Introduction to Marxan:

Marxan in Planning

Delivered by: **Trevor Wiens**

Materials provided by:

PacMARA

info@pacmara.org

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Based on materials developed by:

Matthew Watts, Lindsay Kircher, and Hugh Possingham

aeda
Applied Environmental Decision Analysis
Commonwealth Environmental Research Facility

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

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Introductions

Course Agenda Day 1

February 3, 2015 – National Conservation Training Center

9:00 – 9:10	Course overview
9:10 – 9:20	Introduction of course participants
9:20 – 10:15	Talk I - Key concepts in systematic conservation planning
10:15 – 10:45	Interactive session I - Planning activity
10:45 – 11:00	Morning break
11:00 – 11:30	Talk II - Case study exercise introduction
11:30 – 12:30	Interactive session II - begin case study exercise (creating Marxan input files)
12:30 – 1:30	Lunch
1:30 – 2:15	Talk III - Marxan case study application
2:15 – 4:30	Interactive session III - Creating Marxan input files continued, parameter setting, setting up the file structure, and running Marxan

Course Agenda Day 2

February 4, 2015 – National Conservation Training Center

9:00 – 9:45	Talk IV - How does Marxan find good solutions?
9:45 – 10:15	Talk V - Zonae Cogito and Simulated Annealing demonstration
10:15 – 10:45	Begin Interactive session IV - Running Marxan with ZC and understanding output files
10:45 – 11:00	Morning break
11:00 – 12:30	Continue Interactive session IV - Running Marxan with ZC and understanding output files
12:30 – 1:30	Lunch
1:30 – 2:15	Talk VI - Marxan case study application
2:15 – 3:00	Interactive session V - Calibration, configuration editor, and cluster analysis
3:00 – 3:30	Talk VII – Introduction to Marxan with Zones
3:30 – 4:30	Continue interactive sessions, question/answer session, extra activities

Introduction to Marxan Part 1: Systematic Planning

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What is systematic conservation planning?

- **Conservation planning**: guides decisions about the location, configuration and management of conservation areas

- **Protected Areas**: "An area of land and/or sea especially **dedicated to the protection of biological diversity**, and of natural and associated cultural resources, and managed through legal or other effective means"(IUCN, 1994)

- **Systematic Conservation Planning** is process for making conservation decisions in a manner that is **efficient, repeatable, transparent & equitable**

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What has typically determined conservation priority?

Suitability for other uses, scenic beauty, recreational value

Charismatic animals

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What should determine conservation priority?

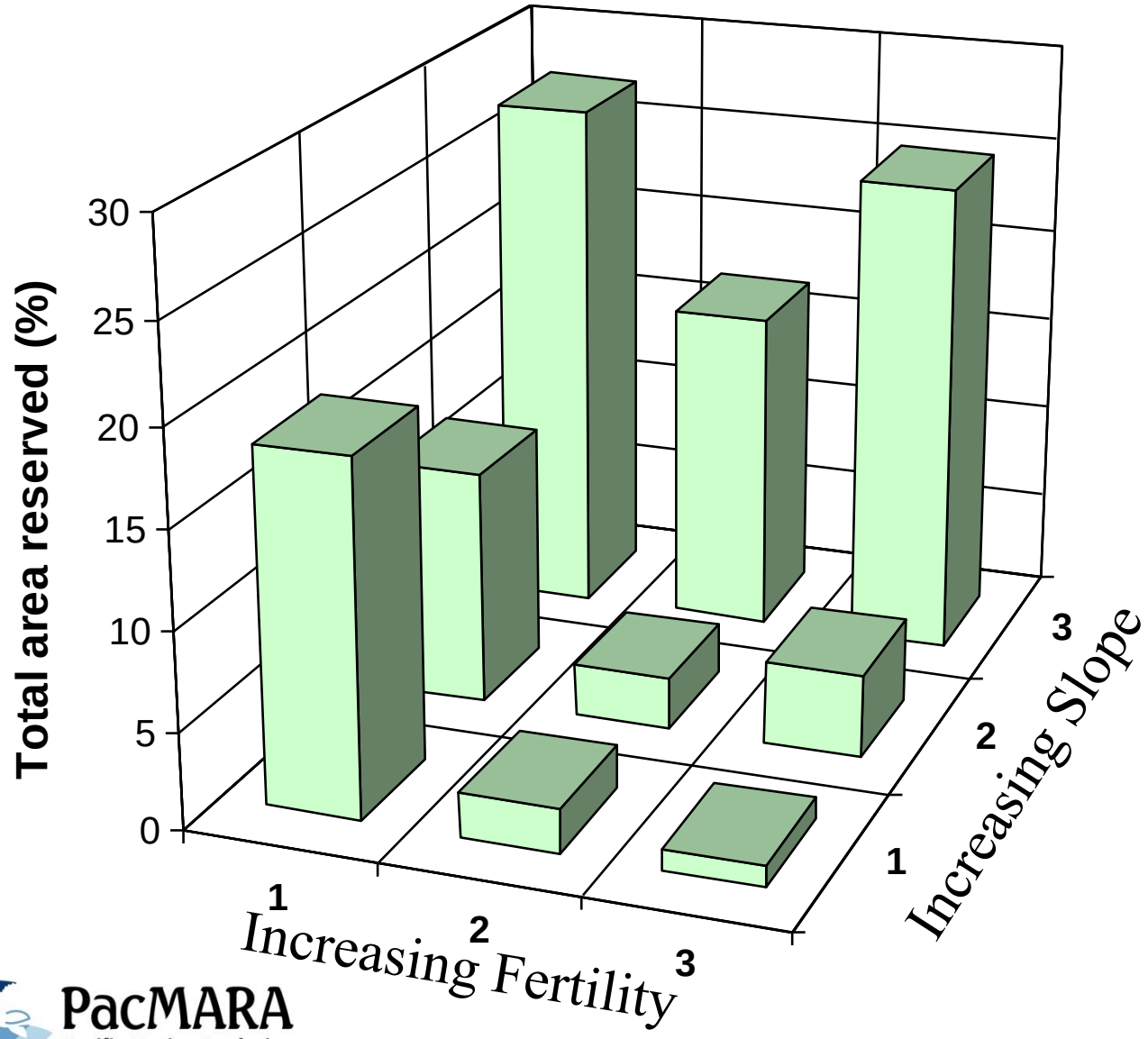
Suitability for other uses,
scenic beauty, recreational value

Charismatic animals

vs

All levels of biodiversity, ecosystem processes, cost-effectiveness, threats, condition …

Biases in the location of conservation areas



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Source: Pressey et al. (2002)

Key principles in conservation planning

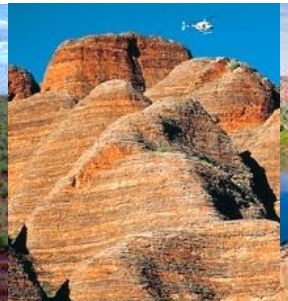
Comprehensive

Adequate

Representative

Efficient




Key principles in conservation planning

Comprehensive

- The "ideal" is to sample every kind of biodiversity
- In practice, this is not possible so we should try to include data on:
  - species (and genes) — *composition*
  - habitats — *structure*
  - ecological processes — *function*
  - ecological 'regions' — *biogeography*

Key principles in conservation planning

Adequate

Protecting enough to ensure persistence of biodiversity features

How much is enough? (difficult question!)

- Usually addressed with targets
- Consideration of threats / habitats outside protected areas will influence how much is needed inside

Key principles in conservation planning

Representative

Sampling across the full range of variation of each feature (e.g. species or habitats)

Key principles in conservation planning

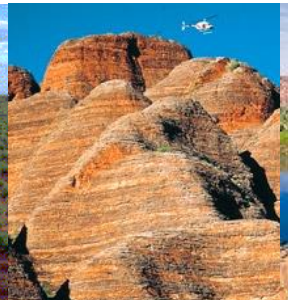
Efficient

Achieving objectives for minimal "cost"

Cost can be defined in terms of:

- acquisition cost ($)
- operational costs ($)
- opportunities lost (for users and industries)
- social values (local 'importance')
- political (gain or loss of credibility / votes)
- A combination of the above




Establishing sites in a network brings new considerations:

Existing protected areas usually have to be factored in, even if they are not ideal.

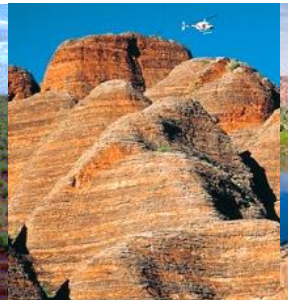
Special places ("jewels") recognised for their unique / irreplaceable ecology.

Threats in some places are more pressing than in others.

Achievable? (financially, legally, mandates)

Broadly supported? (Now and/or in the future?)




Systematic Conservation Planning steps:

1. Scope and cost
2. Identify and involve stakeholders
3. Identify goals
4. Compile data
5. Set conservation targets
6. Assess existing conservation areas
7. Select new conservation areas ⇦ Marxan
8. Implement conservation action
9. Maintain and monitor

Source: Ardron (2010)

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Introduction to Marxan Part 2: Marxan in Planning

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Selecting conservation areas

- First, we need to establish this question clearly and as a formal problem.
- Two typical conservation area selection problems are:
  - The ***minimum set problem***; capture a set amount of biodiversity for the least cost
  - The ***maximum coverage problem***; capture as much biodiversity as possible with a fixed budget

Minimum Set Problem in Marxan

Marxan objective is to:

1. Minimize:

a) The total **"Cost"** of the reserve network

b) Total **"Boundary"** of the reserve network.

2. While meeting all conservation targets (i.e., minimizing the penalties for not adequately representing conservation features)

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How Marxan scores itself to find the most efficient solution?

Marxan "Score"

=

Combined Planning Unit Cost (efficiency)

+

Combined Boundary Length (clumping)

+

Combined Target Shortfall

(penalty for not achieving conservation targets)

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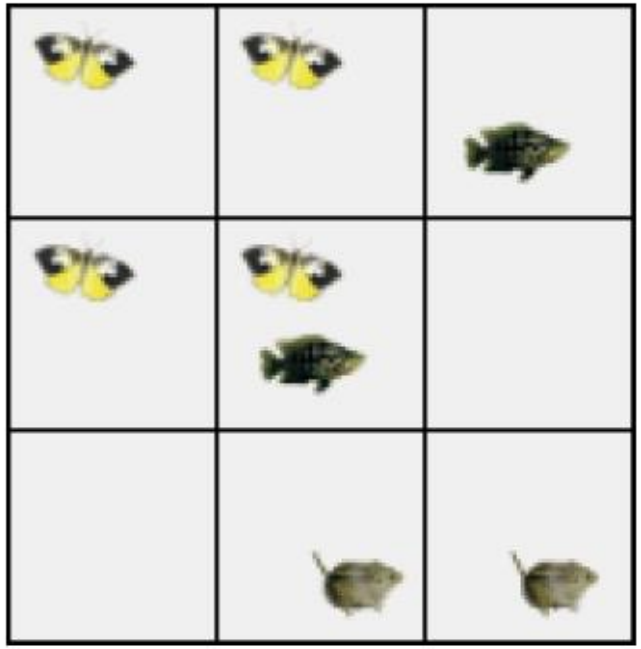
Example of Marxan "Scoring"



PU area = 1 km x 1km => PU cost

Boundary length = 1 km

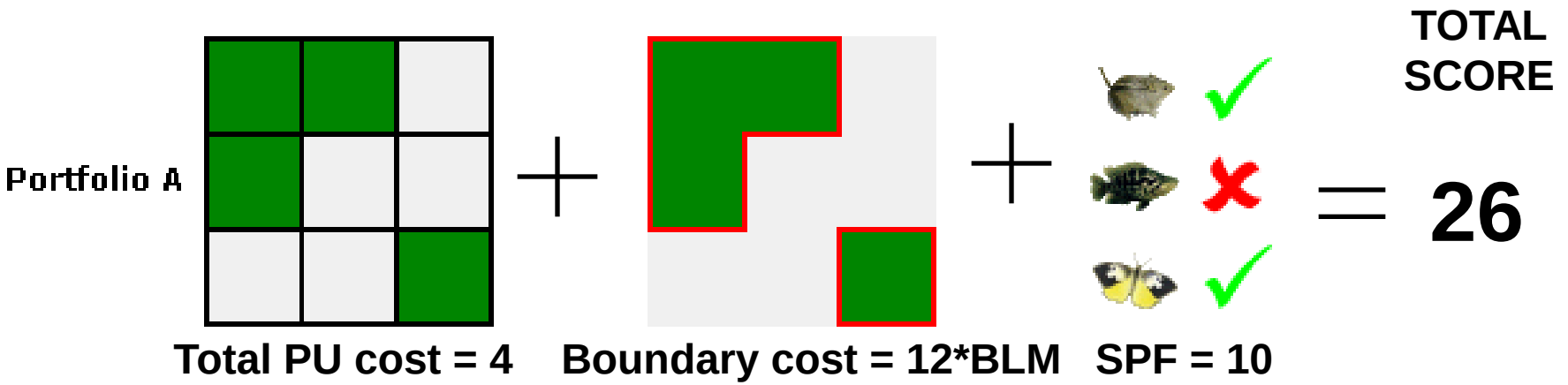
BLM = 1

Target for all 3 species = to be represented at least once

SPF = 10

Source: Modified from Smith, 2004

Example of Marxan "Scoring"



*Modified from: Bob Smith (*http://www.kent.ac.uk/dice/cluz/marxan2.html)

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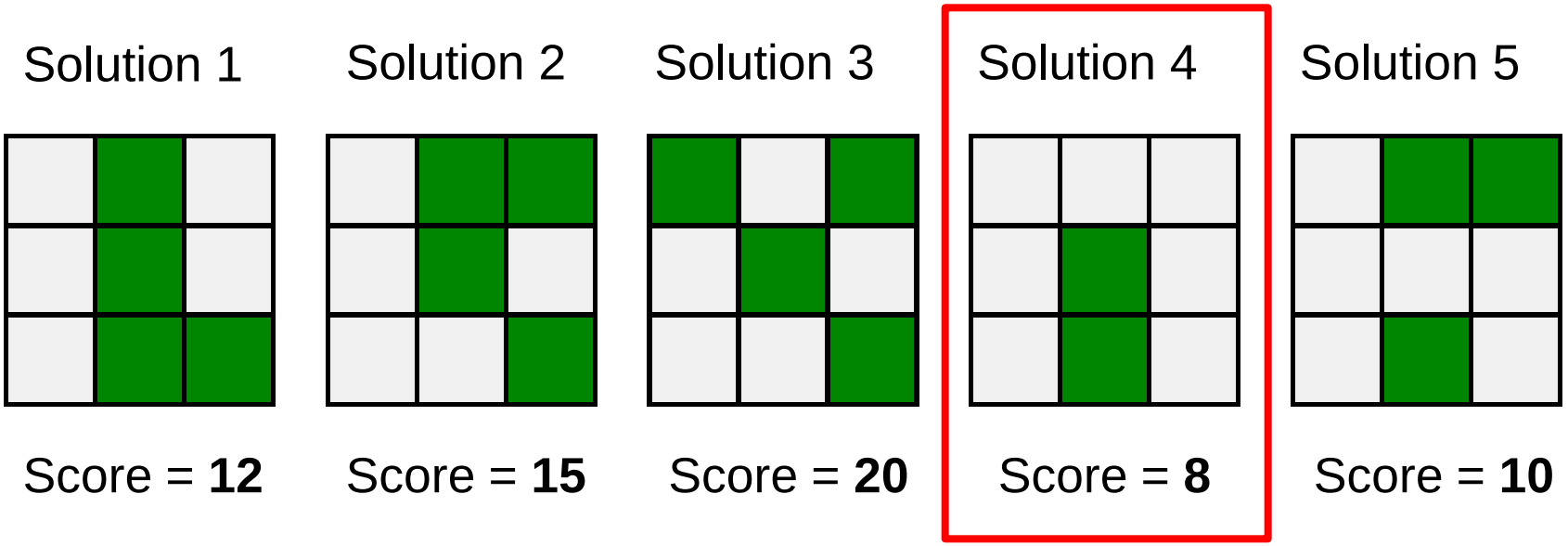
Marxan Outputs

"Best" Solution (or solution with the lowest score)



MARXAN then identifies **the best solution** of the five, based on the lowest score

Source: Smith, 2004

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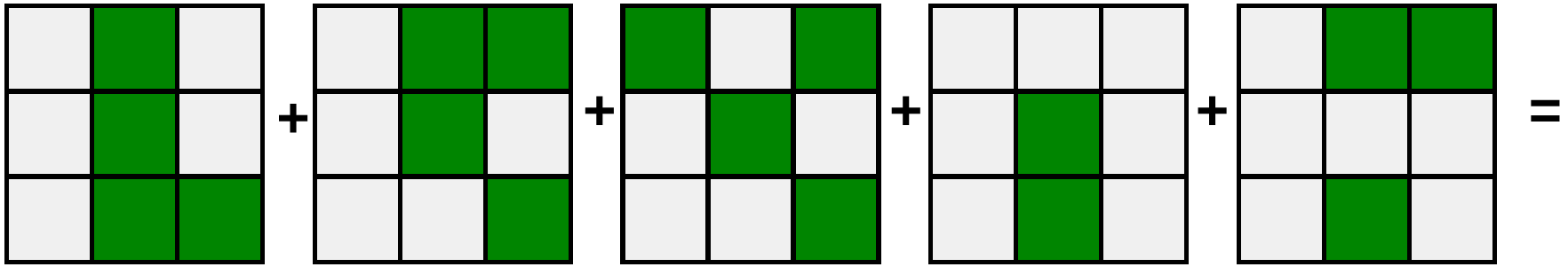
Marxan Outputs

Selection Frequency (or Sum Solution)

Solution 1 + Solution 2 + Solution 3 + Solution 4 + Solution 5 =



The numbers represent the number of times each PU was selected

1	3	3
0	4	0
0	3	3

Mathematical Formulation

1 2 3

$$\sum_{PUs} Cost + BLM \sum_{PUs} Boundary + \sum_{ConValue} SPF \times Penalty$$

Minimise:

1. **Sum of Costs** (or sum of PUs costs) of the reserve network
2. **Sum of Boundary Cost** modified by **Boundary Length Modifier** (BLM) for all the PUs in the solution.

Subject to:

3. **Sum of penalties** for not adequately representing conservation features, adjusted by the Species Penalty Factor

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Marxan is a tool that:

- Addresses core '**Systematic Conservation Planning**' principles (representation, cost efficiency, spatial constraints, complementarity, etc.)
- **Identifies multiple good solutions**, even to very large problems
- Selects areas in a **systematic, repeatable and transparent** manner
- It is **free!**

Decision-support tool, not a decision-maker!

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Brief History of Marxan

- **Siman**: product by Ian Ball's PhD thesis, supervised by Professor Hugh Possingham, University of Adelaide
- **Spexan**: Sponsored by Environment Australia
- **SITES**: Spexan linked to Arcview, Sponsored by TNC
- **Marxan**: Great Barrier Reef Marine Park Authority and National Marine Fisheries Services
- **Marxan with Zones**: The University of Queensland, Ecotrust and The University of California

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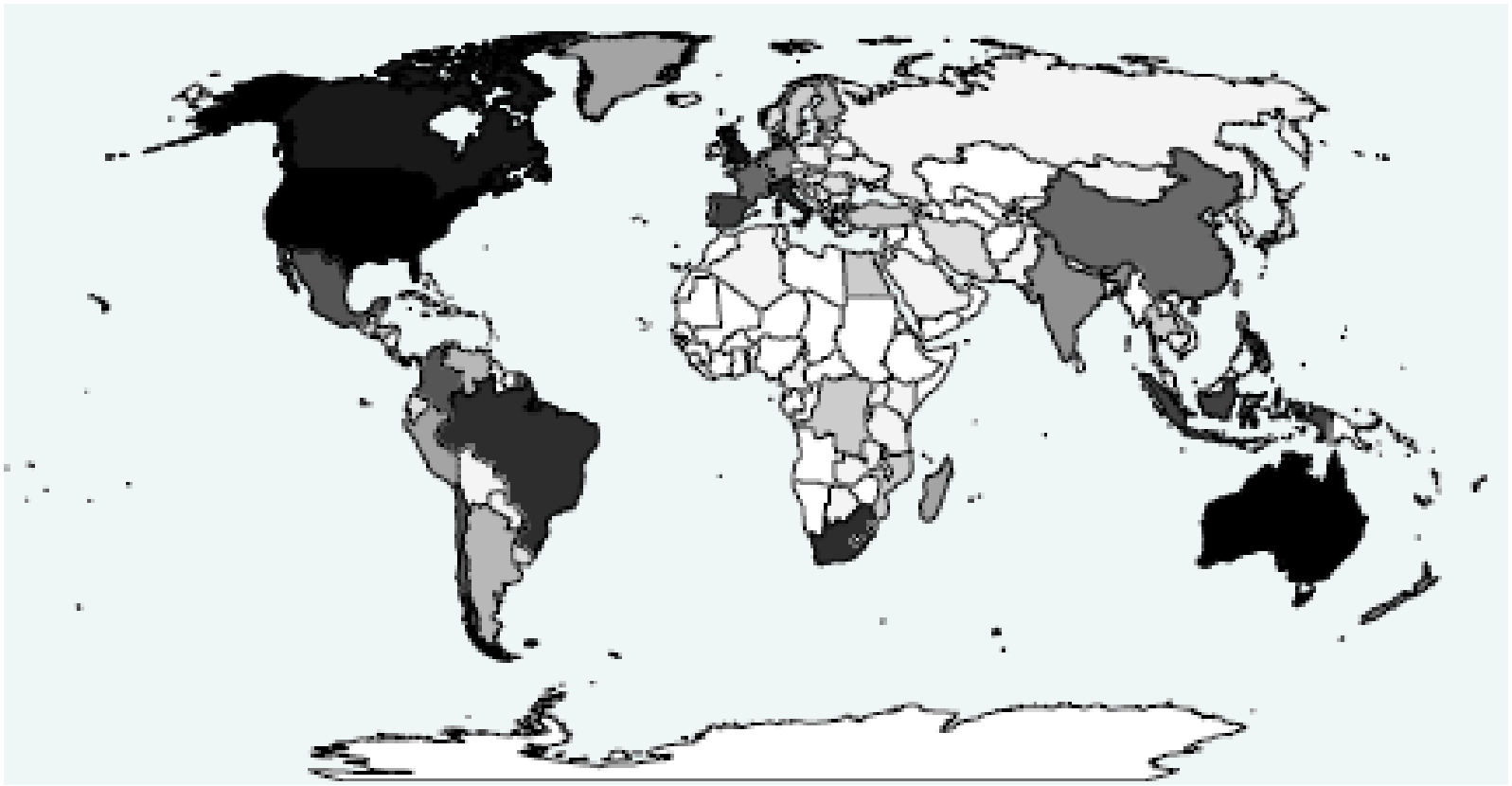
Where in the World is Marxan?

Over 2000 users from more than 105 countries and at least 1200 organizations



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Example Application I: California

Objectives:

- Identify a network of marine reserves
- Represent biological and physical diversity
- Minimize impact to commercial and recreational fishing industries

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Planning Units

- 1 NM^2 planning units

- Chosen because they are the CA Department of Fish and Game management units

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Conservation Features

Examples

Rocky reefs

Kelp beds

Estuaries

Bird colonies

Breeding sites

Seamounts

Canyons

Pinnacles

Choices guided by legislation, science advisory team, and data availability

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Socio-economic "cost" of Reservation

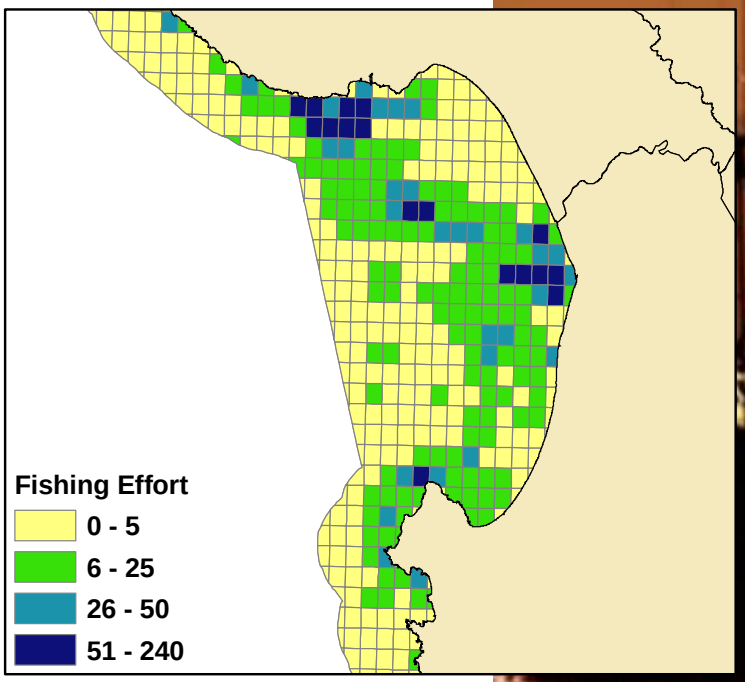
"Cost" is not spatially homogenous!

In this example, cost is measured as:

-Recreational fishing effort

-Commercial fishing effort

Goal: Minimize socio-economic impact



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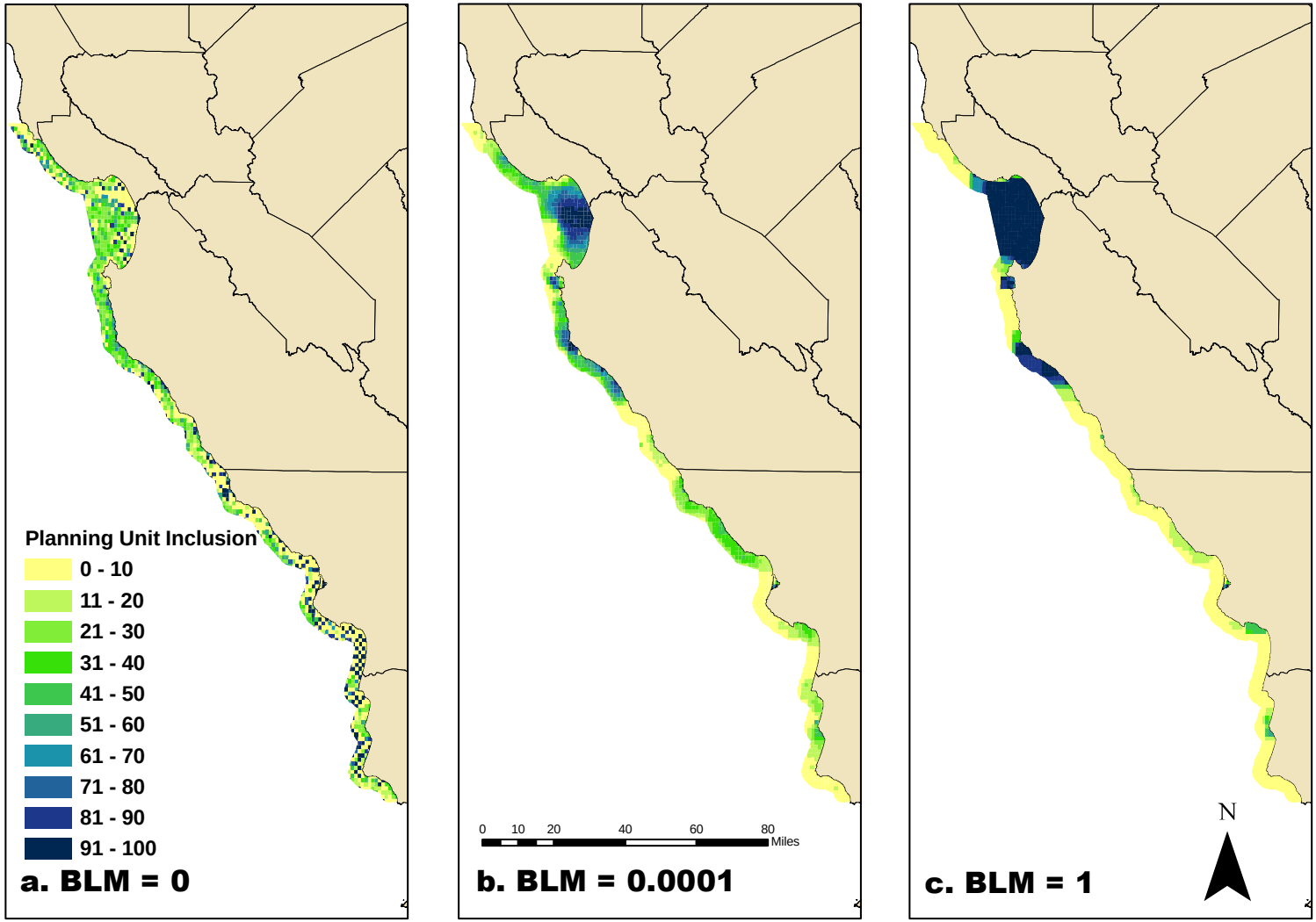
Spatial Compactness of Reserves



Adjusting Marxan's BLM (***Boundary Length Modifier***)

Benefits of using Marxan (review)

- Useful to see how goals/objectives translate spatially into reserve options
- Provides many good solutions – flexibility for stakeholder engagement
- Identifies 'key' locations
- Ensure solutions consider conservation planning principles (CARE); Comprehensive, Adequate, Representative and Efficient

Marxan is a Decision-Support Tool, not a decision-maker!
Marxan does not decide which specific site(s) will ultimately get protected.

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Some fears and misconceptions about Marxan

- "Black box" –mysterious how it works
- Precludes expert / other stakeholder input
- Only works if data are perfect
- Only applicable to strict reserves
- Technically demanding (A bit, but many learn!)
- Using costs is not biologically "pure"

All of these are incorrect!!!

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Keep in mind …

- Most issues arise because of communication challenges
- Computational capacity or algorithms rarely limit conservation planning – lack of clear objectives do
- Marxan will always produce an "answer", but without clear goals and objectives, it may not be the answer that is needed
- Many complexities can be added later (don't do it all at once); such as zoning, risks, temporal dynamics…

Useful Marxan Websites

PacMARA tikiwiki

http://www.pacmara.org/tikiwiki/

Available for download:

- Course Materials
- **Good Practices Handbook**
- Selected peer reviews
- **Applied applications**
- Other resources
- **Spanish materials**

University of Queensland

www.uq.edu.au/marxan

Available for download:

- Other Course Materials
- Program and Manuals
- Extensions
- Presentations
- Peer Review Literature
- **Listserve**

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Other good decision support tools…

- **C-Plan** (Bob Pressey and Matt Watts)
- **Zonation** (Atte Moilanen)
- **ResNet** (Sahotra Sarkar)
- **SeaSketch** (University of Santa Barbara)

For more visit:

Ecosystem Based Management Tools Network www.ebmtools.org/

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