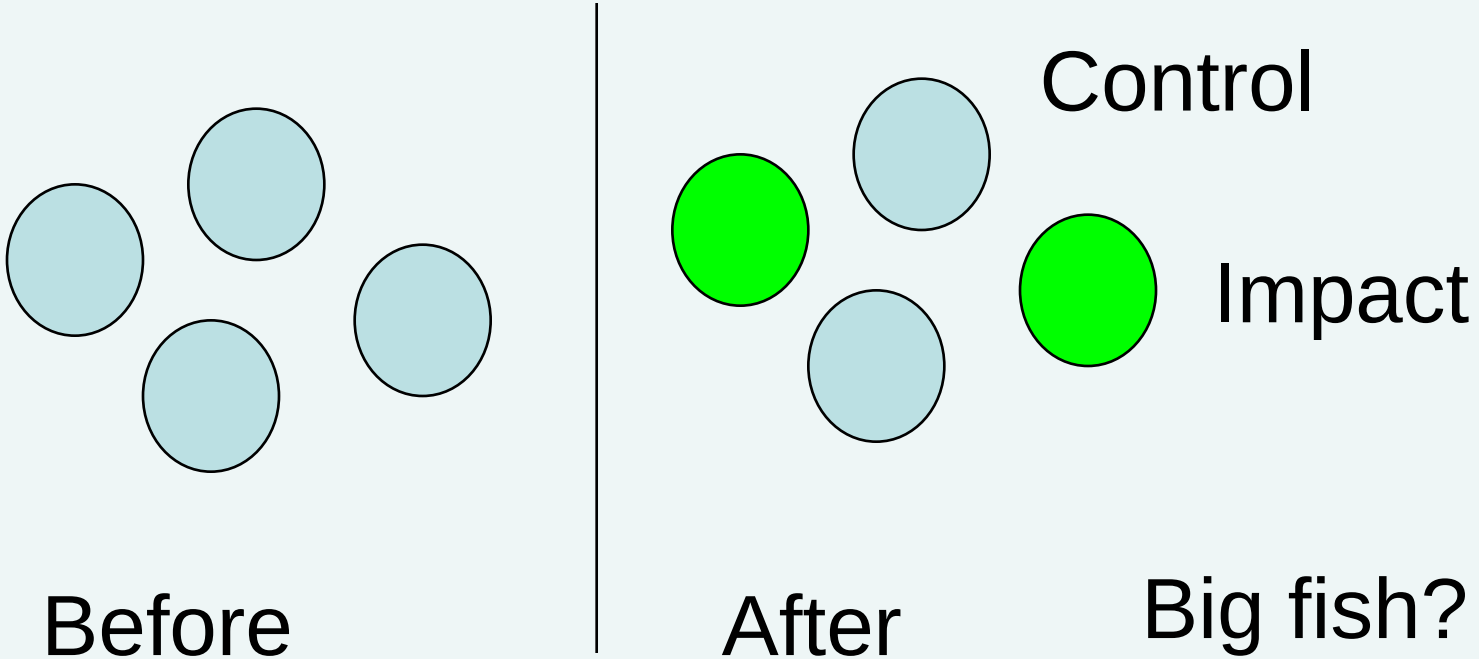
- Surveillance monitoring is a waste of time
- *(Nichols, J. D., and B. K. Williams. 2006. Monitoring for conservation. Trends in Ecology & Evolution **21**:668-673.)*
- All monitoring for conservation should be based in a decision-making framework

  Possingham, H. P., Andelman, S. J., Noon, B. R., Trombulak, S. and Pulliam, H. R. 2001. Making smart conservation decisions. In: Research priorities for conservation biology. Eds. Orians, G. and Soule, M. Island Press

Monitoring costs money that could be used for solving the problem = managing



Monitoring marine reserves



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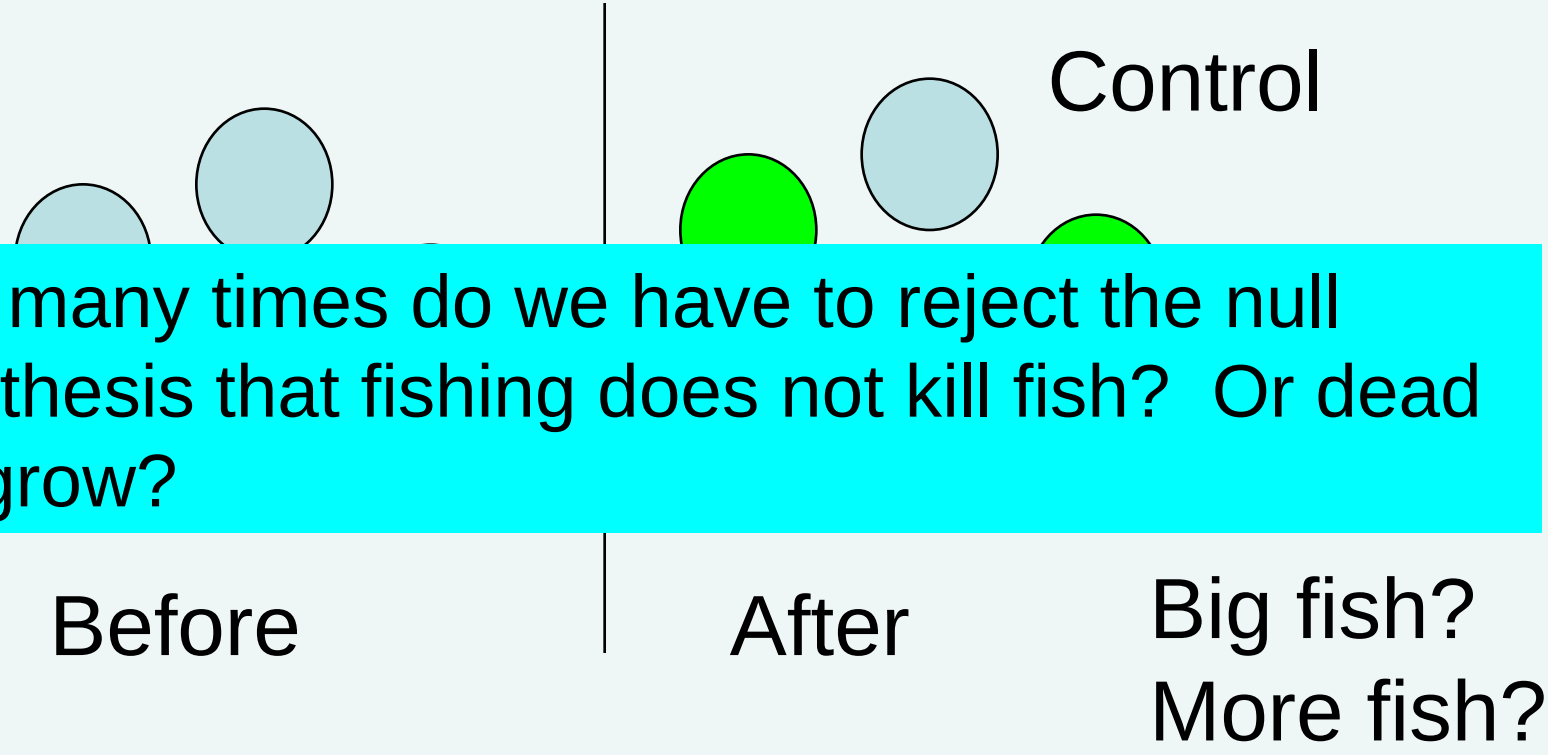
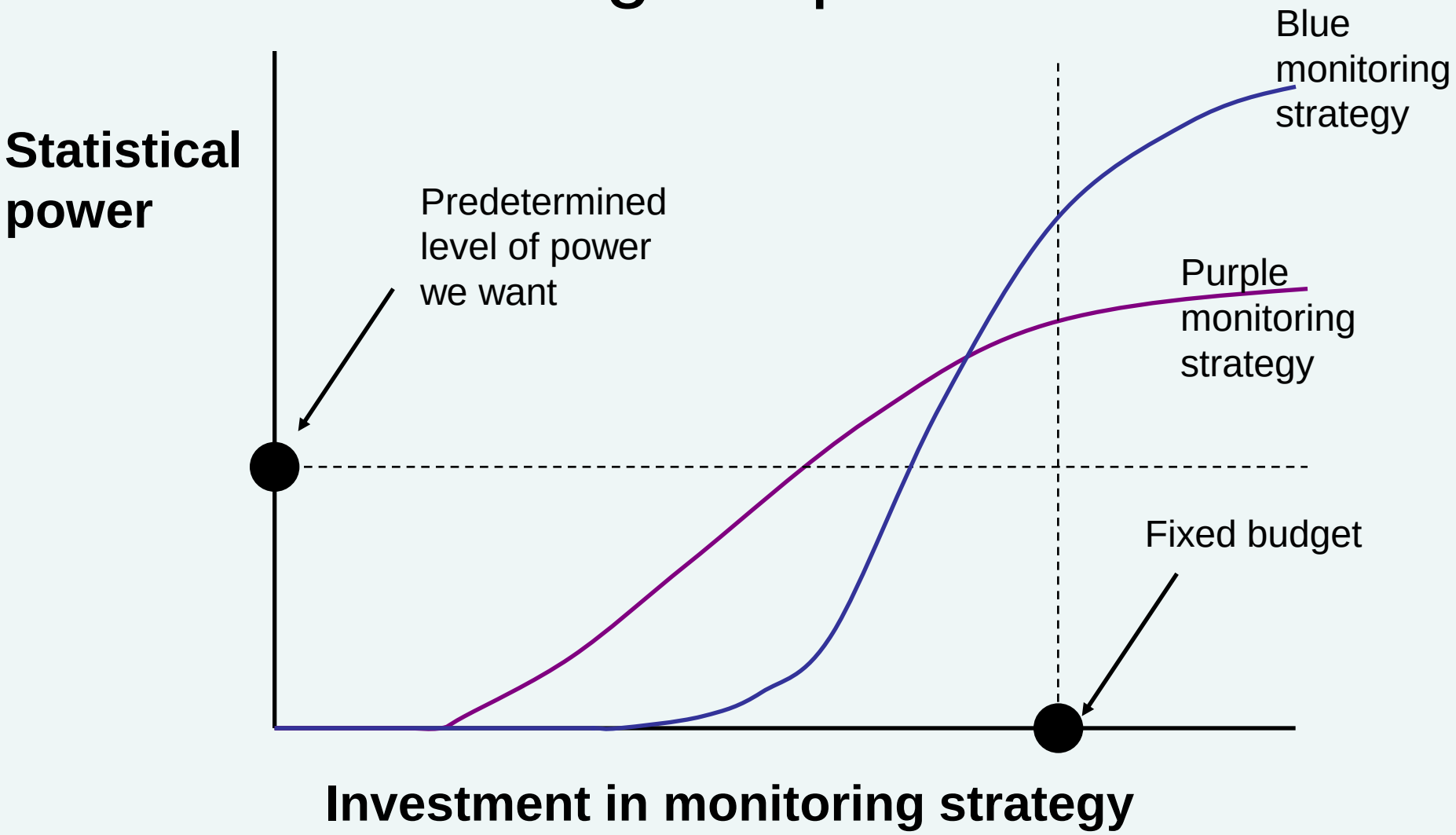


How many times do we have to reject the null hypothesis that fishing does not kill fish? Or dead fish grow?

What marine reserve monitoring could we do that would influence future decisions?

“Classical” approach to optimal monitoring – alpha = 5%



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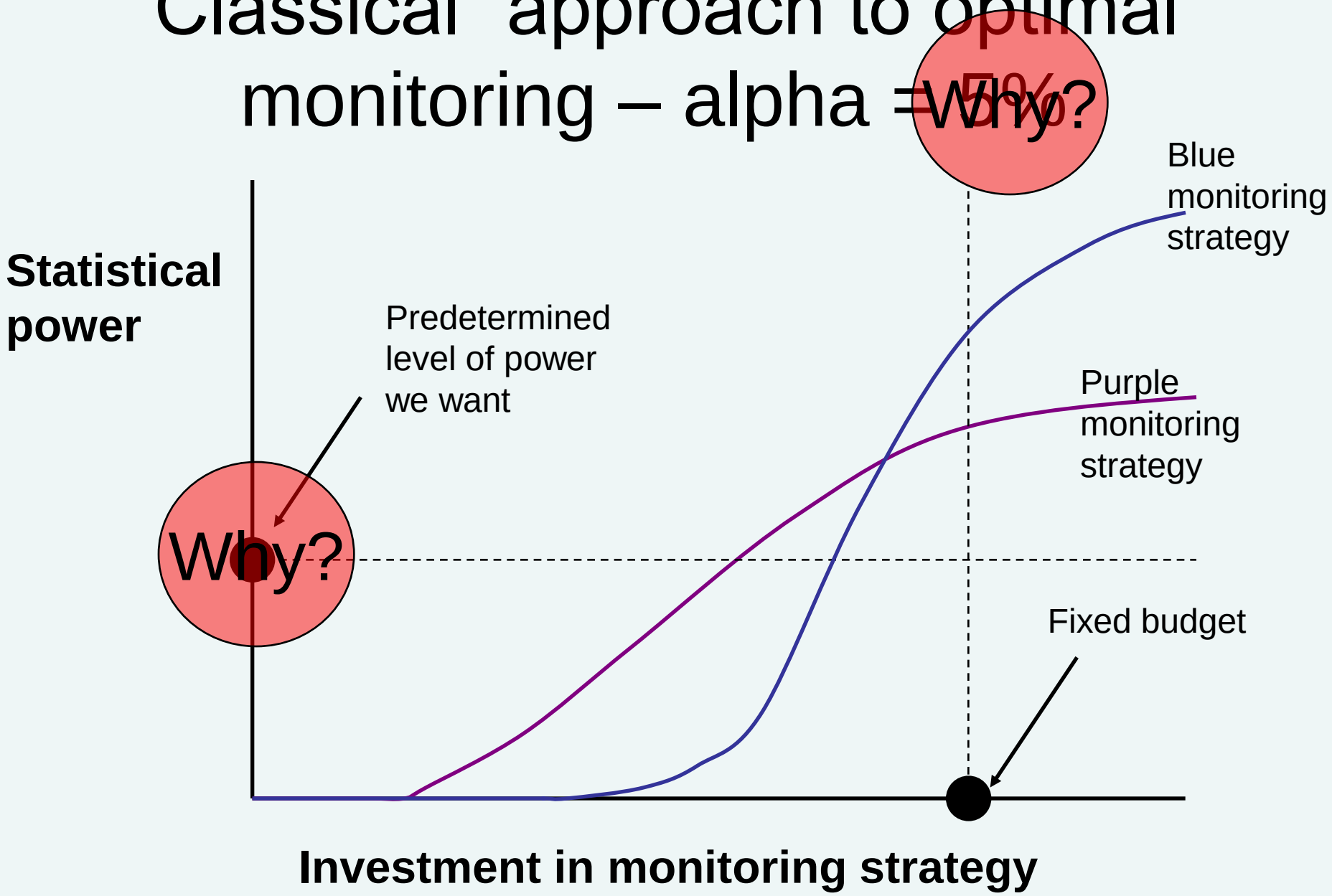

How much monitoring should we do for management/policy? The answer requires an objective. 7 reasons to monitor (Joseph et al.)

1. Audit the to see if actions taken or legislative requirements met or make donors happy
2. State-dependent management – (e.g. setting fisheries quotas, acting to save a threatened species)
3. To learn for learning's sake
4. Active adaptive management – optimal management accounting for the benefits of learning
5. Inform the public and/or politicians of an issue so policy and allocations may change
6. Serendipity, so many breakthroughs have come from just looking
7. People like it and do it for free

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Boring

Irrelevant

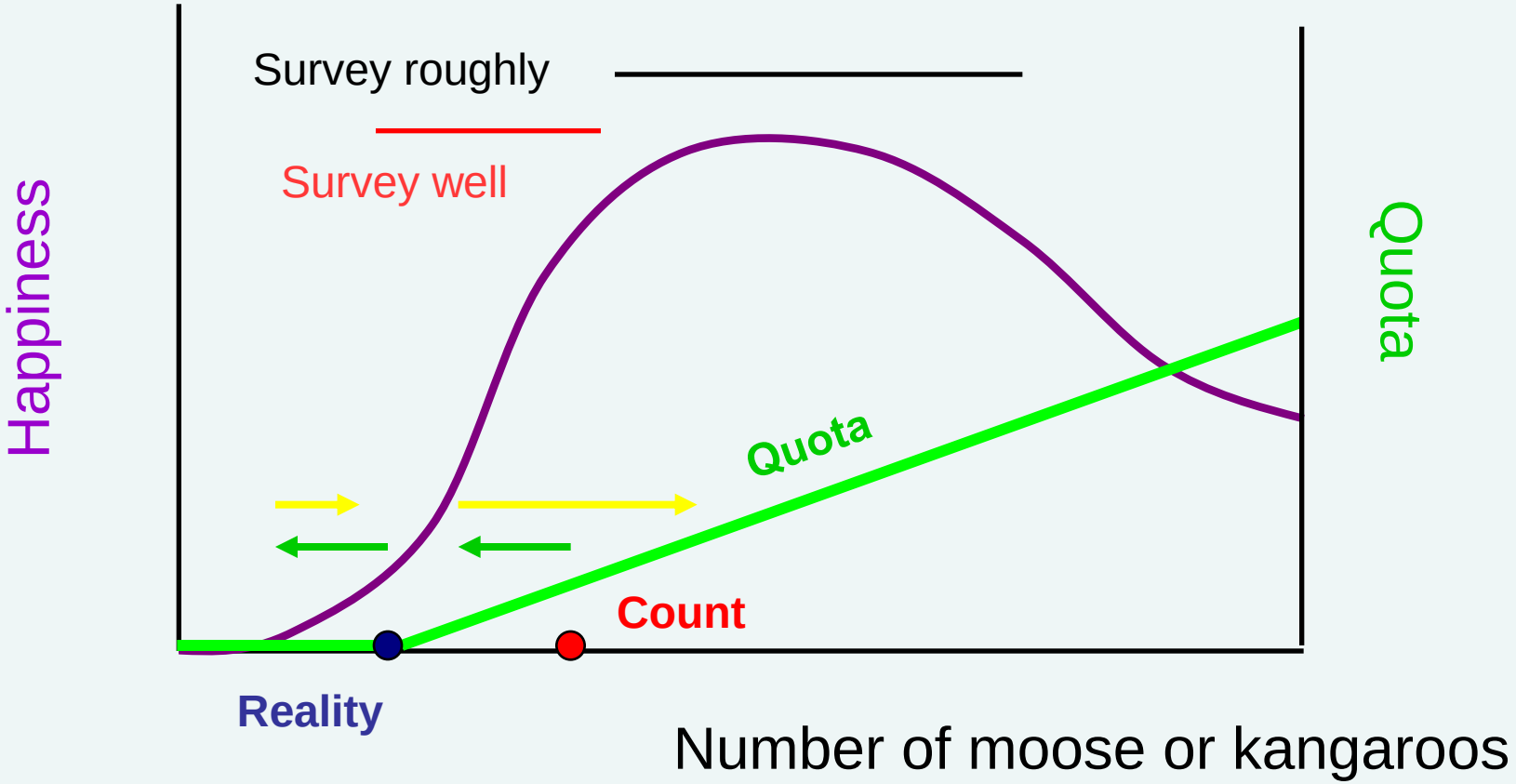
How much is enough?

?

Great

2 State Dependent Management – how much monitoring?

Counting moose or kangaroos (Hauser et al. 2006, Mansson et al.)



Hauser CE, Pople AR, Possingham HP. 2006. Should managed populations be monitored every year? *Ecological Applications* 16:807-819.

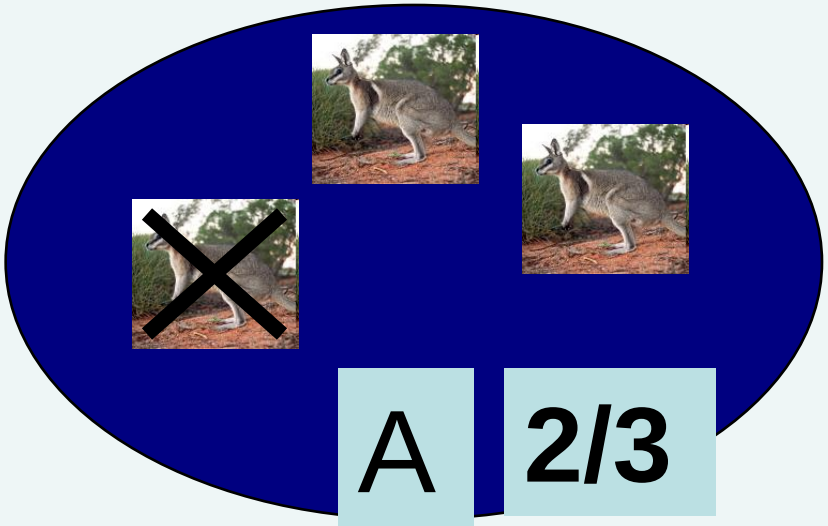
4 Active adaptive management

The holy grail of applied ecology – where we try to gain knowledge only in so far that the benefit of that knowledge gain is expected to outweigh the costs of fiddling with the system and learning about how it works

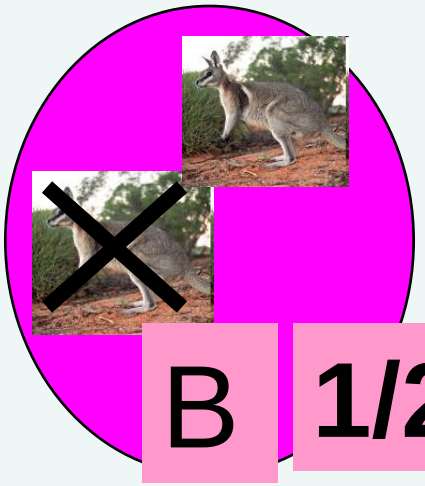
Bridled Nailtail Wallaby
(Onychogalea fraenata)
Endangered

A

B

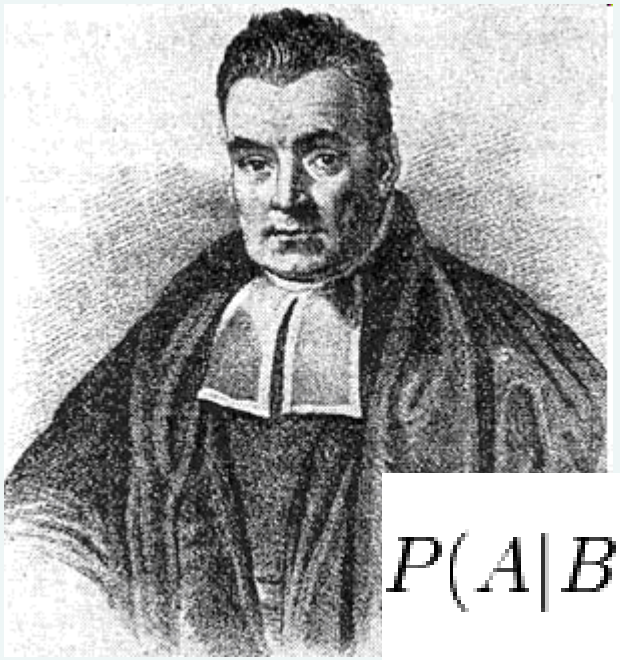


A 2/3



B 1/2

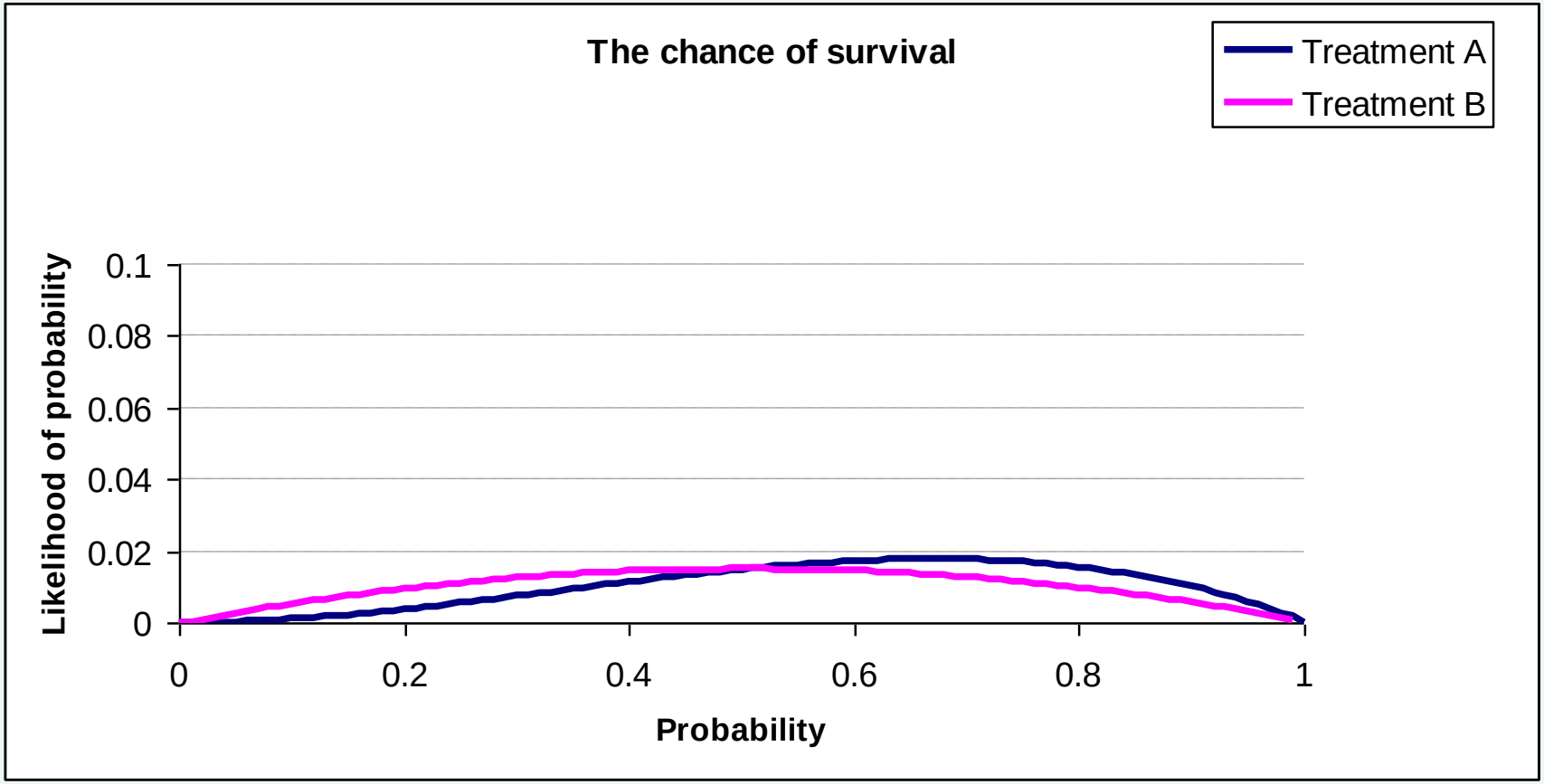
Enter Reverend **Thomas Bayes** and the incredible ***beta*** distribution



$$P(A|B) = \frac{P(B|A)\,P(A)}{P(B)}$$

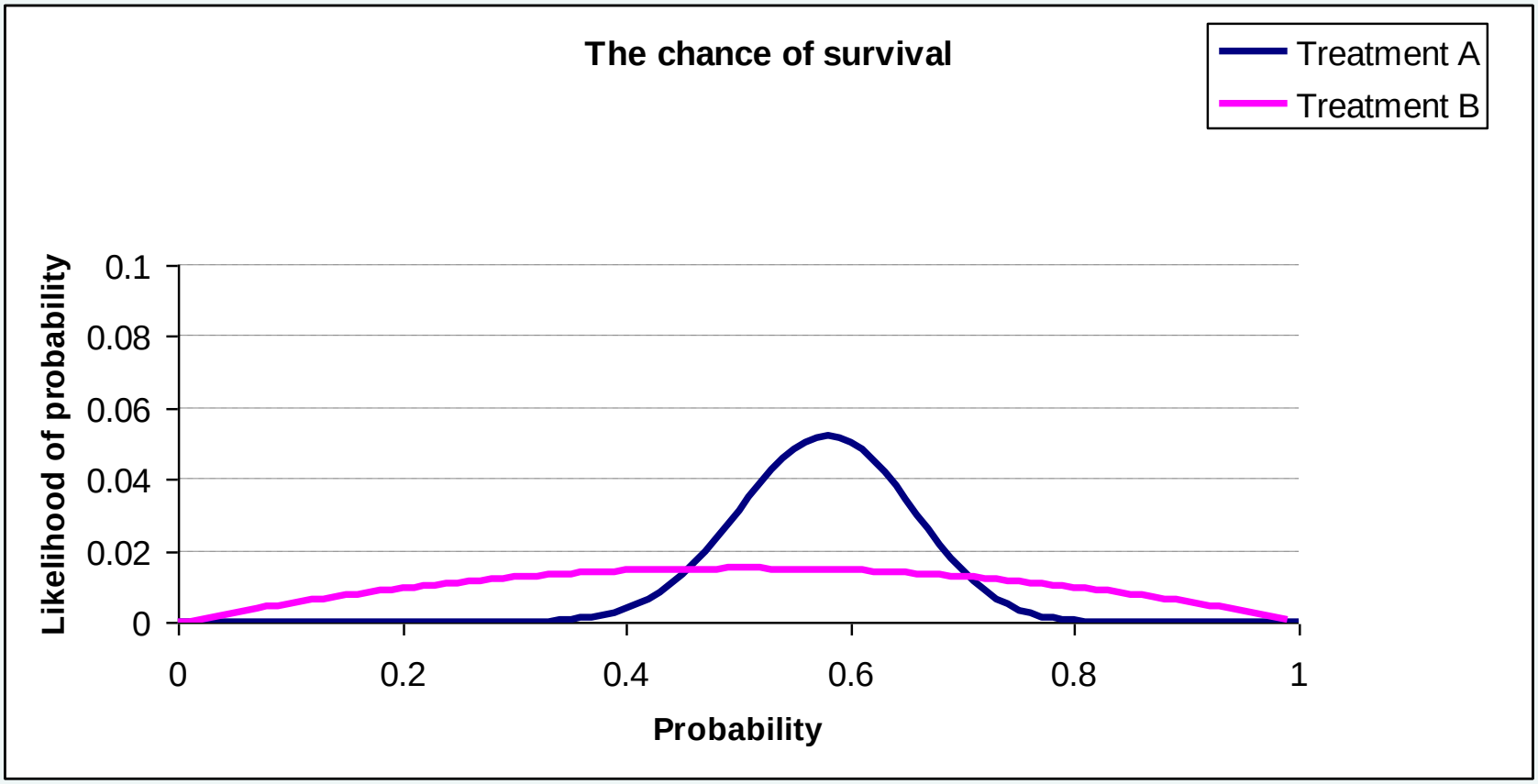
Thomas Bayes (pronounced: *beɪz*), (c. 1702 – 17 April 1761) was a British mathematician and Presbyterian minister, known for having formulated a specific case of the theorem that bears his name: Bayes' theorem, which was published posthumously.

Treatment A: 2/1
Treatment B: 1/1



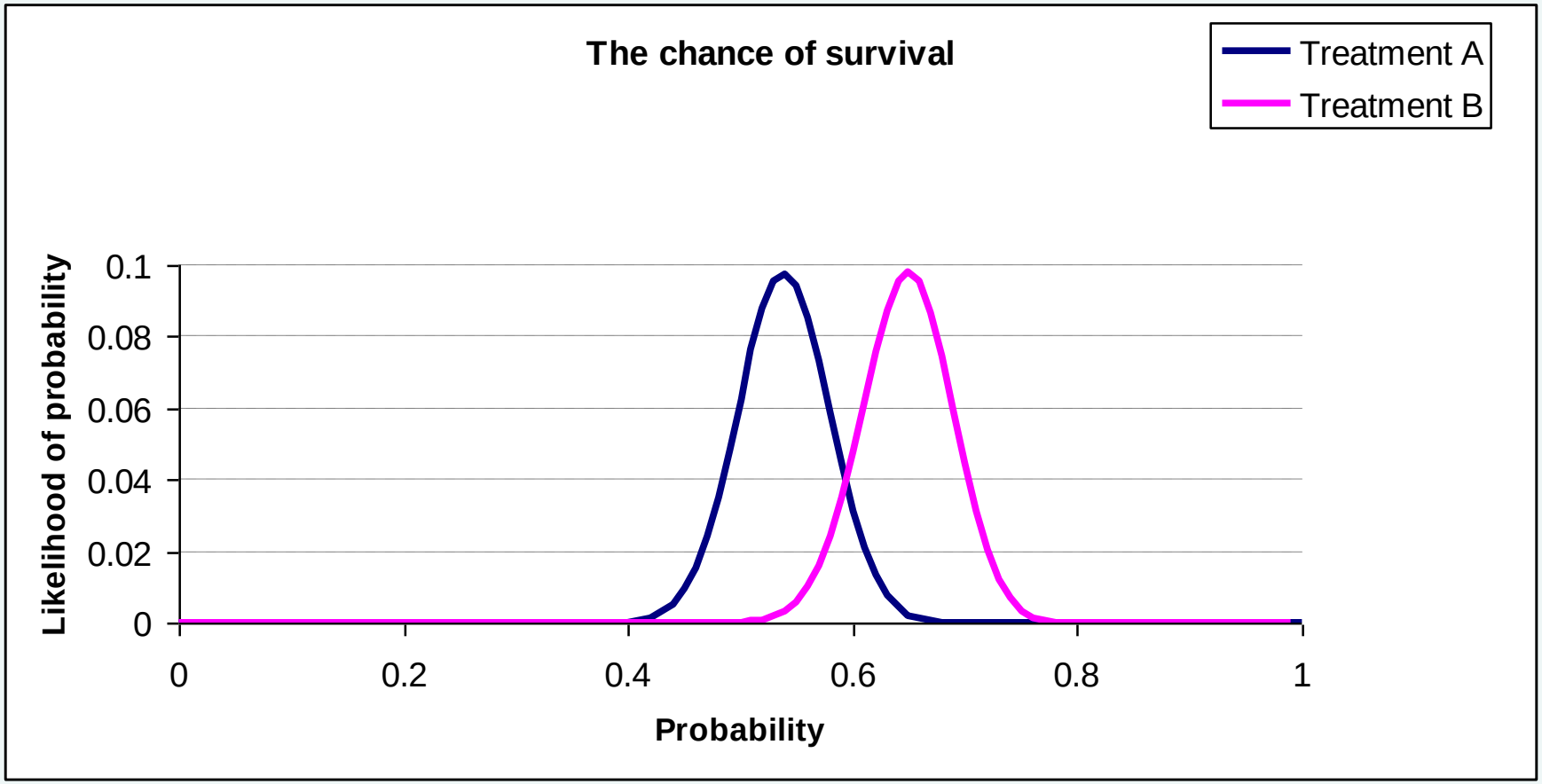
Do what is best for the poor little wallabies

Treatment A: 24/18
Treatment B: 1/1



No, I am a scientist, randomised sequential clinical trial

Treatment A: 80/70
Treatment B: 90/50



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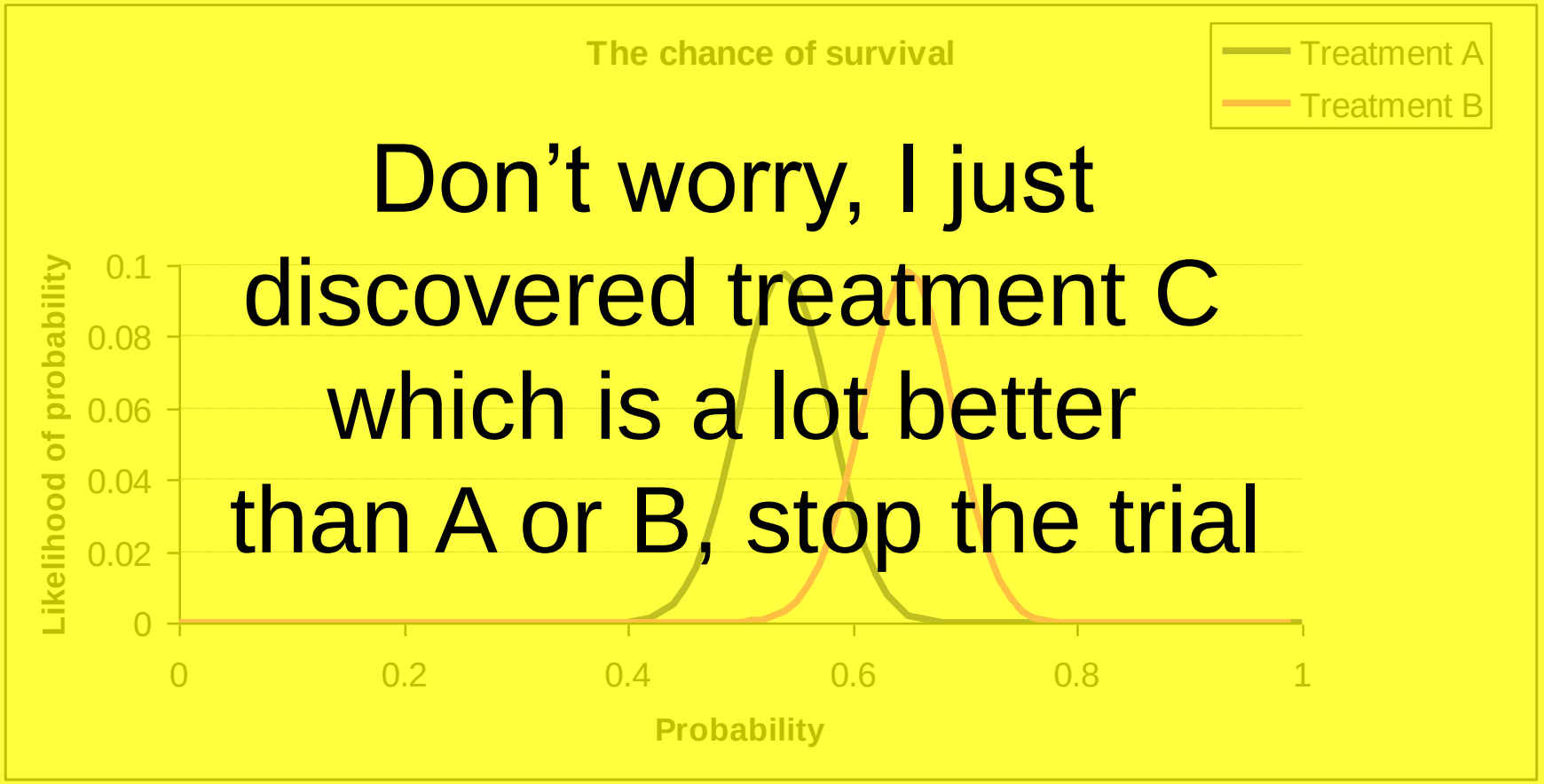


Don’t worry, I just discovered treatment C which is a lot better than A or B, stop the trial

Answer

- There is an optimal state dependent allocation of wallabies to treatments that is a compromise between doing what is best now and reducing uncertainty so we make better decisions in the future = **perfectly optimal active adaptive management**

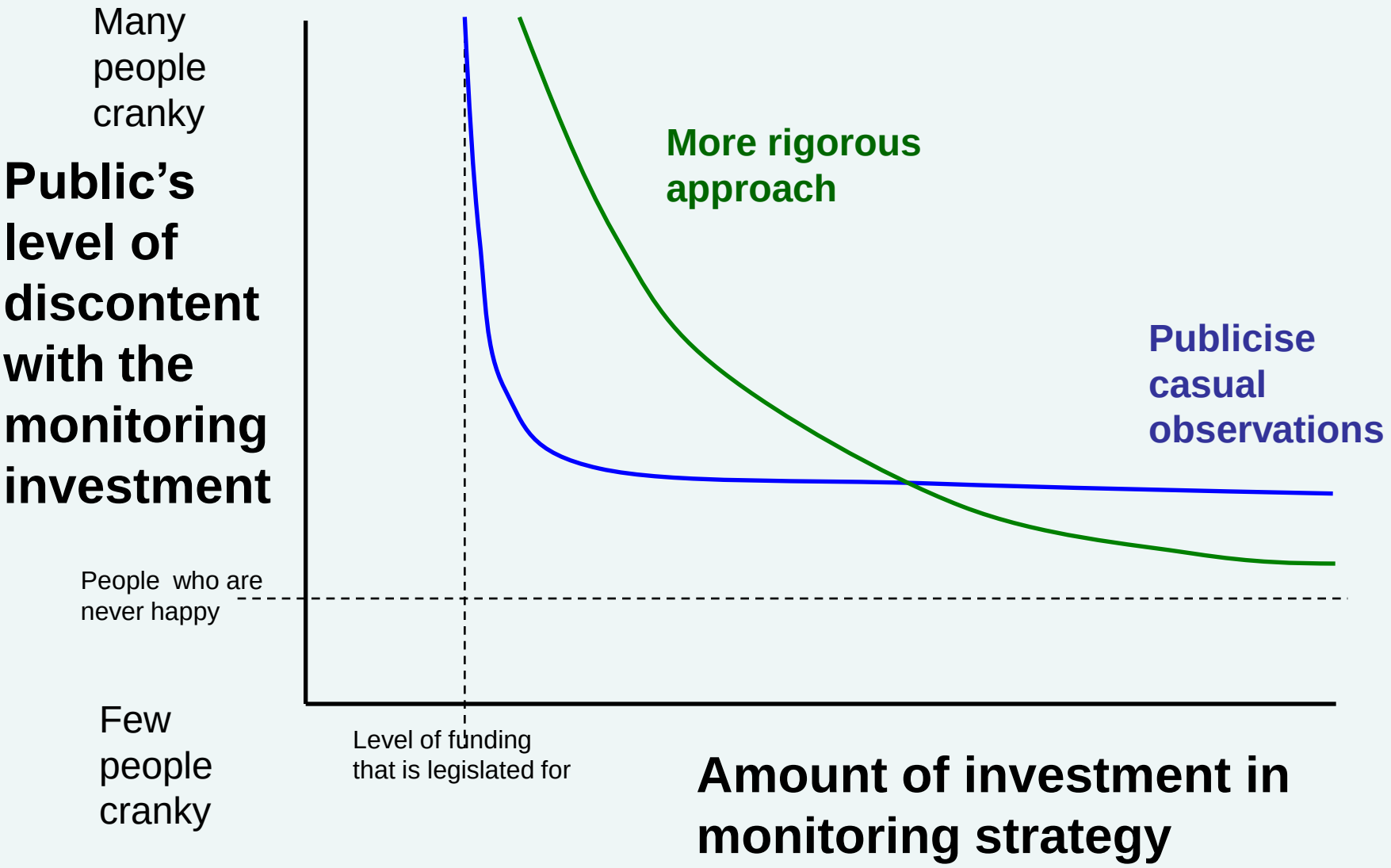
Rout T.M., Hauser C.E. & Possingham H.P. (2009). Optimal adaptive management for the translocation of a threatened species. *Ecol. Appl.,* 19, 515-526

McCarthy M.A. & Possingham H.P. (2007). Active adaptive management for conservation. *Conserv. Biol.*, 21, 956-963

5 A tricky objective

Keep the public and/or politicians happy, or provide them with enough information to drive actions

Another new problem: How much monitoring do we need to keep the masses/politicians happy?



6 Serendipity

Can this be quantified hence optimised?

Thoughts

- Many things should not be monitored because the costs outweigh the benefits
- Monitoring is first and foremost an optimisation problem. Statistics is part of the mechanics but should not proceed without being nested in a decision theory problem
- Ecological stats is taught in the context of pure science not applied science which is why we are in a mess
- Is monitoring a political displacement activity intended to keep scientists busy?
- How much data do we need to convince the masses that everything is bad/ok? Is some data more compelling than other data?
- Is there an optimal amount of surveillance?
- What should I tell TNC to do?

Some more of our papers on optimal monitoring and information gain

- How long should I monitor a fix stock before fixing the reserve size?
  - Gerber, L. R., M. Beger, M. A. McCarthy, and H. P. Possingham. 2005. A theory for optimal monitoring of marine reserves. ***Ecology Letters*** 8:829-837
- Monitor or manage? – **uses POMDPs**
  - Chades I., McDonald-Madden E., McCarthy M.A., Wintle B., Linkie M. & Possingham H.P. (2008). When to stop managing or surveying cryptic threatened species. ***PNAS***, 105, 13936-13940
- More recent papers by McDonald-Madden et al.

Before you monitor

- Stop, Think
- Maybe monitor less, better and longer
- Work out what you might do with the information that could alter future actions (even public opinion) and increase the chance of delivering a net conservation outcome relative to other forms of expenditure
- Place it in a decision theory or forecasting context and work out how long it will take and how much it will cost – can you afford it? Maybe you should act with what you know now?

Read Decision Point (monthly): www.aeda.edu.au/news

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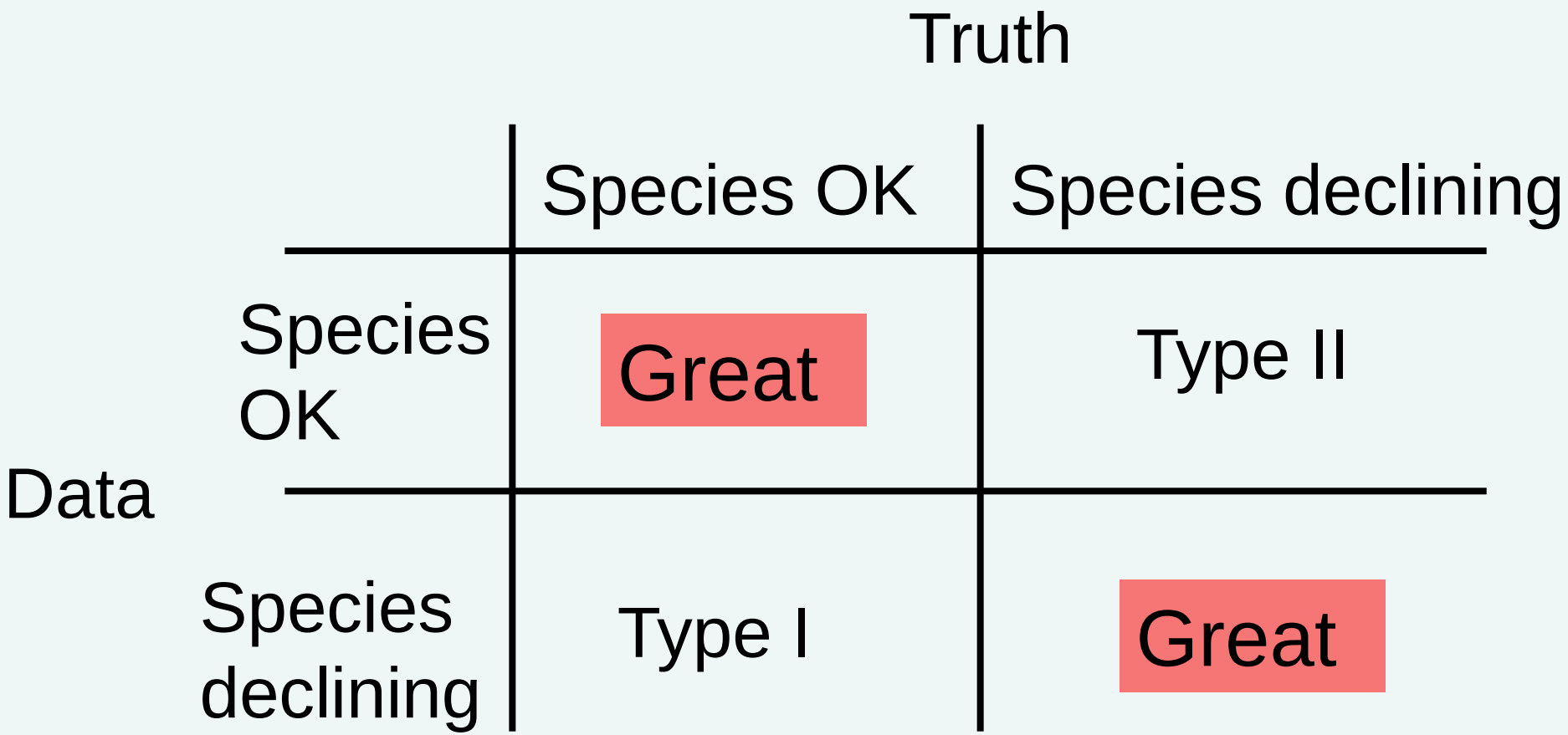
2 Trading type I and type II errors
Mapstone (1995), Field et al. (2004)



Field, S. A., A. J. Tyre, N. Jonzén, J. R. Rhodes, and H. P. Possingham. 2004. Minimizing the cost of environmental management decisions by optimizing statistical thresholds. ***Ecology Letters*** 7:669-675

2. Trading type I and type II errors

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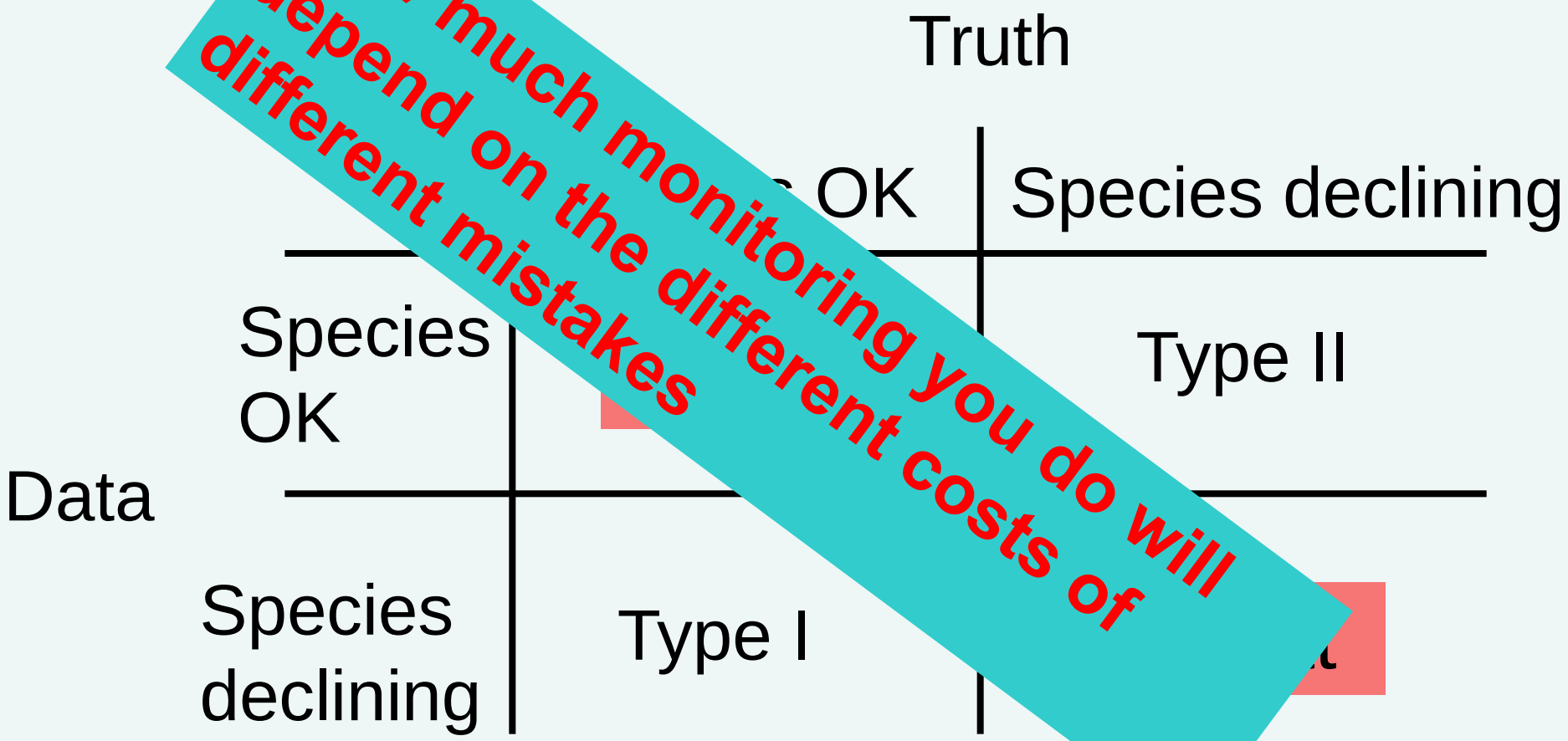

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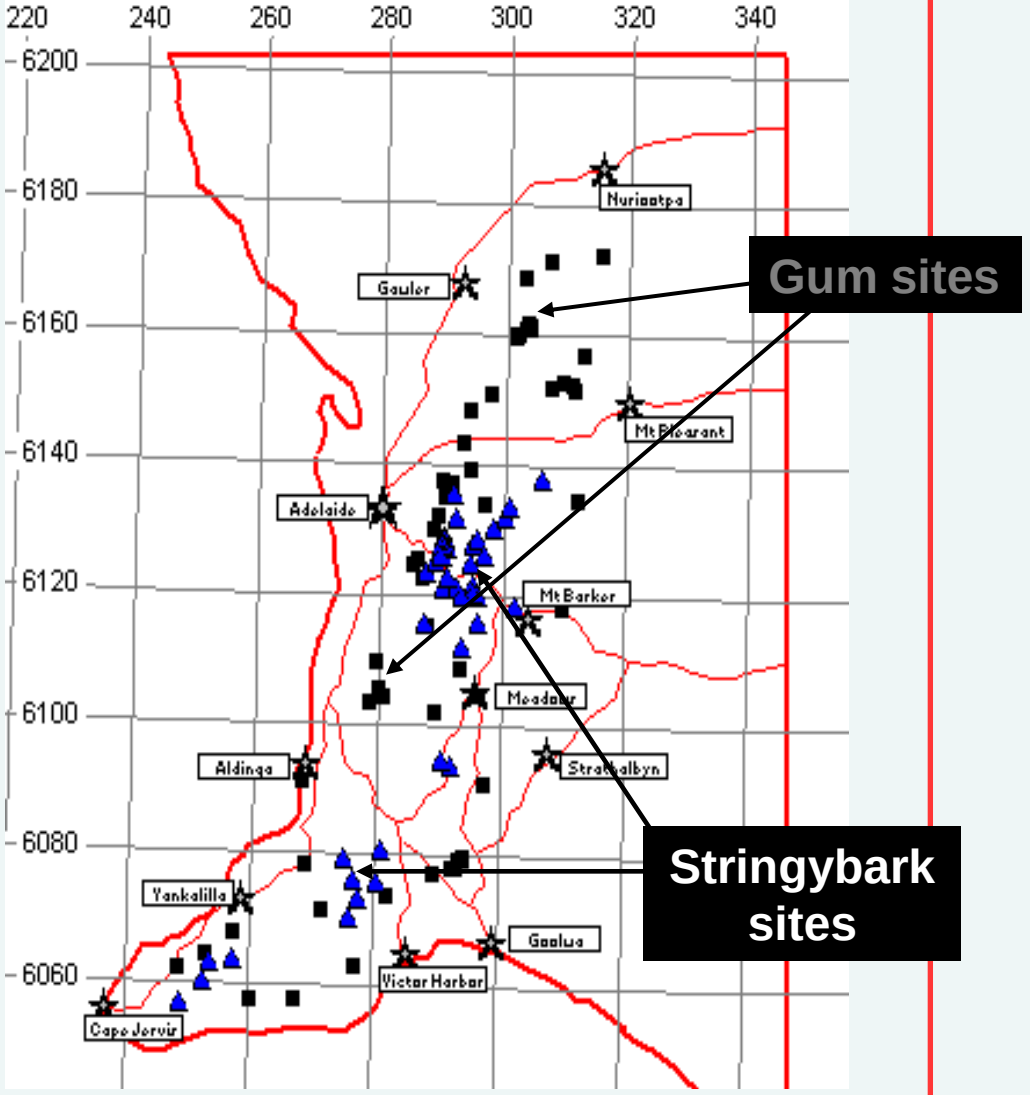
History:

Bob Howe, David Paton, Drew Tyre, Tim and Patrick

Three 20min 2ha counts - c160 sites from 1999 to now



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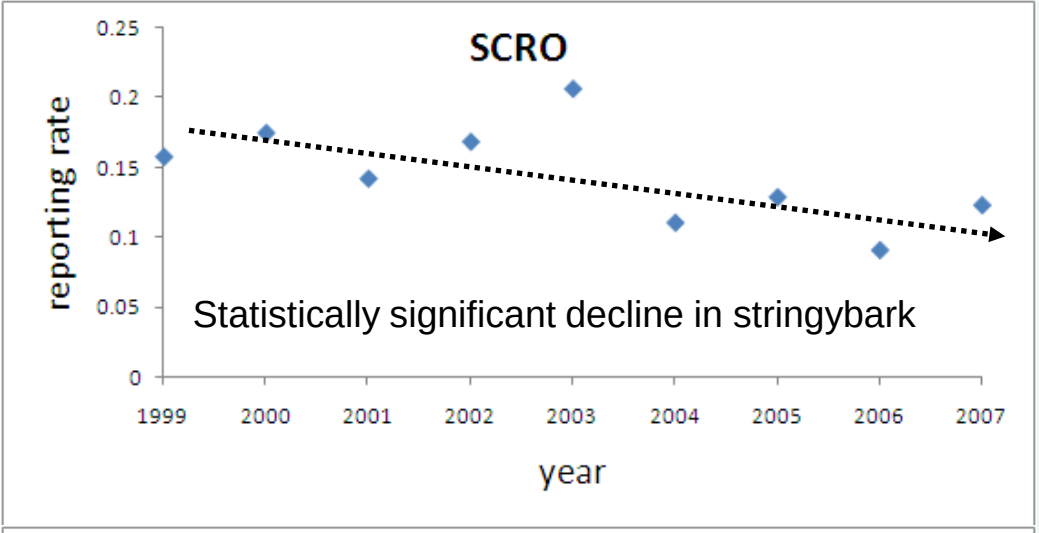
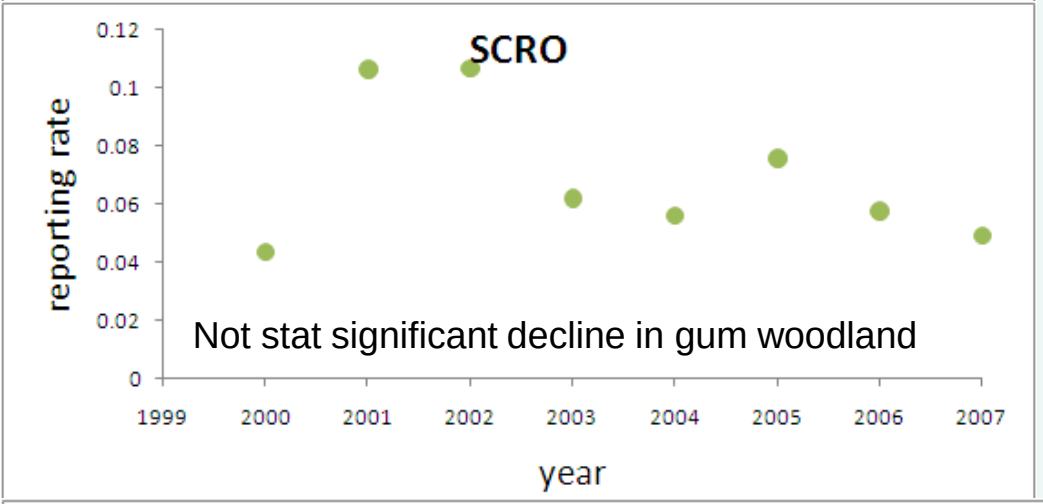
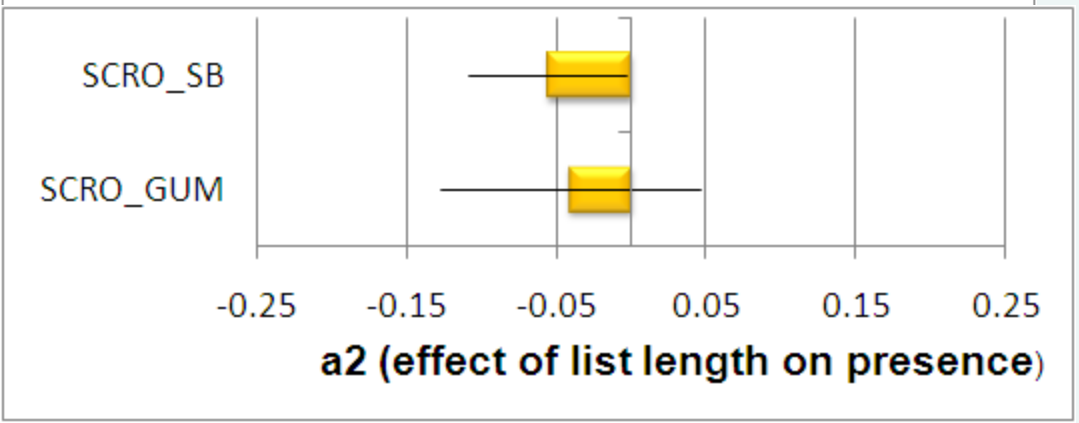
Commonwealth Environmental Research Facility







The canary of the canaries. All is not well for **Scarlet Robins** in stringybark.

This is not surprising as there is ample local and national evidence that this species is going downhill steadily.

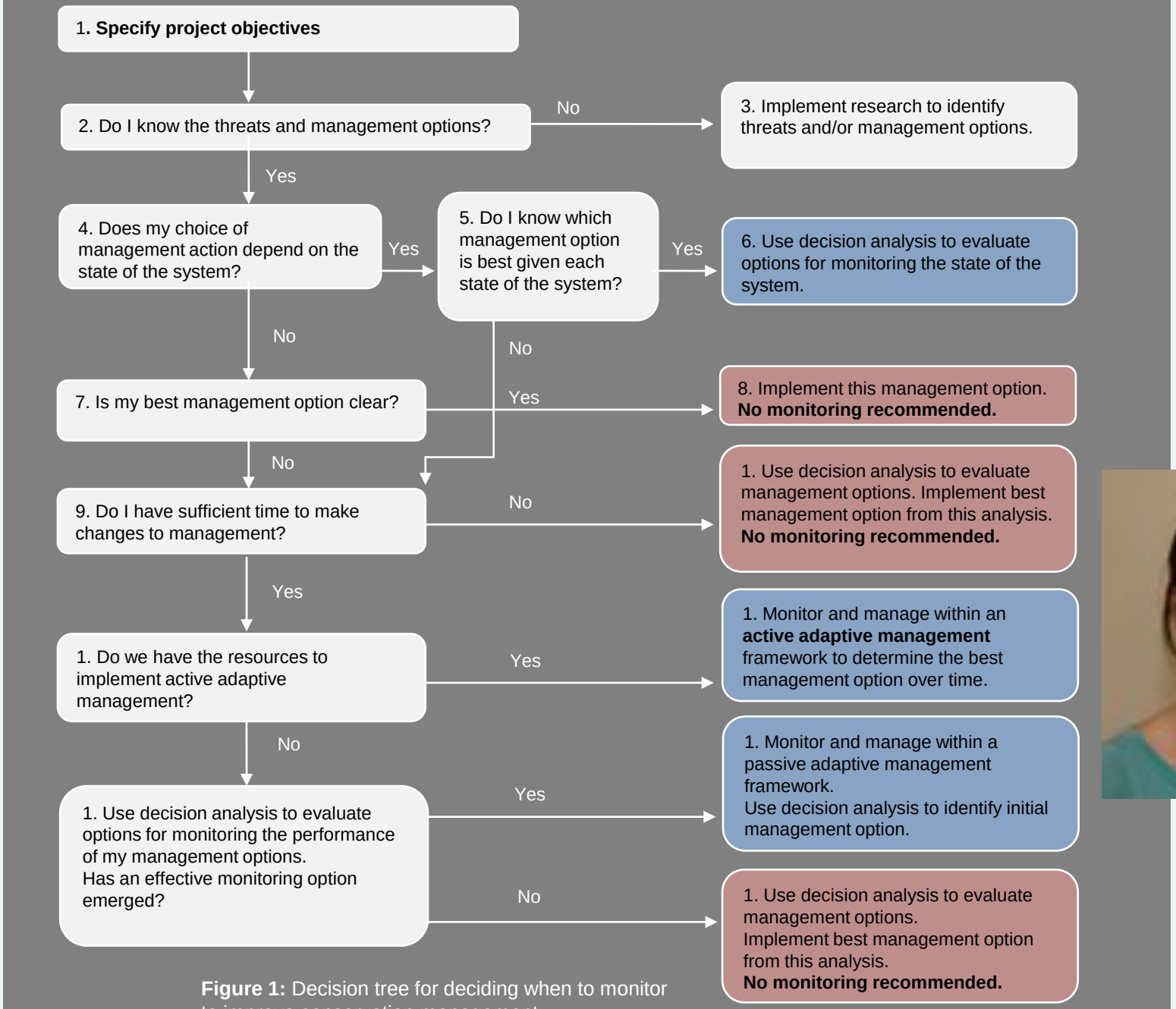
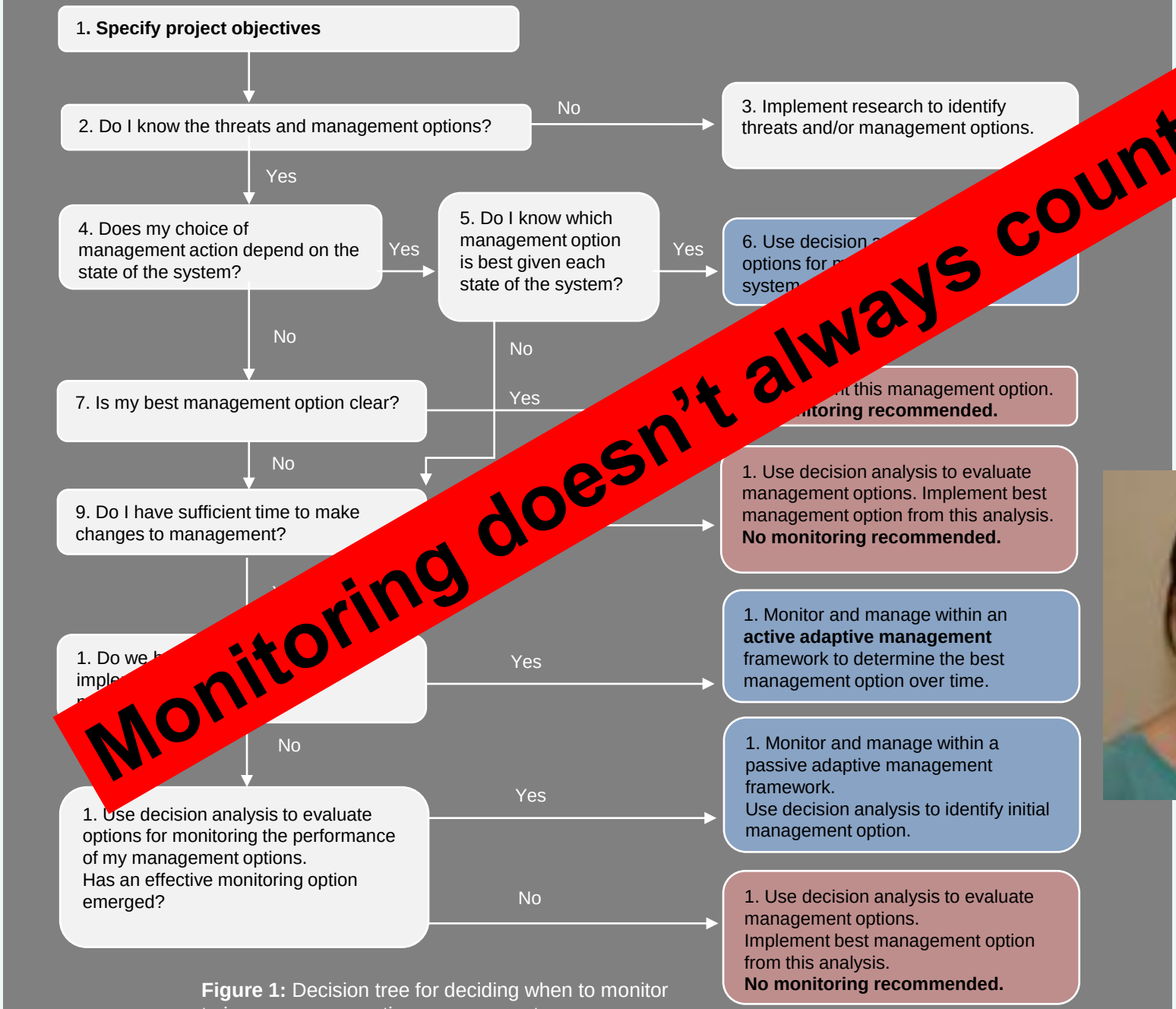


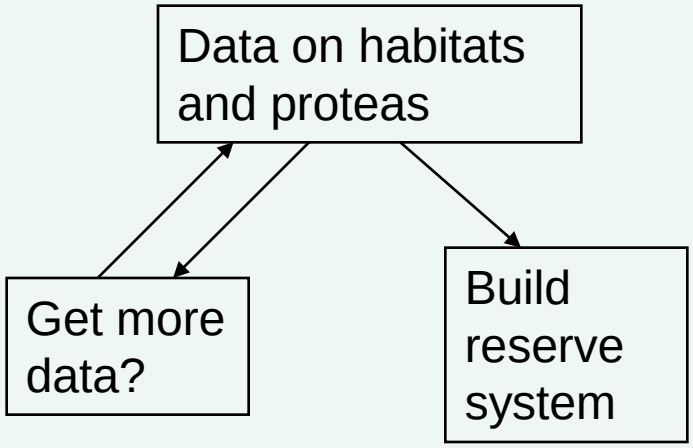
Figure 1: Decision tree for deciding when to monitor to improve conservation management.

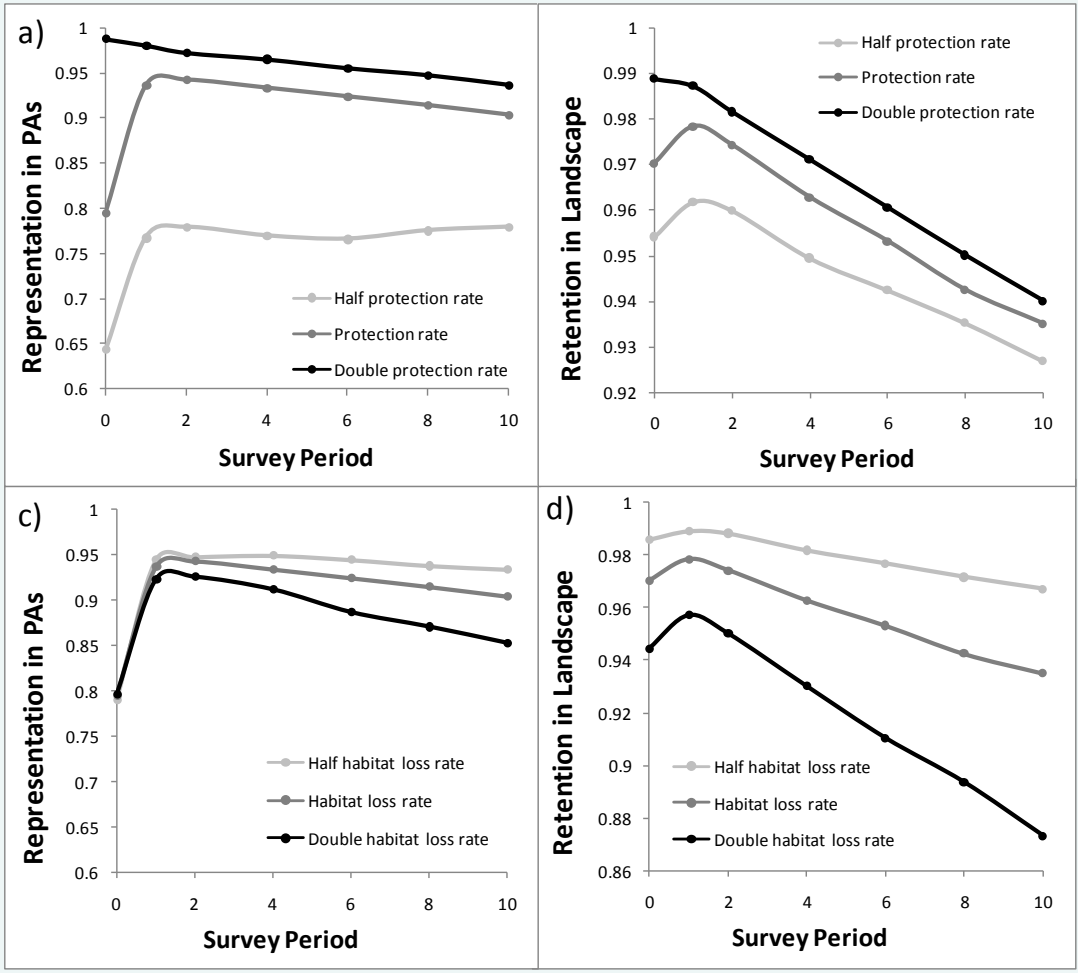


Monitoring doesn't always count

Figure 1: Decision tree for deciding when to monitor to improve conservation management.

Number of species saved as a function of years spent collecting protea data





(Grantham H.S., Wilson K.A., Moilanen A., Rebelo T. & Possingham H.P. (2009). Delaying conservation actions for improved knowledge: how long should we wait? Ecology Letters, 12, 293-301) – similar concept in Gerber et al. 2004.

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