Lecture 21: Land use optimization

Learning objectives:

Understand the basic

Appreciate the core principles of LULCC m.

Understand the strengths and weaknesses of models

Readings:

- Venter in Prep Near-term wilderness loss most likely in places with high concentrations of threatened species

Projection vs Optimization

- What would happen to the things we care about if we managed in ‘x’ way?

Projection vs Optimization

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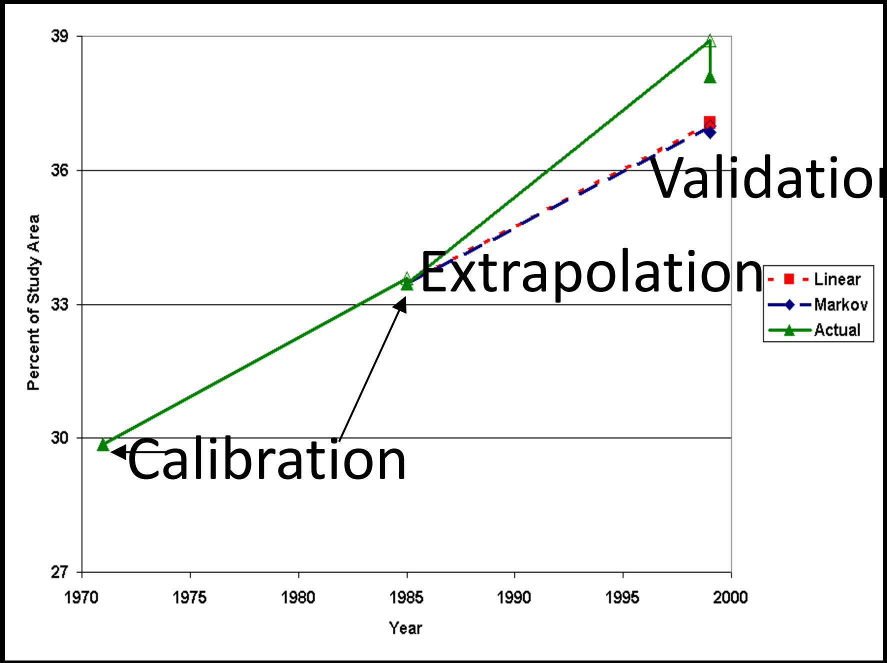

Projection vs Optimization

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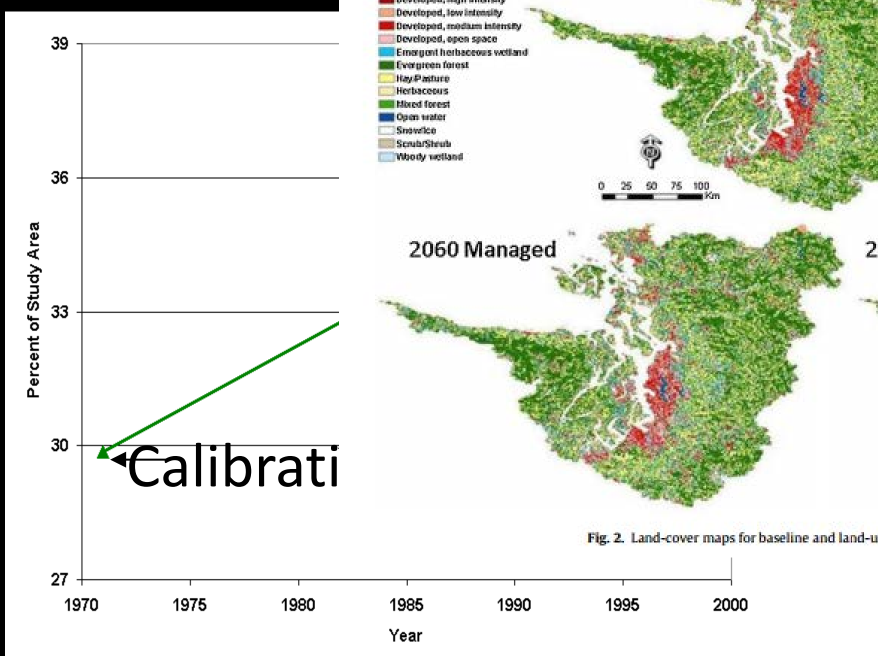


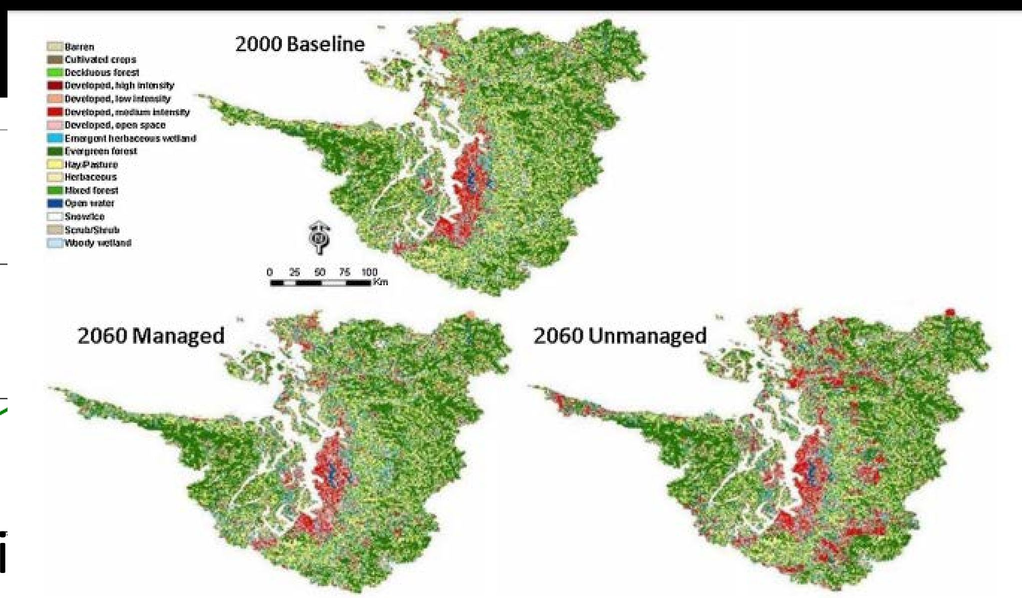
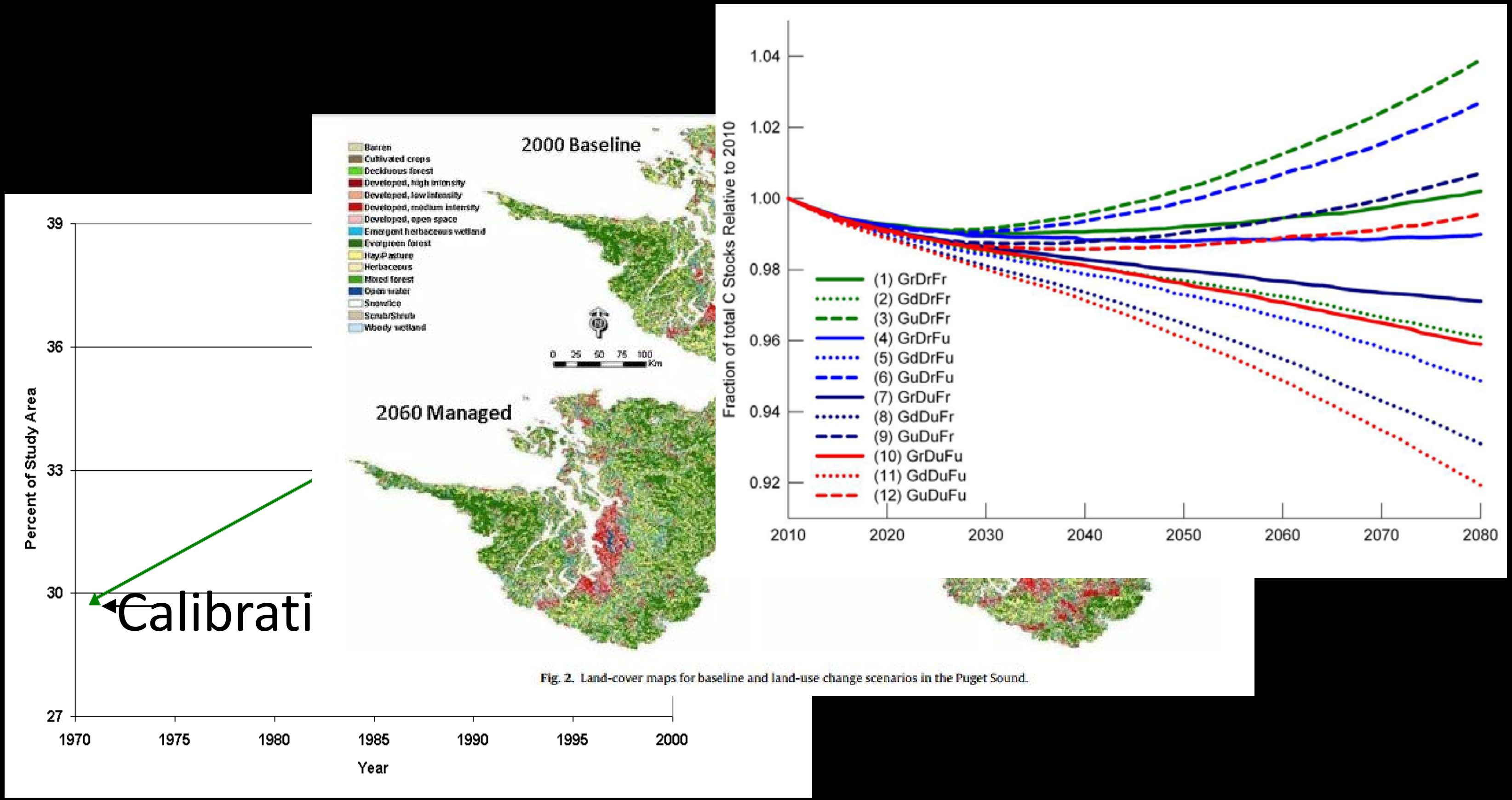


Fig. 2. Land-cover maps for baseline and land-use change scenarios in the Puget Sound.

Projection vs Optimization

- What would happen to things we care about if we managed in 'x' way?



Projection vs Optimization

- What is the best way to manage for the things we care about?

Projection vs Optimization

- What is the best way to manage for the things we care about?
  - Maximize timber harvest
  - Maximize forest carbon stores
  - Maximize provision of ecosystem services
  - Maximize biodiversity habitat
  - Maximize forest resilience
- Maximal coverage problem

Projection vs Optimization

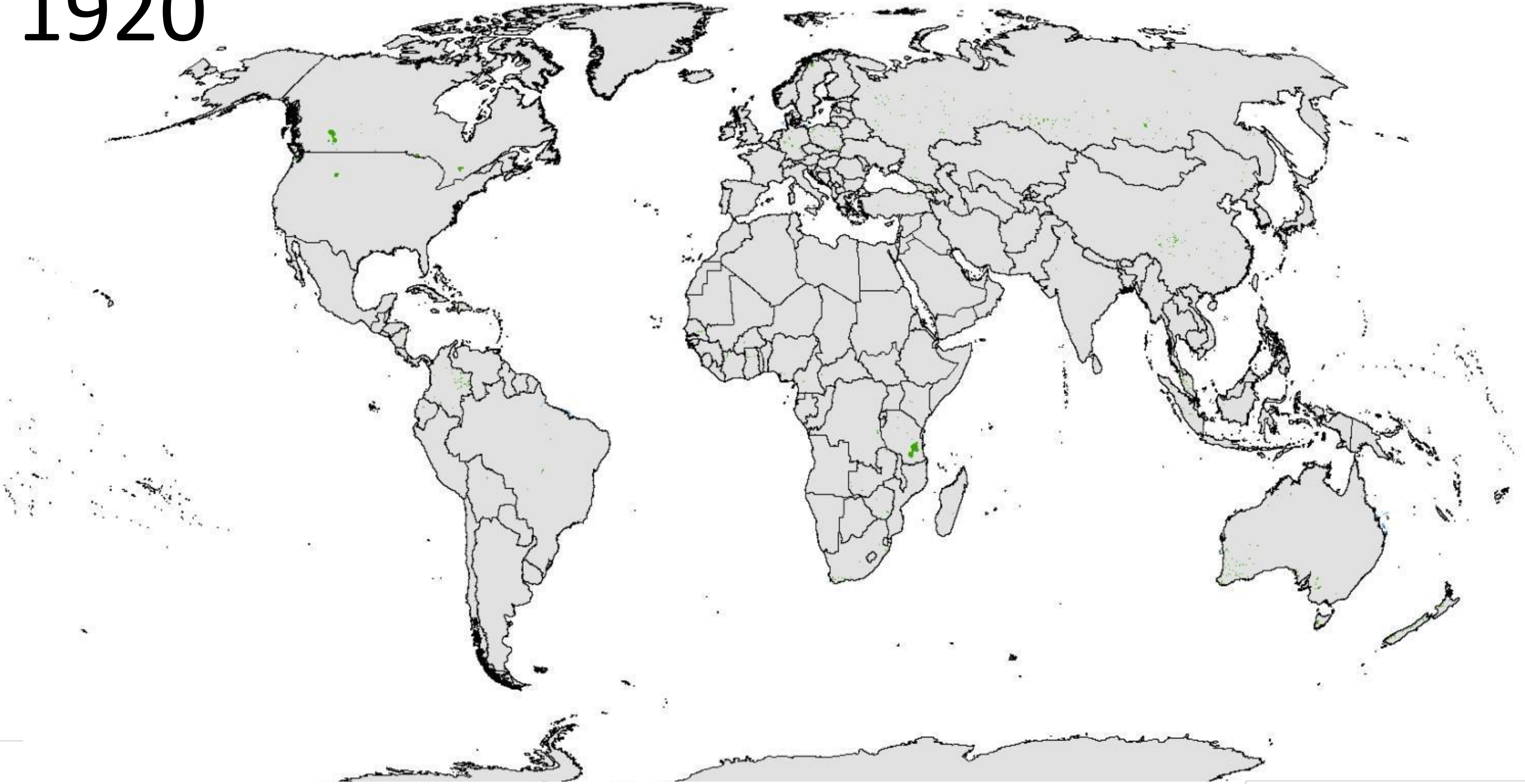
- What is the best way to manage for the things we care about?
  - Meet timber harvest while minimizing costs
  - Maintain carbon stores while minimizing costs
  - Provide ecosystem services while minimizing costs
  - Maintain biodiversity habitat while minimizing costs
  - Ensure forest resilience while minimizing costs
- Minimum set problem

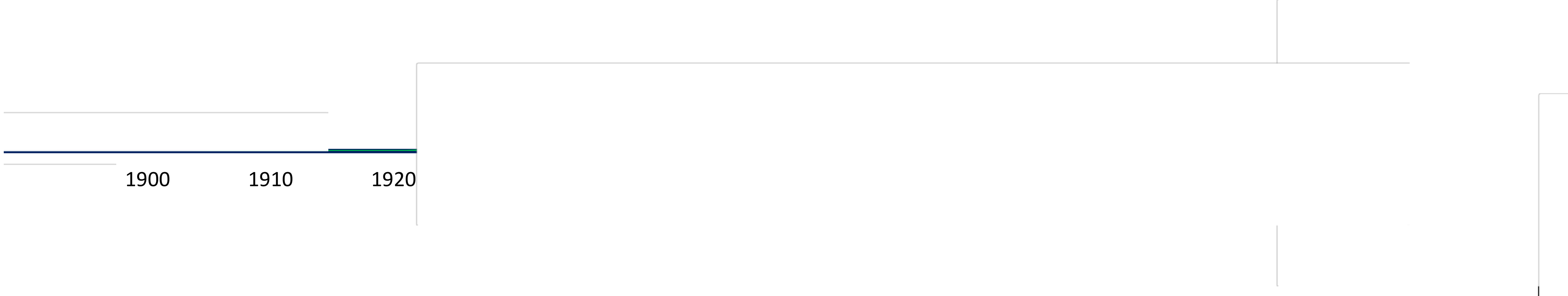
Land use optimization for biodiversity

1900

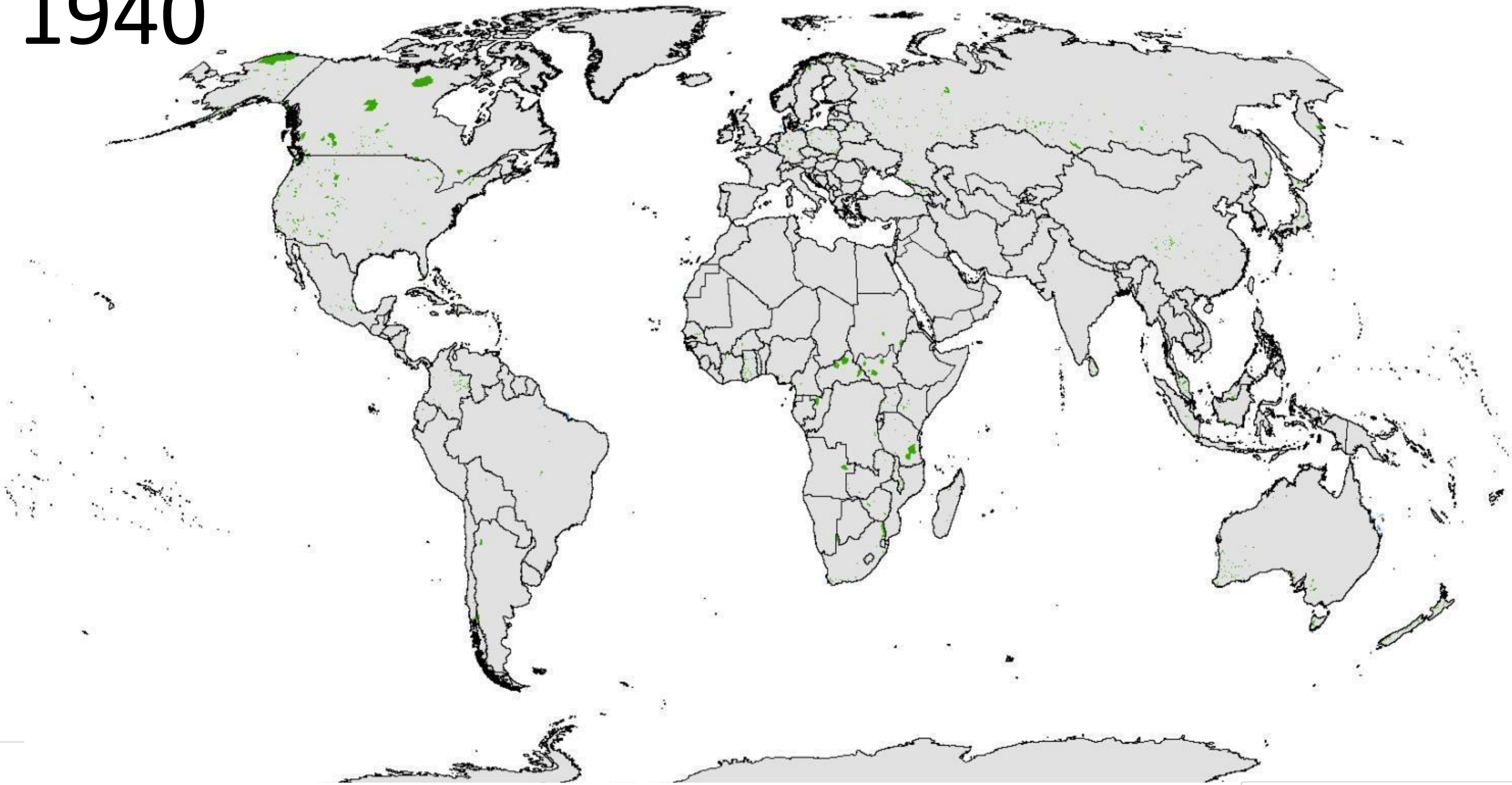
1900

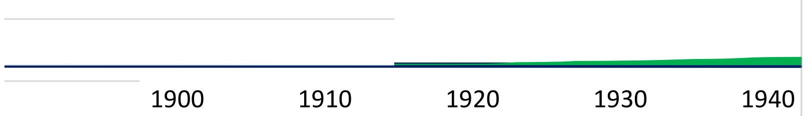
1920



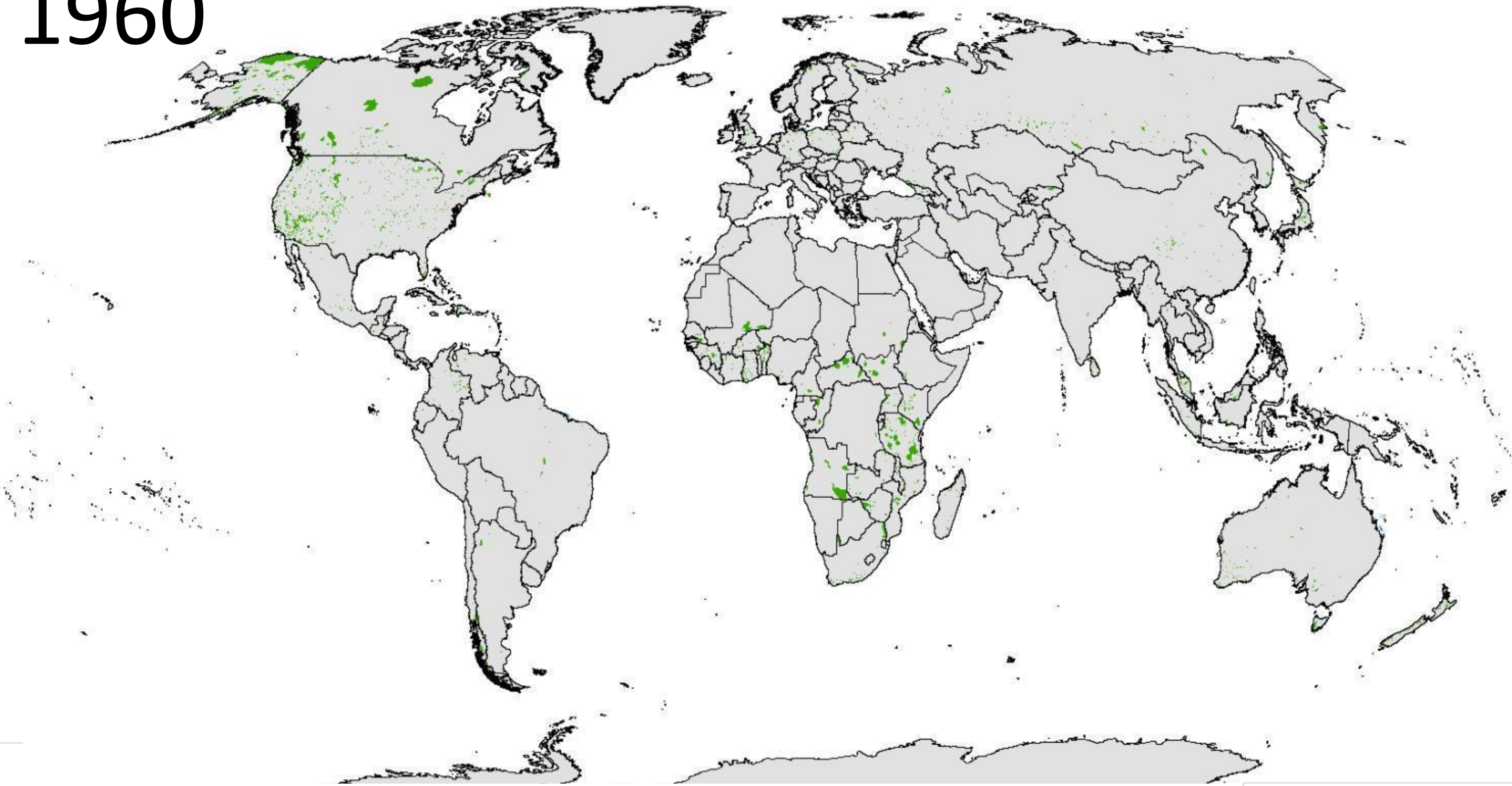


1940

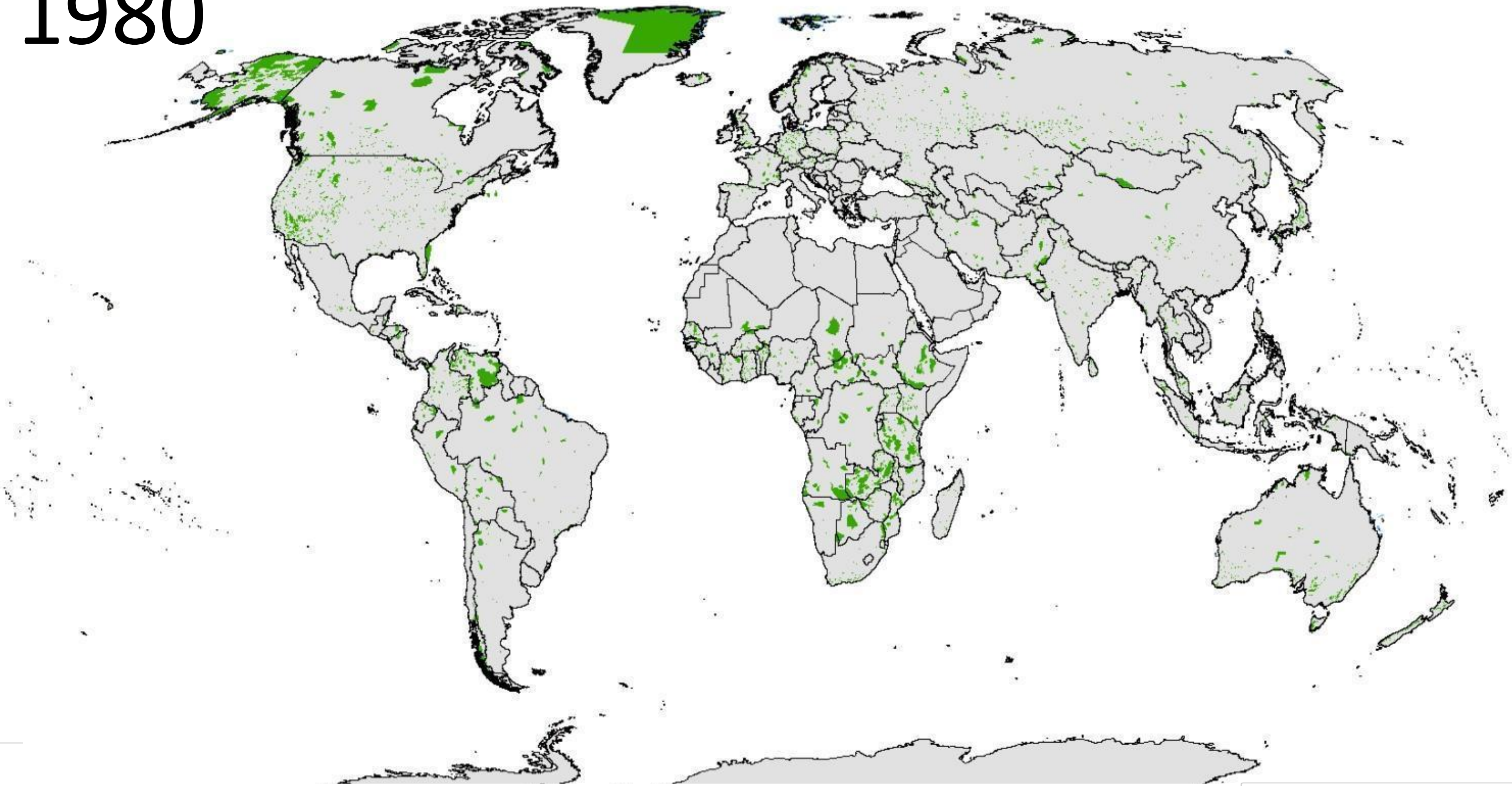


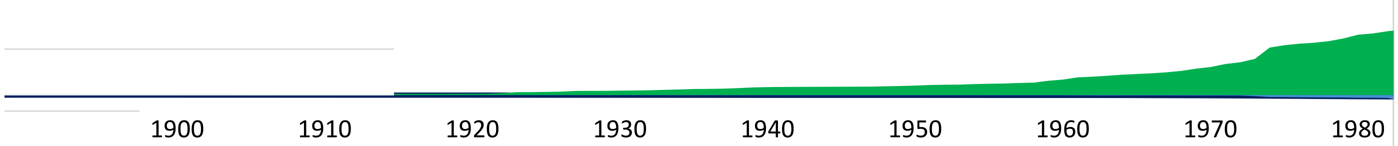


1960

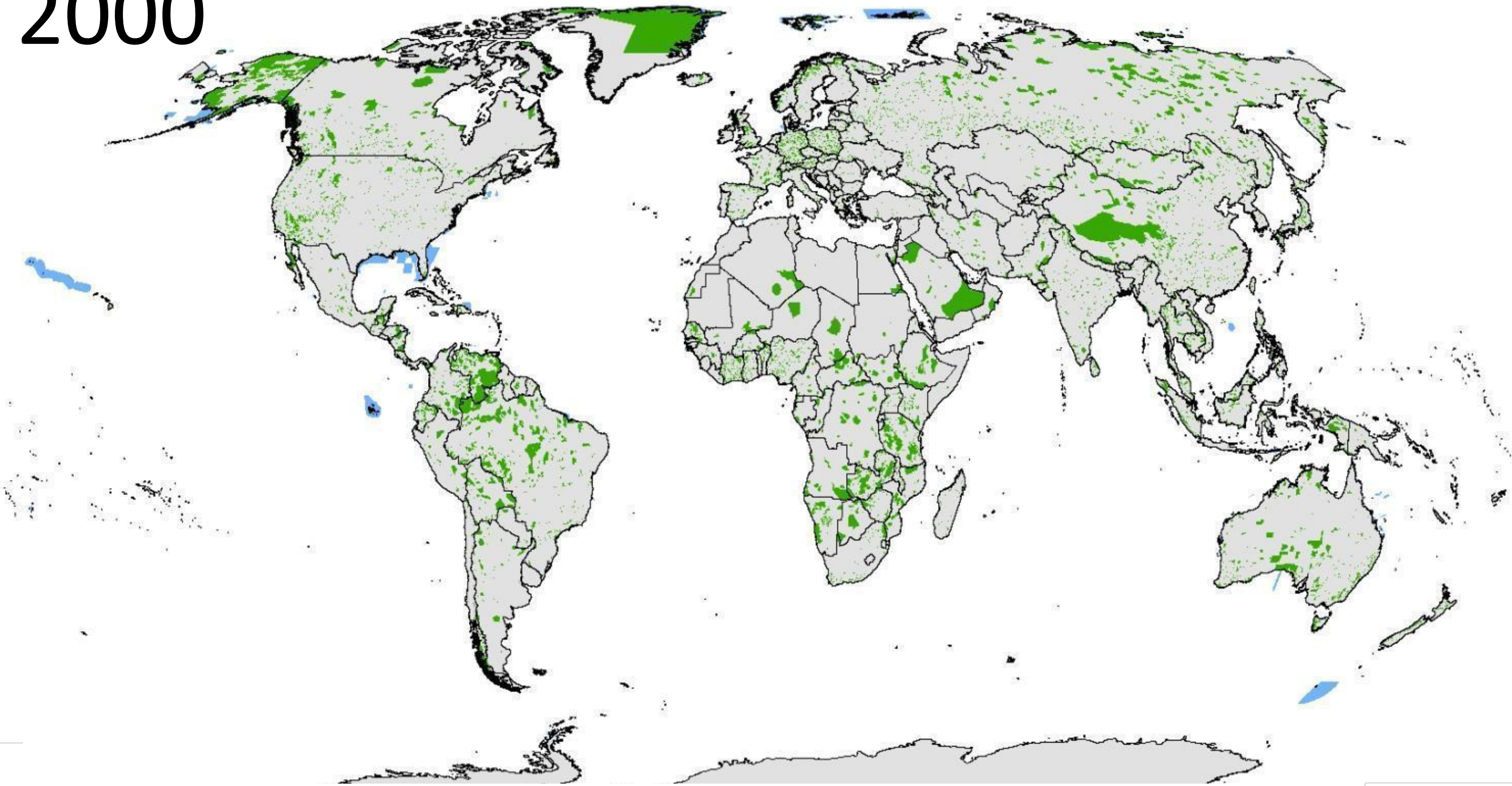


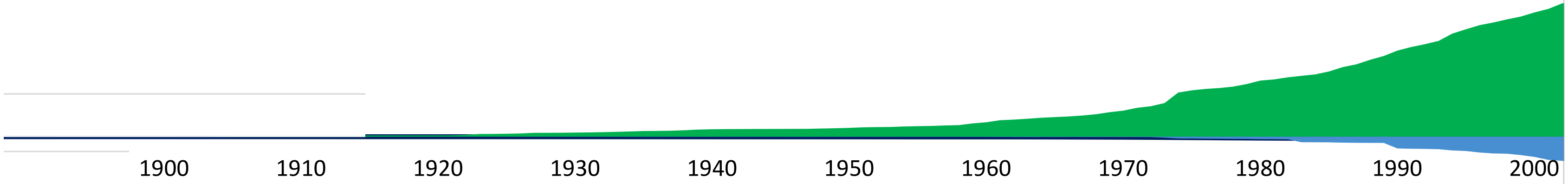
1980



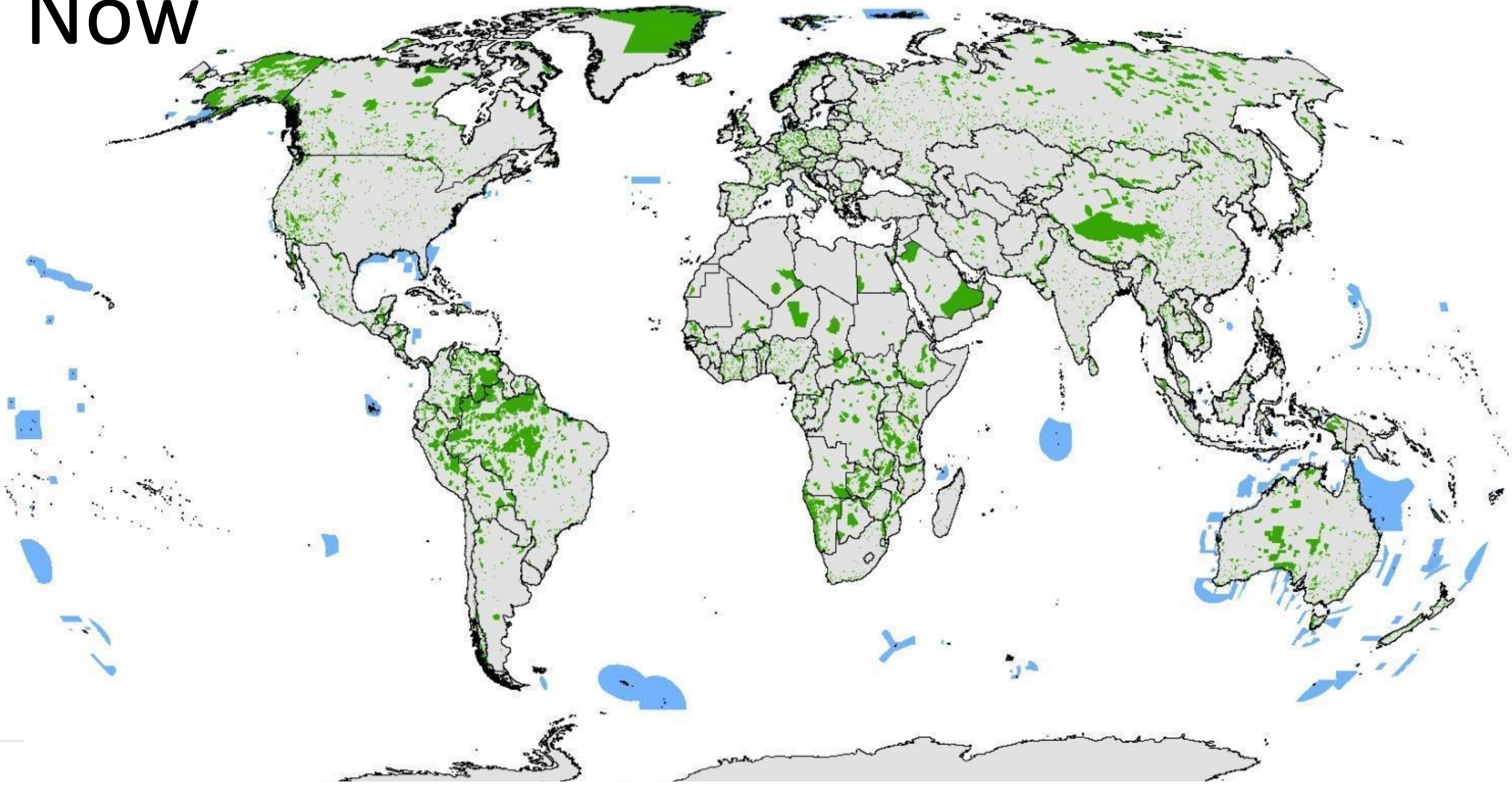


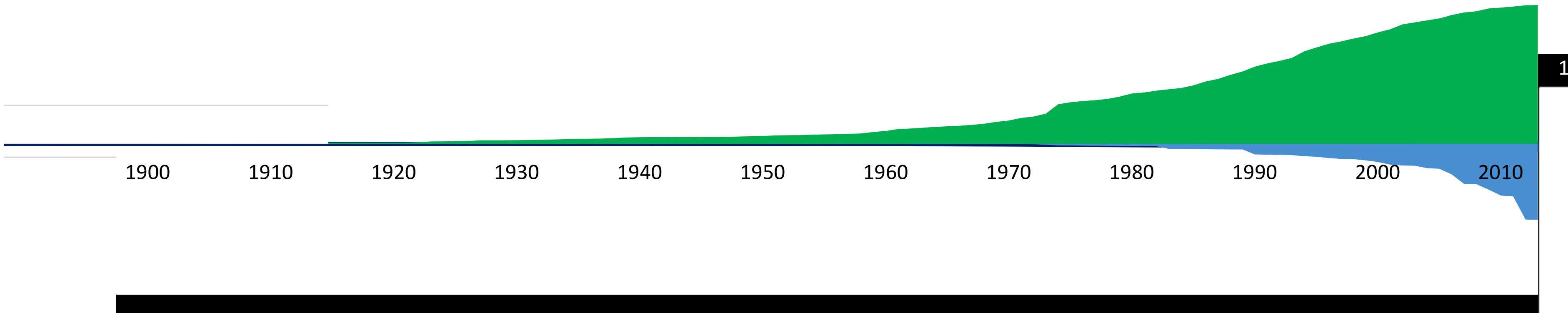
2000



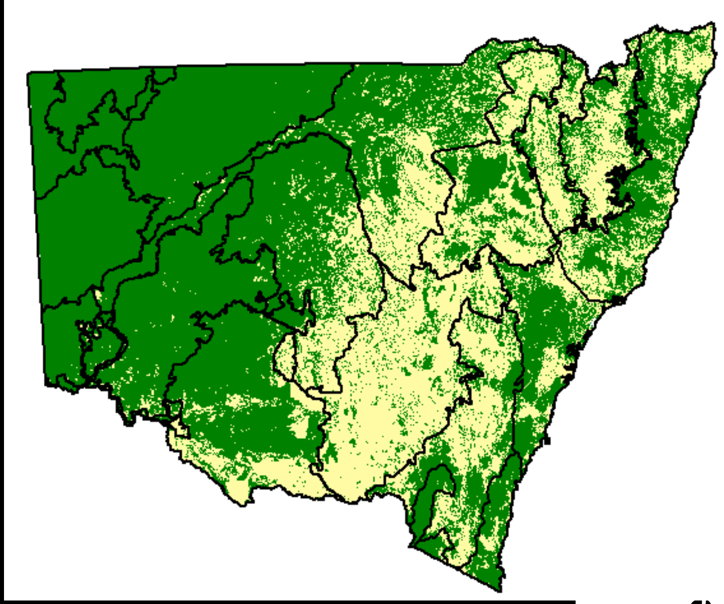


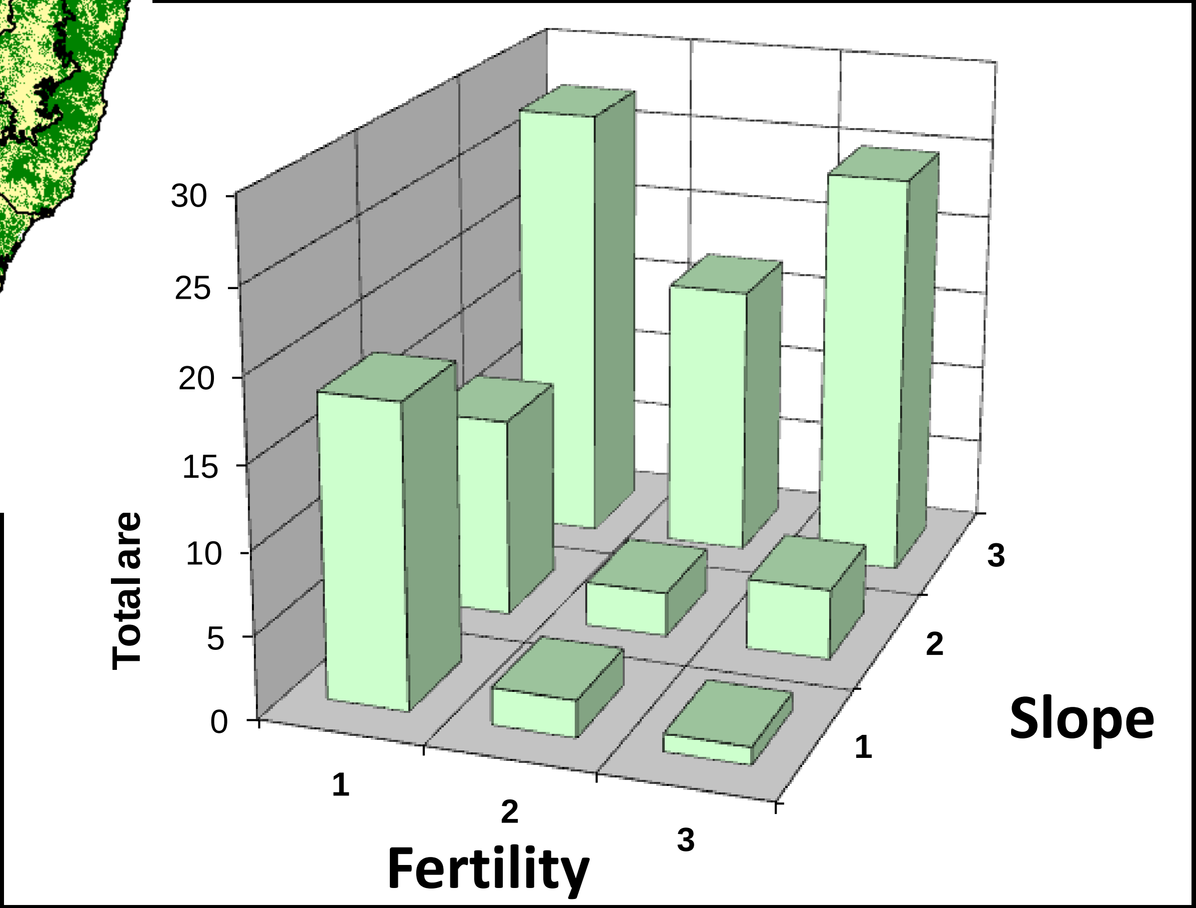
Now





Land use optimization for biodiversity





Pressey et al 1994

Table 1. Summary statistics for all land areas and for protected areas established over the three time periods analysed in this study.

Category	PA Count	Total PA (km^2)	Mean cost (2012 US$ per ha)	Mean species richness
All land	na	127,331,523	61.54	6.81
pre-2004	157,964	16,108,966	37.77	7.37
2004-2009	30,894	2,029,430	35.14	7.53
2010-2014	13,663	1,110,729	16.13	6.31

Venter et al 2017

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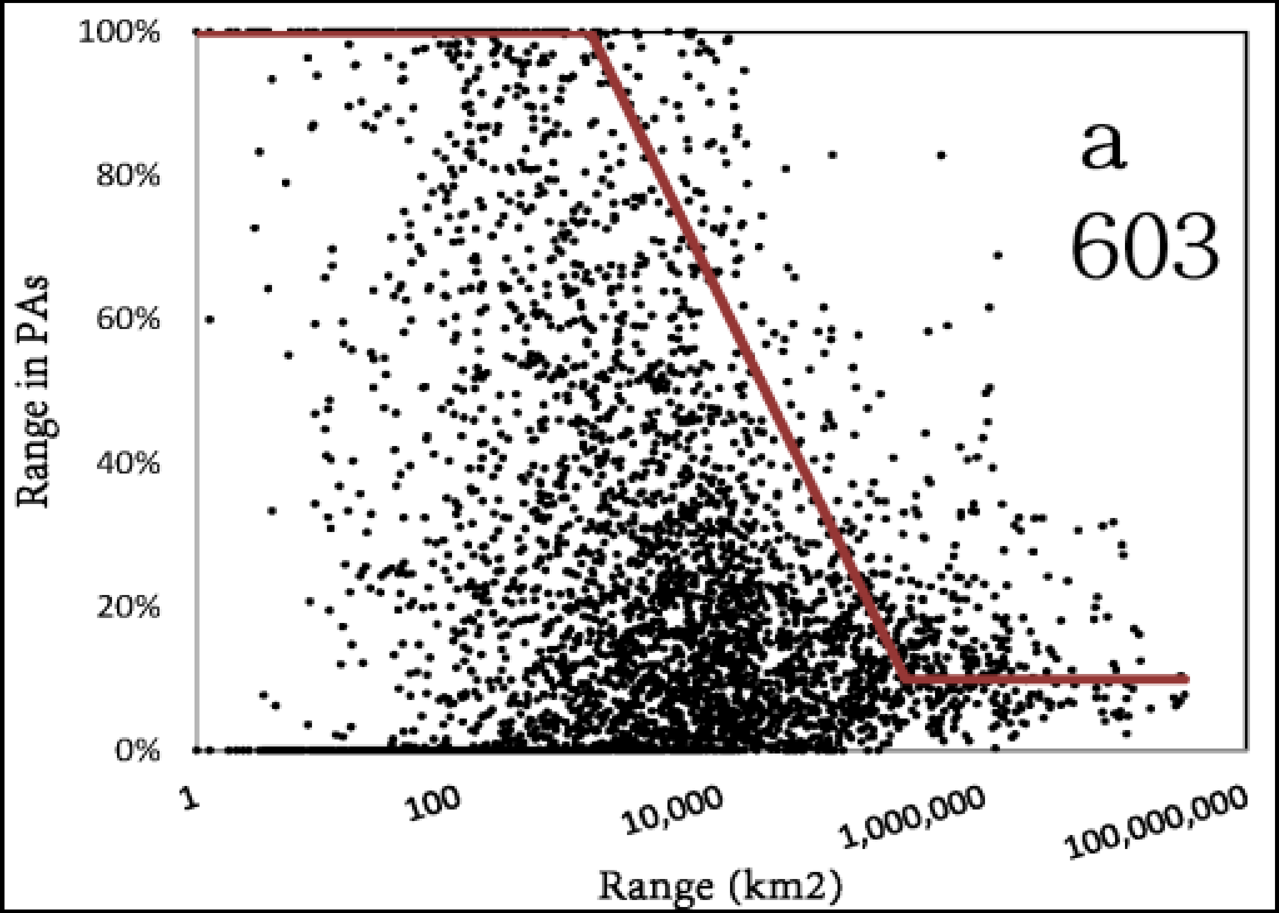
Venter et al 2017

Current coverage of threatened species



Venter et al 2014

Location, location, location…

- Competition for land is strong
- Strategically locate protected areas
- The problem is big

Systematic Conservation Planning

1 Identifying and involving stakeholders
2 Identifying conservation goals
3 Compiling data
4 Formulating conservation targets
5 Reviewing existing target achievement
6 Selecting new conservation areas
7 Implementing new conservation areas
8 Maintaining and monitoring

Margules and Pressey 2000 *Nature*

Systematic Conservation Planning

Computational methods for identifying locations to establish conservation areas

- Can handle large planning problems
- Efficiency
- User friendly and free
- Scenario analyses for trade-offs

Computational tools

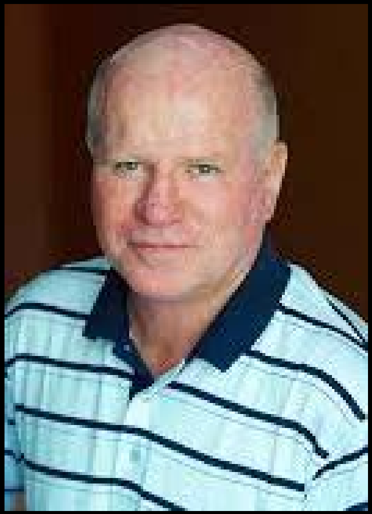
Marxan

Hugh Possingham

Zonation

Atte Moilanen

C-plan



Bob Pressey

Typical decision problem: Objectives

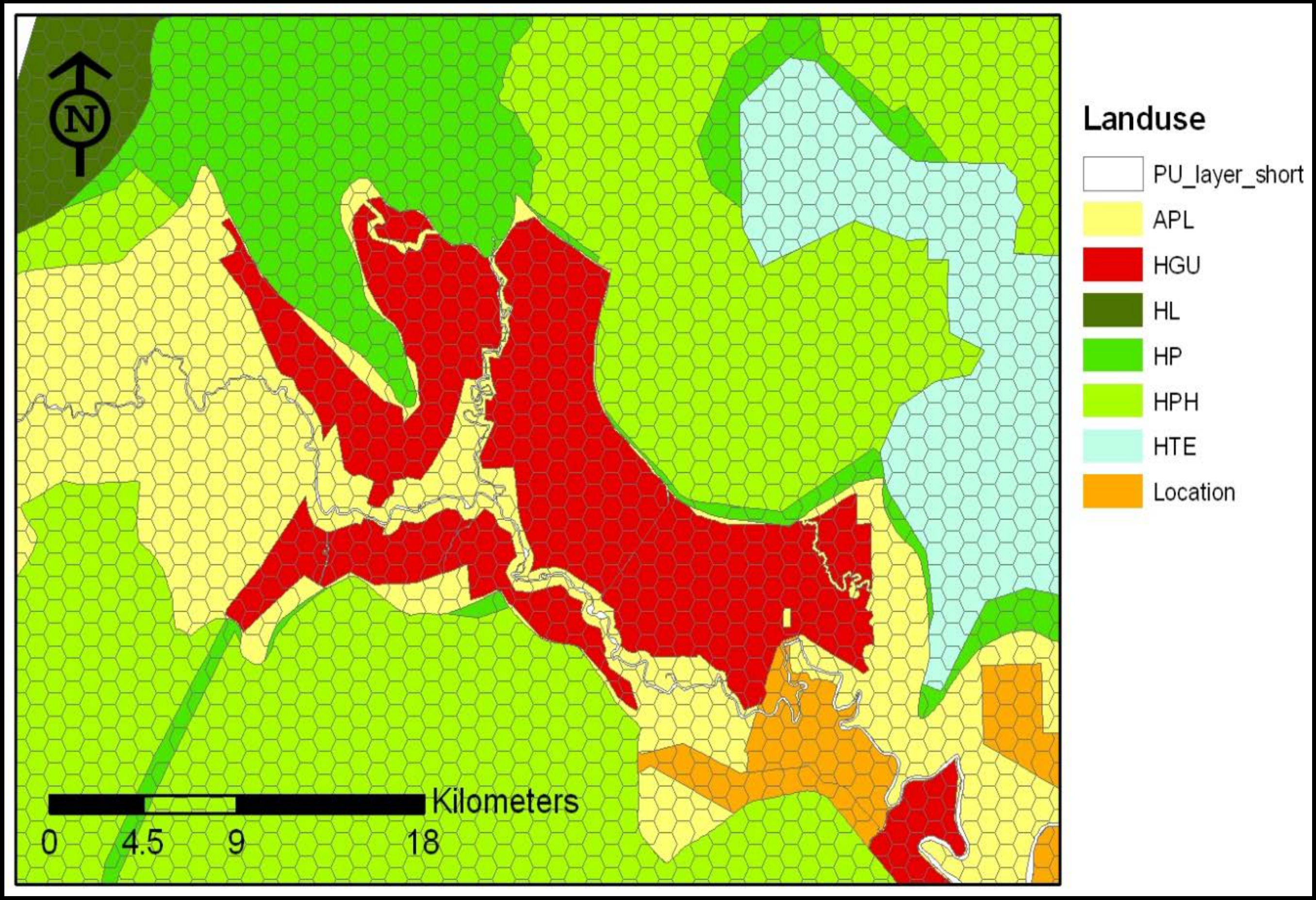
Typical decision problem: Objectives

• ecological ‘regions’	*biogeography*
• ecological processes	*function*
• habitats	*structure*
• species (and genes)	*composition*
• Ecosystem services	*Human values*

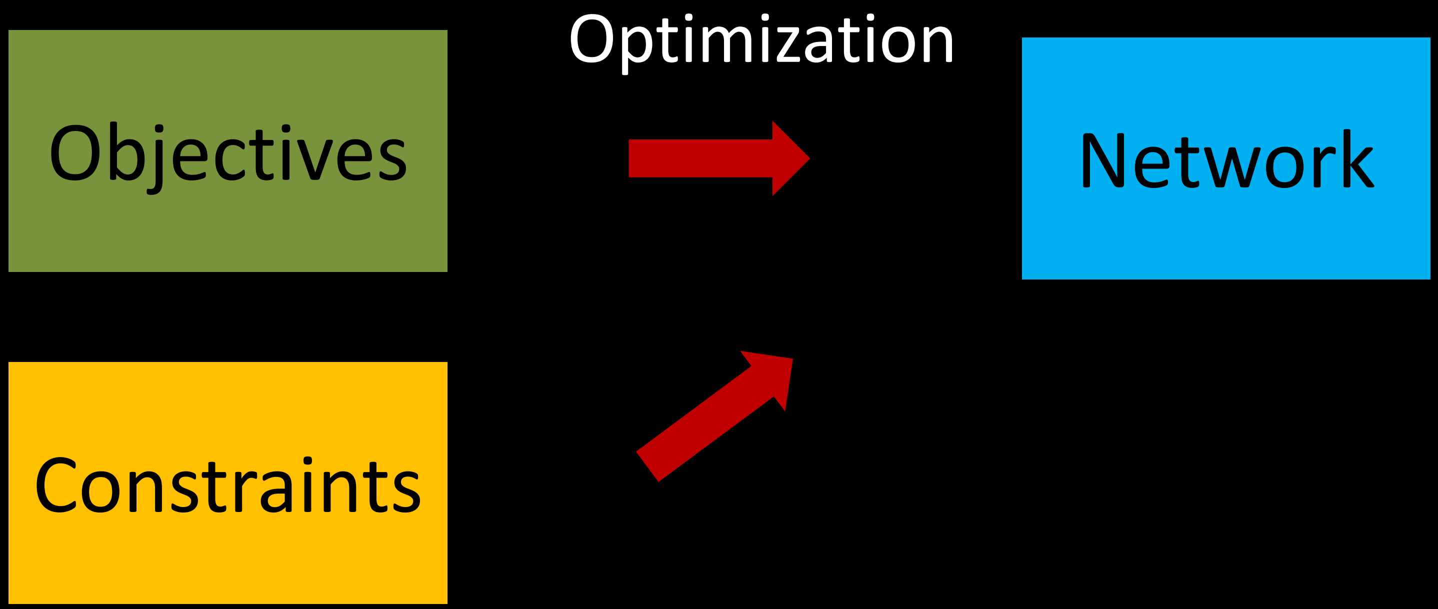
Typical decision problem: Targets

• ecological ‘regions’	*biogeography*	*17%*
• ecological processes	*function*	*All*
• habitats	*structure*	*20%*
• species (and genes)	*composition*	*XX%*
• Ecosystem services	*Human values*	*10%*

Typical decision problem: Constraints



Typical decision problem: Optimization



Optimization problem

- Starts with a clear objective…

"What is the land use configuration that meets all my conservation targets for the lowest cost, while maintaining spatial cohesion of protected areas?"

Optimization problem

Which can be represented numerically…

Minimise $$\sum_{j=1}^{m} c_j . x_j + \alpha.\text{BoundaryLength}$$

Subject to $$\sum_{j=1}^{n} a_{ij} x_j \ge T_i \qquad i = 1, \ldots, m$$

a_{ij} = amount of feature i in planning unit j

T_i = target for feature i

$x_j = 1$ if the planning unit is in the reserve system

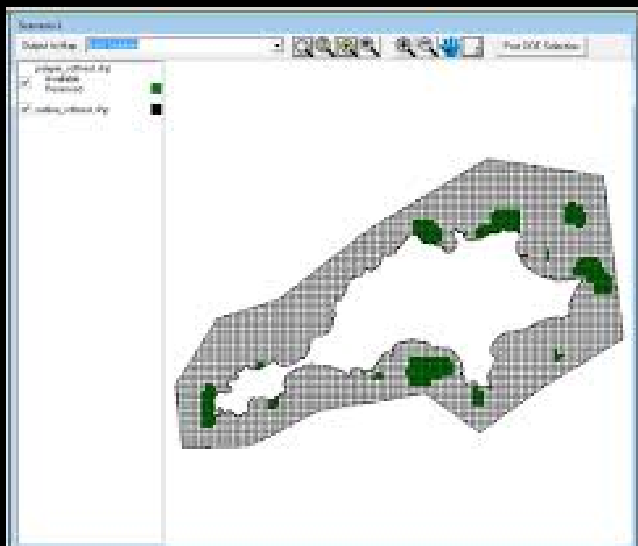
Optimization problem

And solved using…

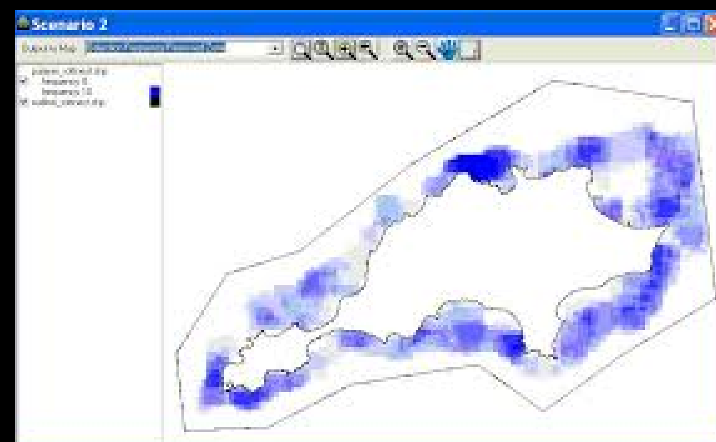
- Wild guess
- Heuristics (eg grab the site that adds most)
- Mathematical Programming: Cocks, K. D., and Baird, I. A. (1989) “Using Mathematical Programming to Address the Multiple Reserve Selection Problem: An Example from the Eyre Peninsula, South Australia”, *Biological Conservation,* **49,** 113-130.
- Heuristic algorithms
  - Simulated annealing
  - Genetic Algorithms

optimization outputs

PA network



Irreplaceability



Models, problems and algorithms

- A model of the system is a prediction in space or time – for decision-making it is often a prediction of the future. PVA is a model. In reserve design we use species distribution models
- A problem is a translation of human's hopes dreams and desires into maths. The reserve design problem is a conservation problem
- An algorithm is a method for finding good answers to a problems

Next Monday

Let’s see how this all works in the lab

3pm