Learning about colonisation under an adaptive management framework

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- Habitat fragmentation a major threat to biodiversity
- Many species now occupy meta-populations
- Persistence governed by dispersal and extinction rates

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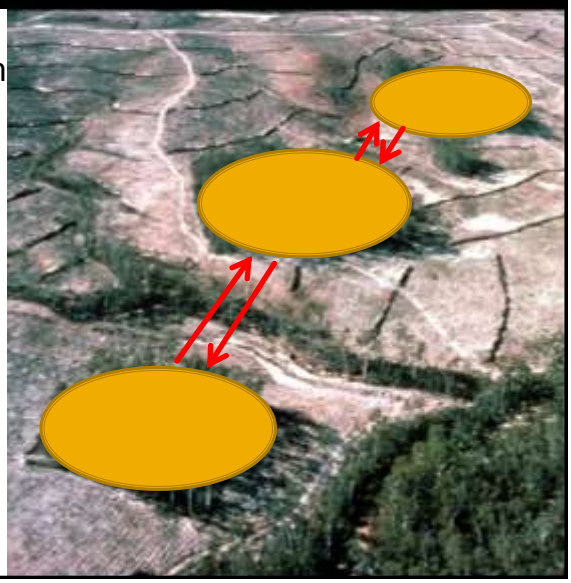

Metapopulatio

- Restoration strategies:
  - Improve patch quality
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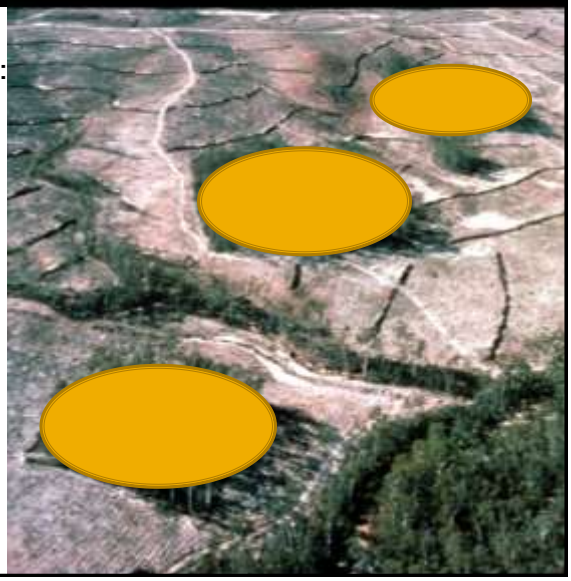
  - Corridors
- Optimal strategy often sensitive to the colonisation rate
- Colonisation rate rarely known with certainty



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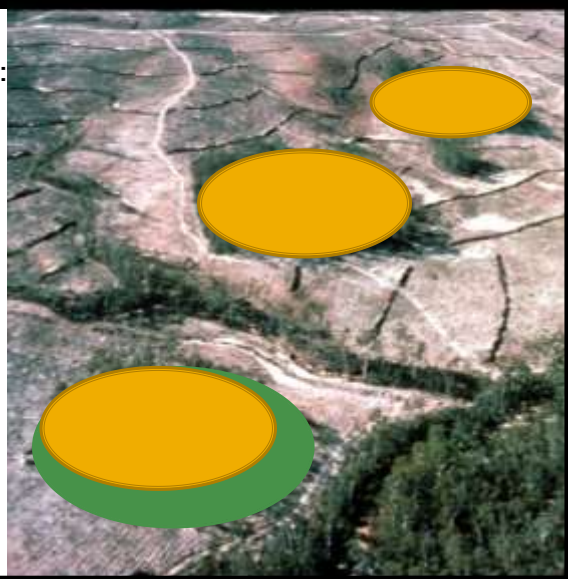

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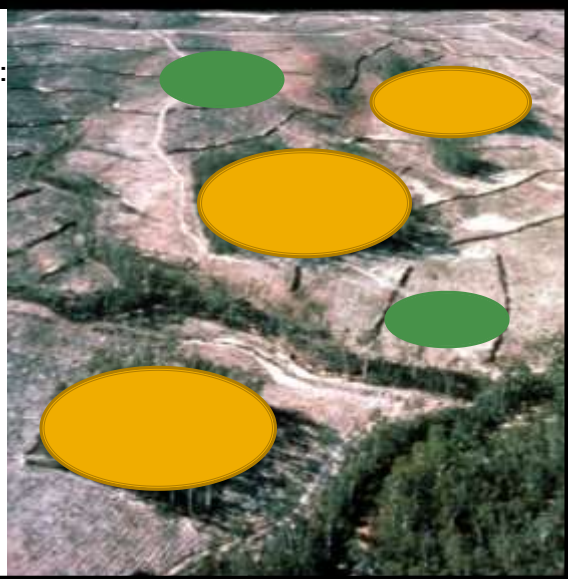

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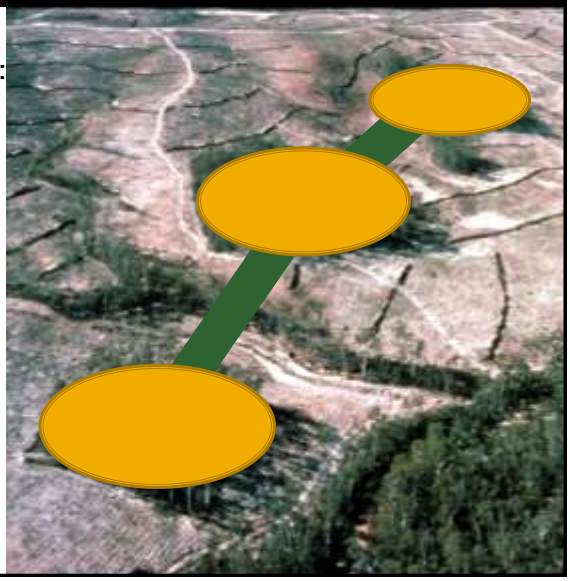

Adaptive management

- Adaptive management is a framework for learning while doing
  - Passive adaptive management
  - Active adaptive management
- Applied to many areas in conservation science
- Yet to be applied to meta-population restoration



Aim of research

- Find the optimal management strategy for a meta-population
- Research questions:
  1. *What is the optimal management strategy for a meta-population when colonisation is uncertain?*
  2. *What is the optimal way to learn about colonisation as we manage a meta-population?*

Case study: Growling Grass Frog

- When do we improve existing patches?
- When do we add patches to the meta-population?

Method

- 1. Meta-population model
- 2. Incorporate uncertainty into the model
- 3. Uncertainty updated during modelling
- 4. Find optimal management and learning strategy

Meta-population model

- Adapted from Nicol and Possingham (2010)
- Number of patches $\mathbf{M} \in \{M_{min}, M_{min+1}, \ldots, M_{max-1}, M_{max}\}$,
- Area of patches $\mathbf{A} \in \{A_{min}, A_{min} + k, \ldots A_{max} - k, A_{max}\}$,
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- What is the probability of **M, A** and **n** changing in the next time step?

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Do nothing

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- ***e*** is a function of area

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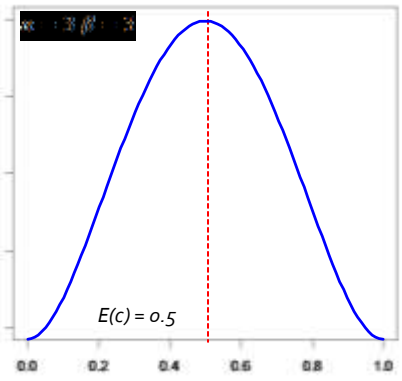
Management actions

- 1. Add area to existing patches
- 2. Create new patches

Incorporating uncertainty in colonisation

- ***c*** modelled with Beta distribution
- Shape defined by parameters: alpha and beta
- Expected value of colonisation equal to mean



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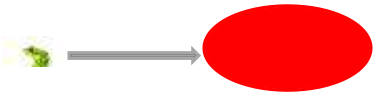

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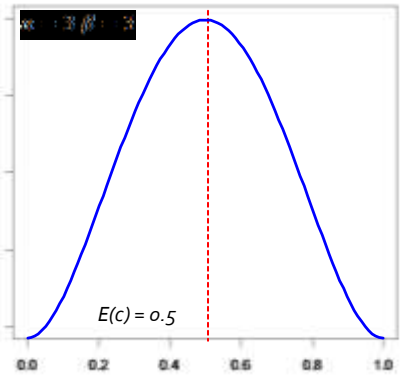

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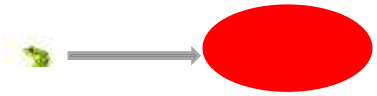

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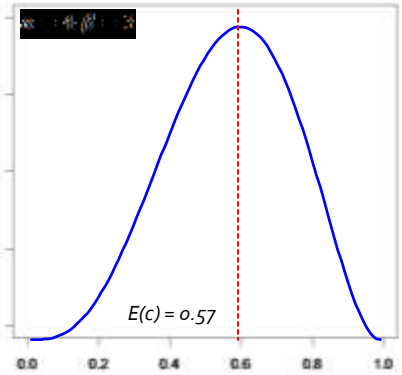

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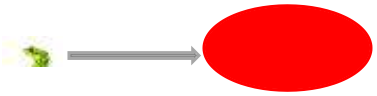

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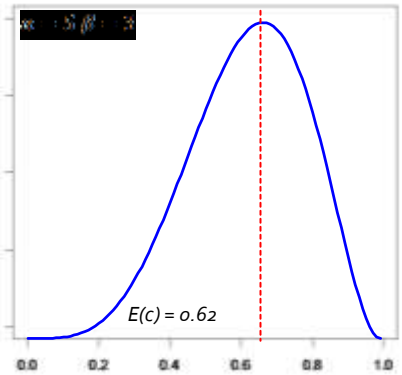

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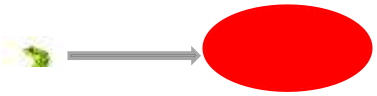

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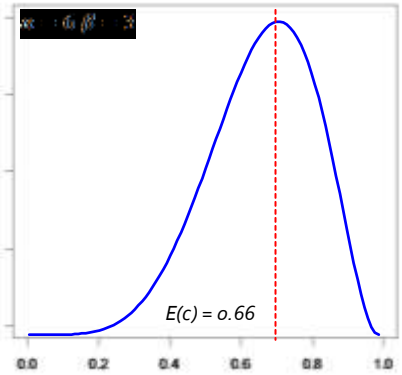

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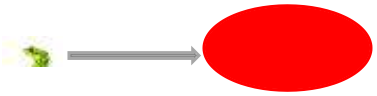

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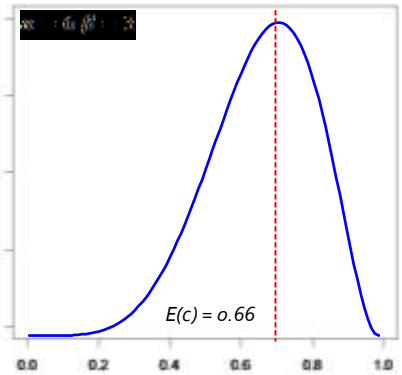

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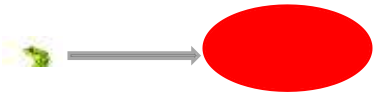

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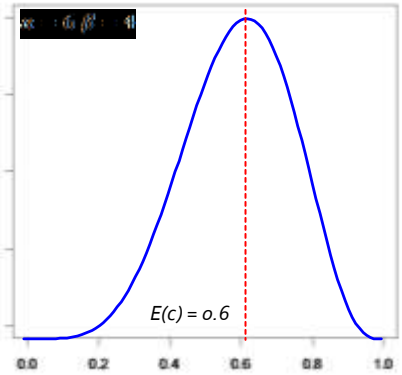

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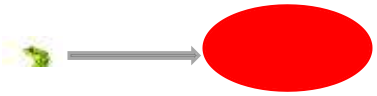

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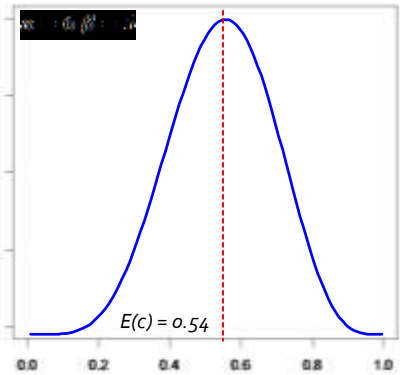

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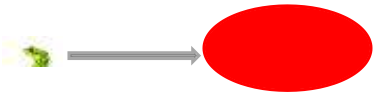

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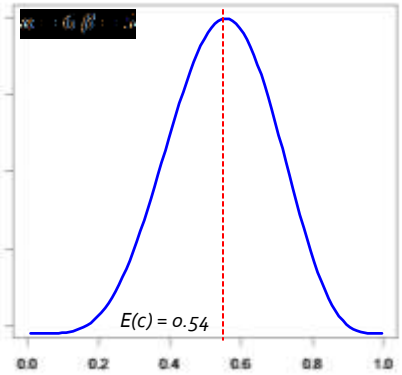
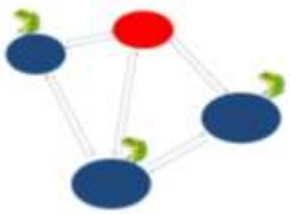


Learning while managing

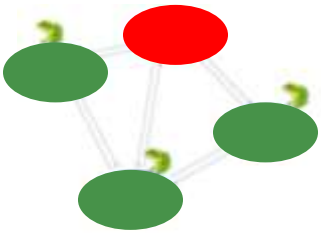
Do nothing



- 1 learning opportunity
- No return

Learning while managing

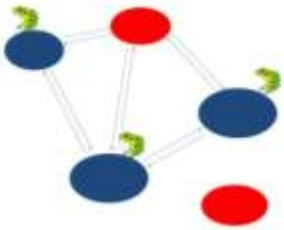
Add area



- 1 learning opportunity
- Extinction rate reduced

Learning while managing

Add patch



- 2 learning opportunities
- No immediate returns

Learning while managing

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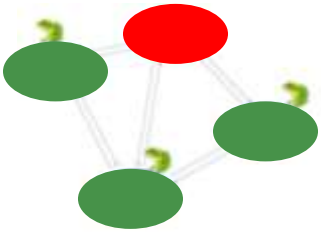

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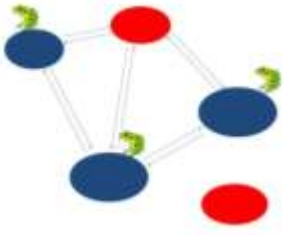

- 2 learning opportunities
- No immediate returns

- Which action should we implement given our belief in colonisation?
- Which action should we implement to manage and learn?

Optimisation

- Optimal strategy found using **stochastic dynamic programming** (SDP)
- Steps of the SDP:
  - 1. Set time horizon and management objective
  - 2. Loops through each time step
  - 3. Searches through each state – all combinations of M, A, n, alpha and beta
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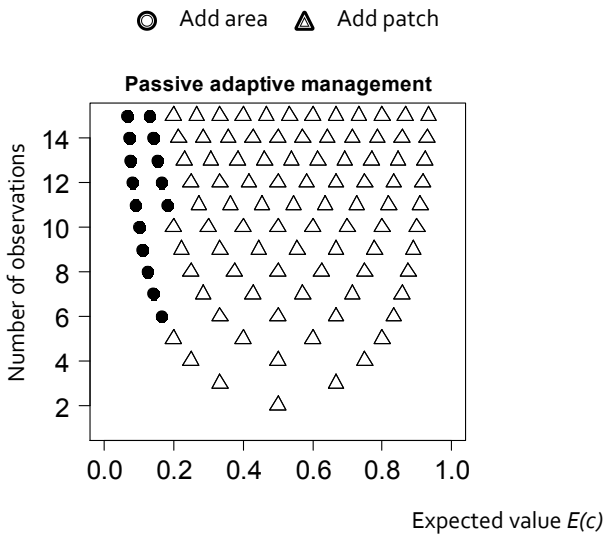
  Updates **belief in colonisation** over time
- Passive adaptive management
  - Beliefs updated retrospectively
- Active adaptive management
  - Value of learning considered prior to management

Preliminary results: 4 patches, 3 occupied, area 2



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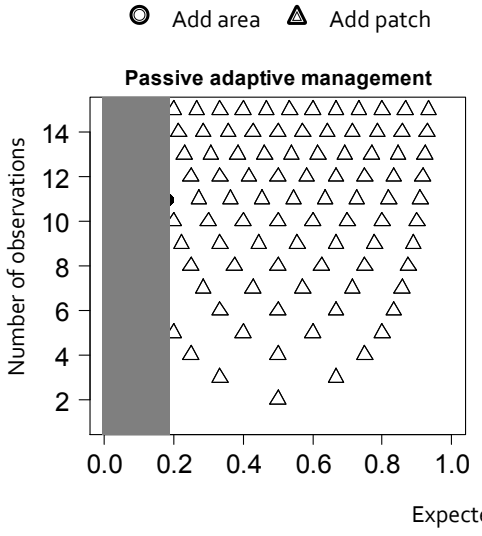

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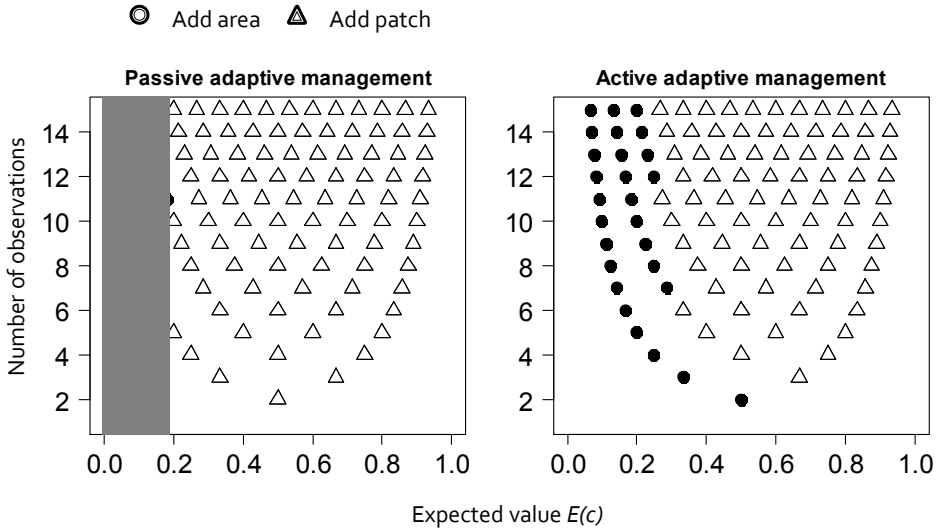

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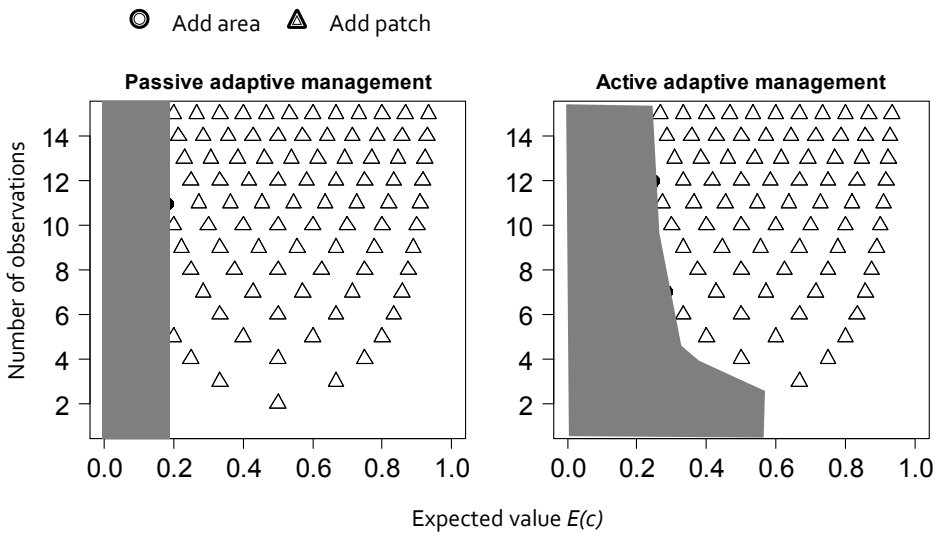

Discussion

- Meta-population assumed to be spatially implicit
- Colonisation not a function of the number of occupied patches
- Number of patches occupied, n, known with certainty
- Relationship between patch area and extinction known with certainty

Summary

- Many species will occupy meta-populations
- Models are useful tools for guiding meta-population restoration
- Model parameters often highly uncertain
- Adaptive management provides a way to act immediately and resolve key uncertainty
- Increasingly important in conservation science

References

- Nicol S.C., and Possingham H (2010) Should metapopulation strategies increase patch area or number of patches? Ecological applications 20(2) :566-581