

# Marxan 101

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Applied Environmental Decision Analysis  
A Centre for Environmental Research Faculty  
smart science for wise decisions



THE UNIVERSITY OF QUEENSLAND AUSTRALIA

www.uq.edu.au/spatialecology

## Course Overview

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**Day 2**

9:00 – 9:30: How does Marxan find good solutions?

9:30 – 10:30: INPUT.DAT & running Marxan with Zonae Cogito

10:30 – 10:50: Morning tea

10:50 – 12:15: Understanding, viewing and editing output files

12:15 – 1:30: Lunch

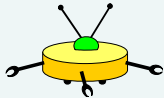
1:30 – 2:30: Marxan with Zones

2:45 – 3:00: Afternoon tea

3:00 – 4:00: Marxan extensions, new stuff & questions

## Searching for life on Mars: a simulated annealing analogy

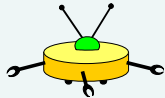
- Life will most likely to be found in low-lying areas
- Problem of finding the lowest-lying area on Mars using a robot is similar to finding the most efficient set of conservation areas (a lot of alternatives)
- How can simulated annealing help solve this problem?



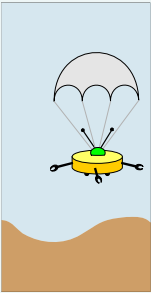
Source: Bob Smith (DICE)

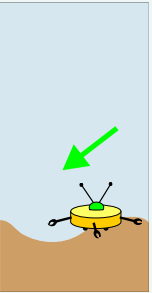
## Simulated Annealing

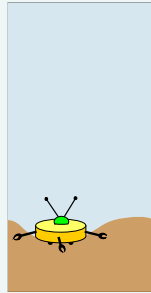
- 1) Measure the elevation of the ground directly beneath the robot body.
- 2) Randomly choose an arm and measure the elevation of the ground beneath the arm.
- 3) If the ground beneath the arm is lower than the robot base then move to the point measured by the arm.



Source: Bob Smith (DICE)

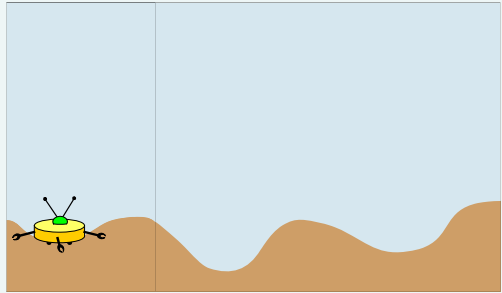






Source: Bob Smith (DICE)

**But...this is a flawed strategy as there are lower areas**



Source: Bob Smith (DICE)





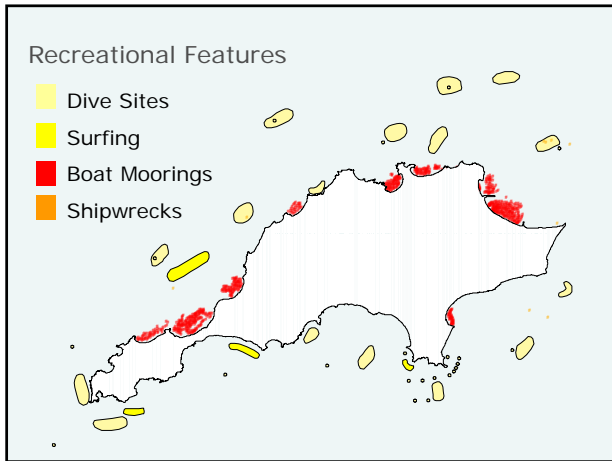
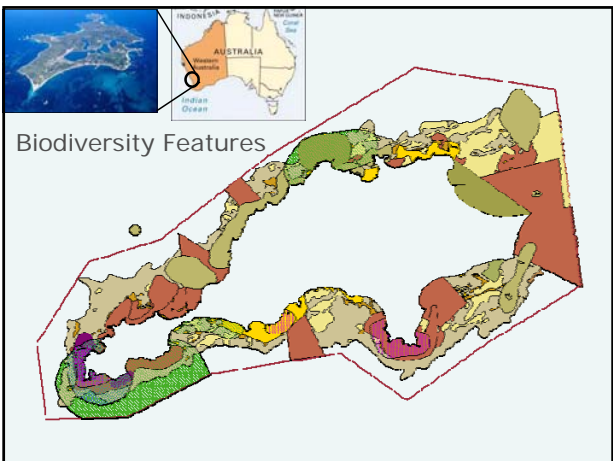
### Marxan with Zones Functionality

Features

- Zone specific features
- Zone specific & overall targets (or goals)

Zone Contribution

- Contribution of each zone towards meeting target



### Contribution of Zone to Targets

	% Target	Contribution of zones		
		Conservation	Recreation	Fishing
Species 1	25%	0.5	0.5	
Species 2	25%	0.9	0.1	
Species n	25%	1		
Fishing n	80%			1
Recreation 1	80%		1	
Recreation 2	80%		1	
Recreation n	80%		1	

- The amount of features required in some combination of zones
- Contribution of zones to targets can be specified

### Marxan with Zones Functionality

Features

- Zone specific features
- Zone specific & overall targets (or goals)

Zone Contribution

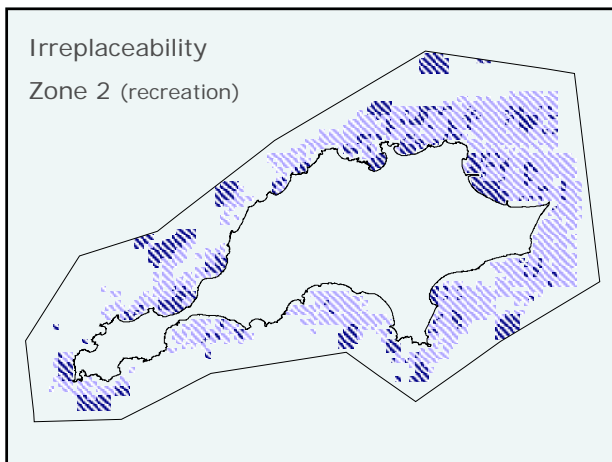
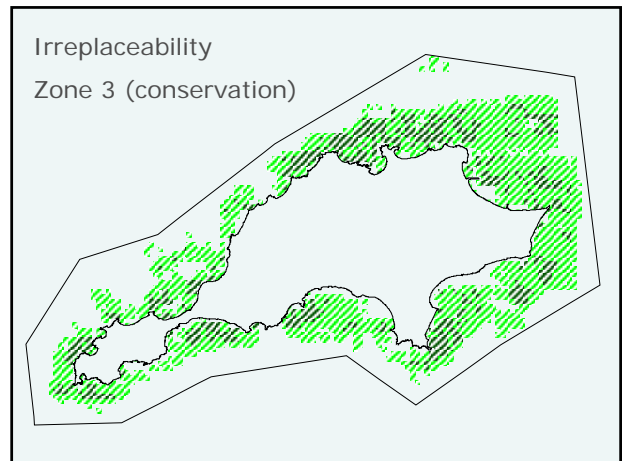
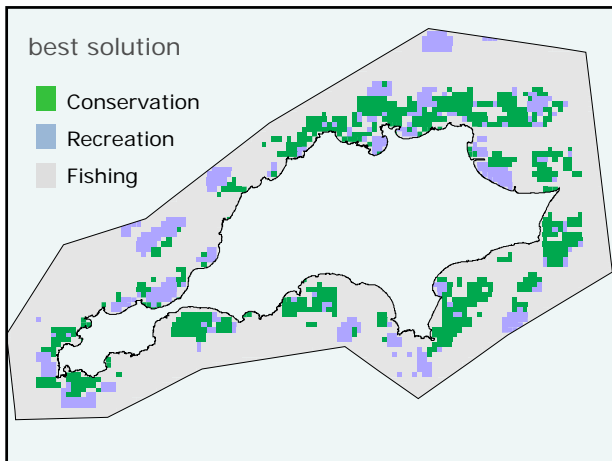
- Contribution of each zone towards meeting target

Boundary Costs

- Between zones and planning units

### Marxan with Zones Output

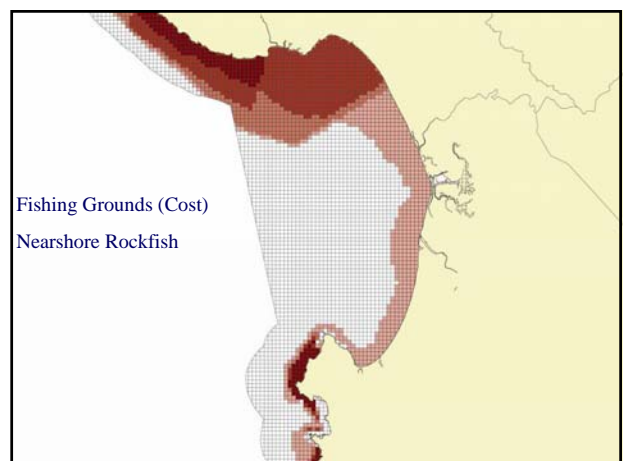
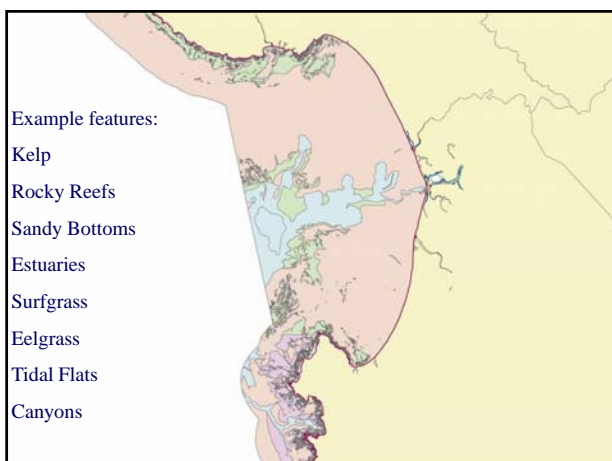
- Summed solution per zone
- Summed solution total
- Individual solutions
- Summary information

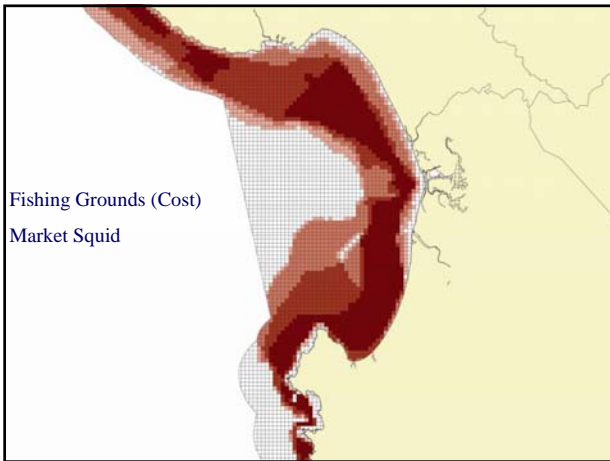
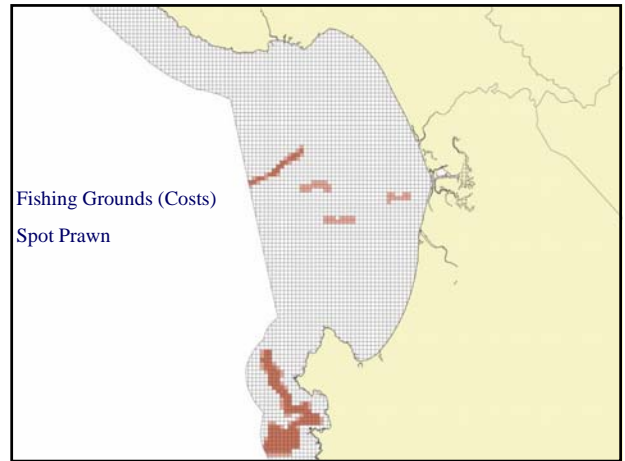
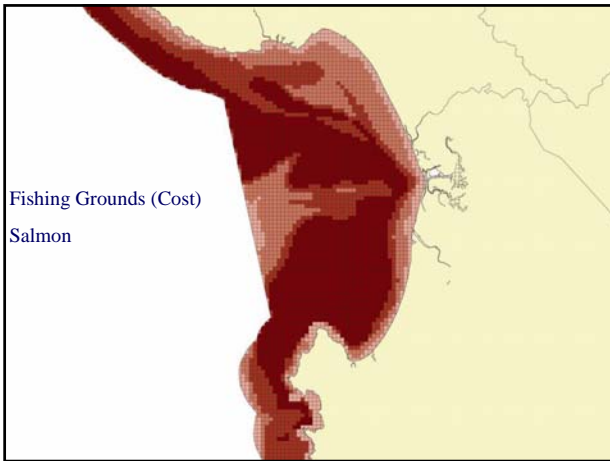


### Multiple Zones

- California's Marine Life Protection Act Initiative
  - Marine Reserves (SMR)
  - Marine Parks (SMP)
  - Conservation Areas (SMCA)
  - Available (Unreserved)
- Planning units must be assigned to one of four management zones

ecotrust





### Multiple Costs

- A different cost is associated with a planning unit being in any one of the zones
- Different costs per zone
- Multiple costs per zone
- Cost is measured by the activities contained in planning unit and the degree to which these activities are compatible with the management designation

### Multiple Costs and Zones

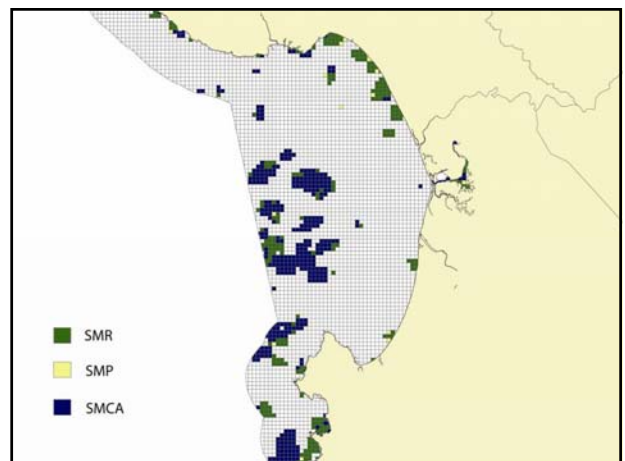
**Marine Reserve (SMR)**  
– Cost to all commercial and recreational fishing

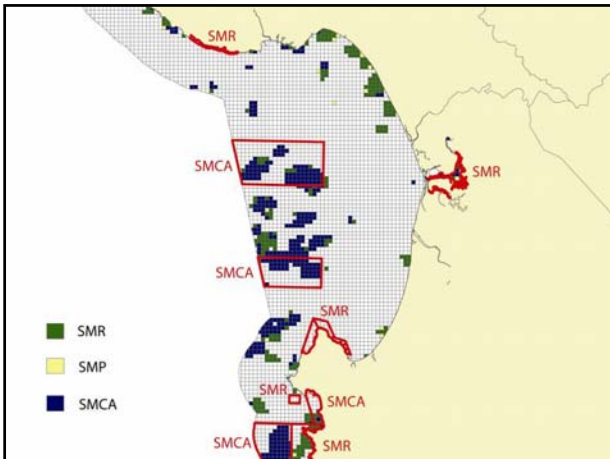
**Marine Park (SMP)**  
– Cost to all commercial, some recreational fishing

**Conservation Area (SMCA)**  
– Cost to some commercial and recreational fishing

Available (Unreserved)

Activity Type	SMR	SMP	SMCA	Available
Rockfish (Com)	1	1	1	0
Salmon (Com)	1	1	0.2	0
Spot Prawn (Com)	1	1	0.2	0
Squid (Com)	1	1	0.5	0
Salmon (Rec)	1	0.5	0	0
Rockfish (Rec)	1	0.5	0	0





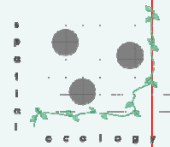
### Caveats

- Increased complexity
- Increase data requirements
- Many assumptions

### Advantages of Marxan with Zones

- Produce indicative sets of areas that meet multiple objectives, through a variety of management objectives
- Integrated planning across sectors (minimize impact on other activities and uses) – conservation, fishing, recreation, wave energy, aquaculture, oil drilling, etc.
- Identify trade offs and areas of competing use
- Flexible, transparent, repeatable, lots of solutions

## cluster analysis of Marxan solutions



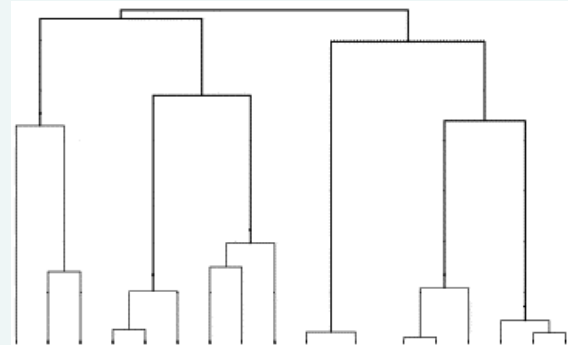
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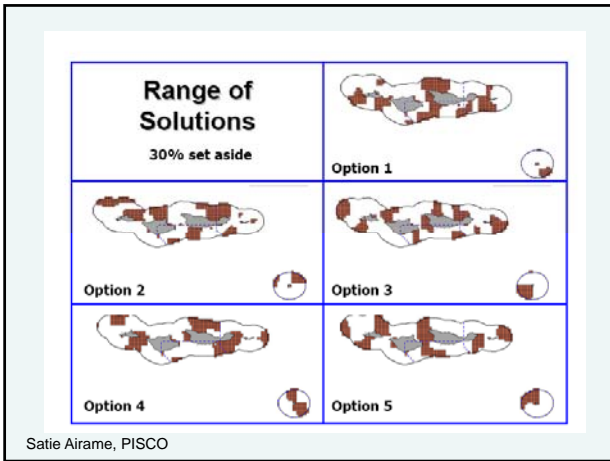
### MarStat, cluster analysis of Marxan solutions

- Links Marxan with the statistical package, R
- Computes similarity of Marxan solutions
- Identifies reserve configurations that are spatially different from each other using a cluster analysis

### Cluster analysis of Marxan solutions



Dendrogram with 17 solutions



## Further Marxan developments

- Marxan cluster analysis
- Asymmetrical connectivity
- Probabilistic treatments of feature occurrence
- Marxan database management system
- Interactive decision support system
- Quantum annealing
- 64 bit Marxan
- Linux Marxan