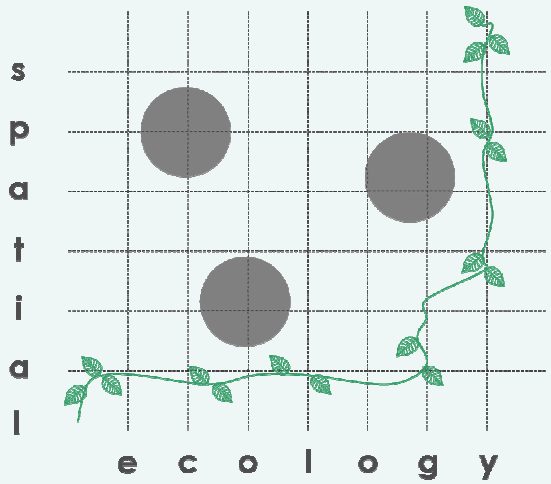
Marxan 101

Kerrie Wilson (k.wilson2@uq.edu.au)

Illustrations and explanations by **Bob Smith (DICE)** (see http://www.mosaic-conservation.org/cluz/ for further information)

Marxan developed by **Ian Ball** and **Hugh Possingham**
Further developed by **Matt Watts** and **Carissa Klein**



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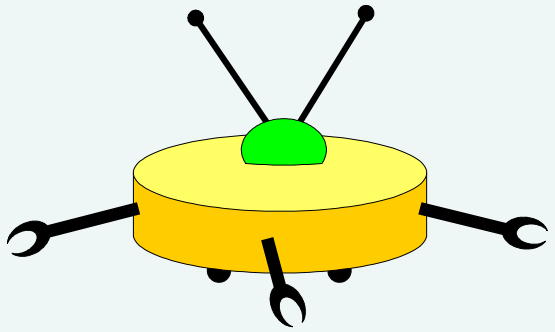
Outline of this session

- Illustrated discussion of simulated annealing
- Marxan and simulated annealing
- Web-based conservation planning game

Searching for life on Mars: a simulated annealing analogy

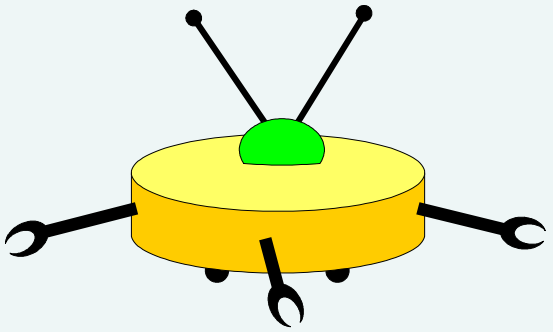
- Life will most likely to be found in low-lying areas
- Problem of finding the lowest-lying area on Mars using a robot is similar to finding the most efficient set of conservation areas (a lot of alternatives)
- How can simulated annealing help solve this problem?



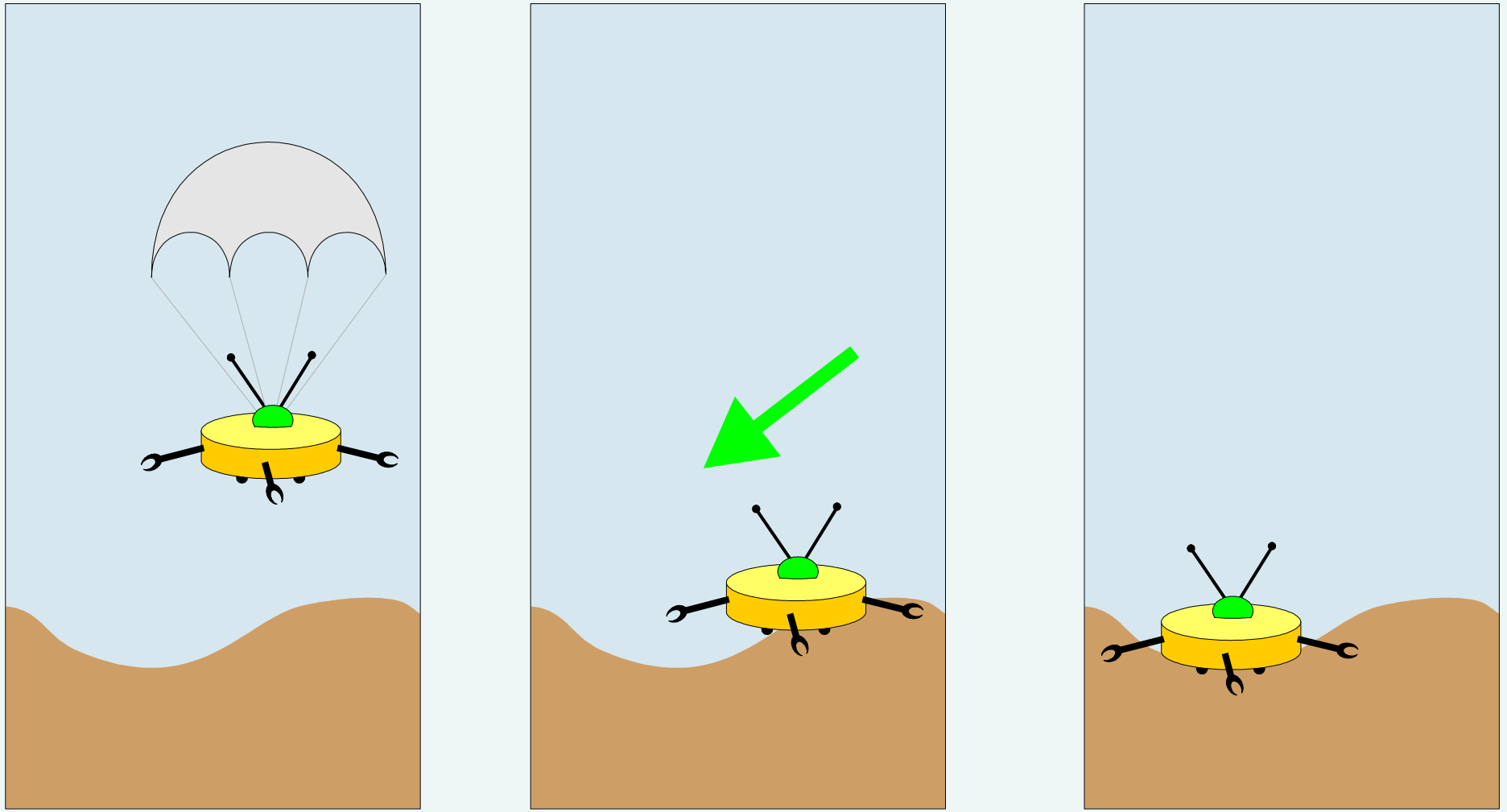
Source: Bob Smith (DICE)

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.

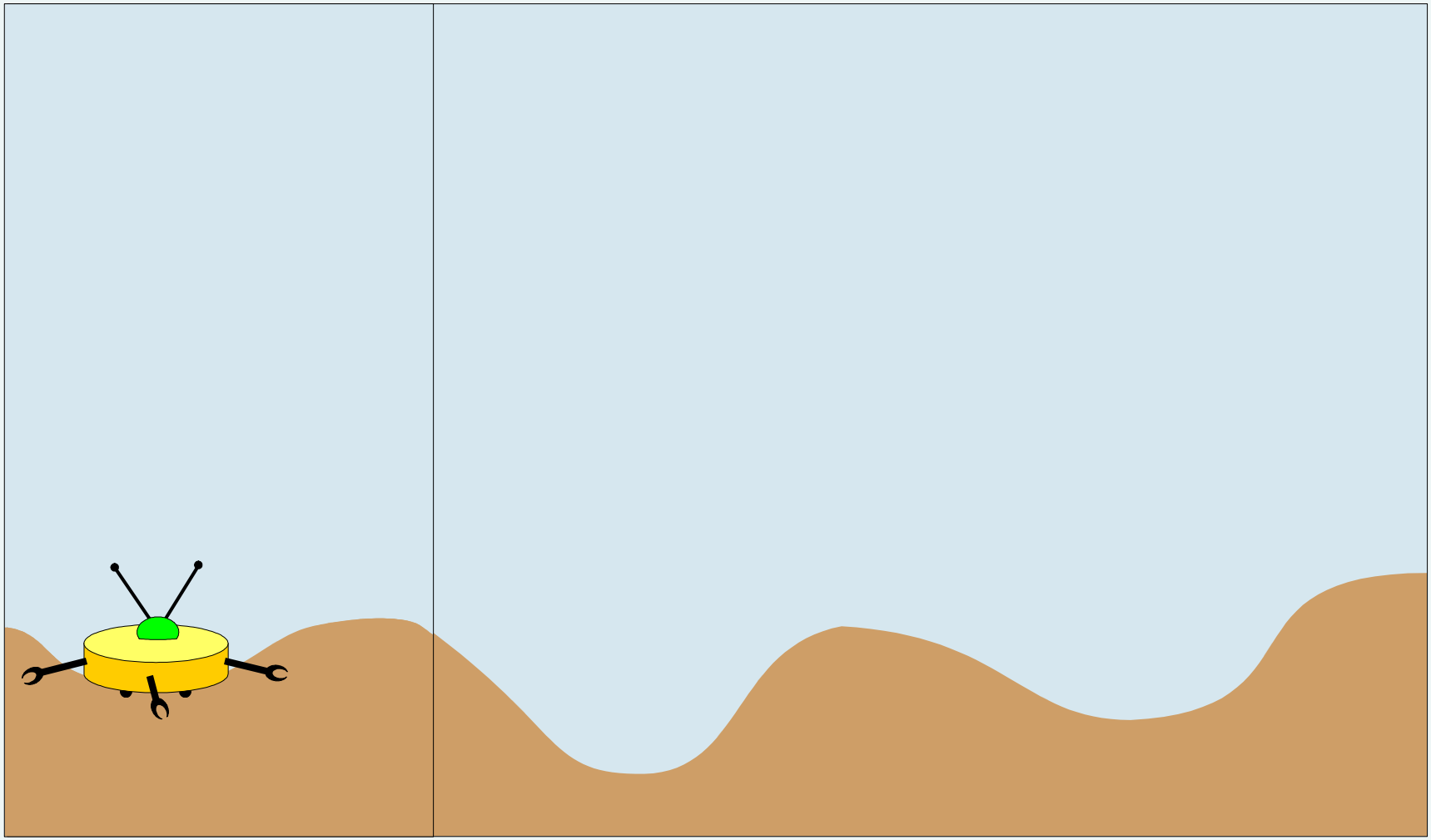


Source: Bob Smith (DICE)



Source: Bob Smith (DICE)

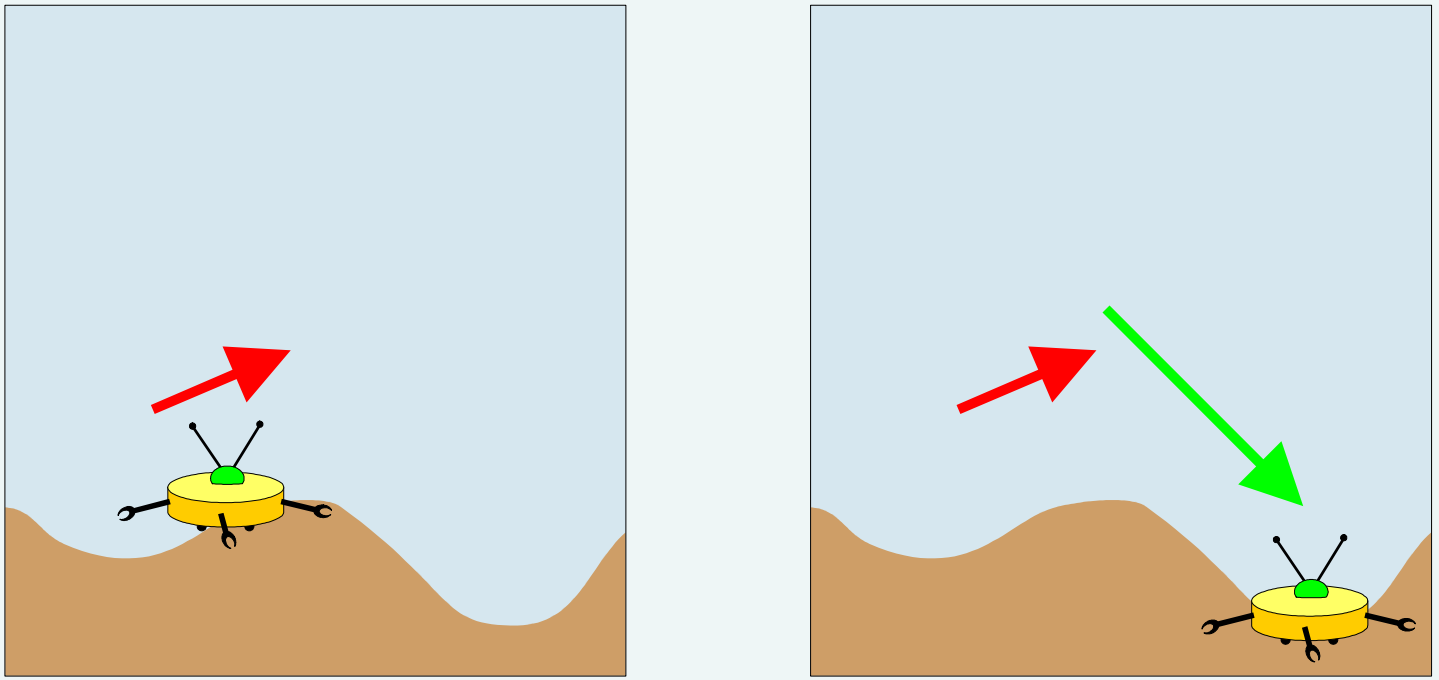
But…this is a flawed strategy as there are lower areas



Source: Bob Smith (DICE)

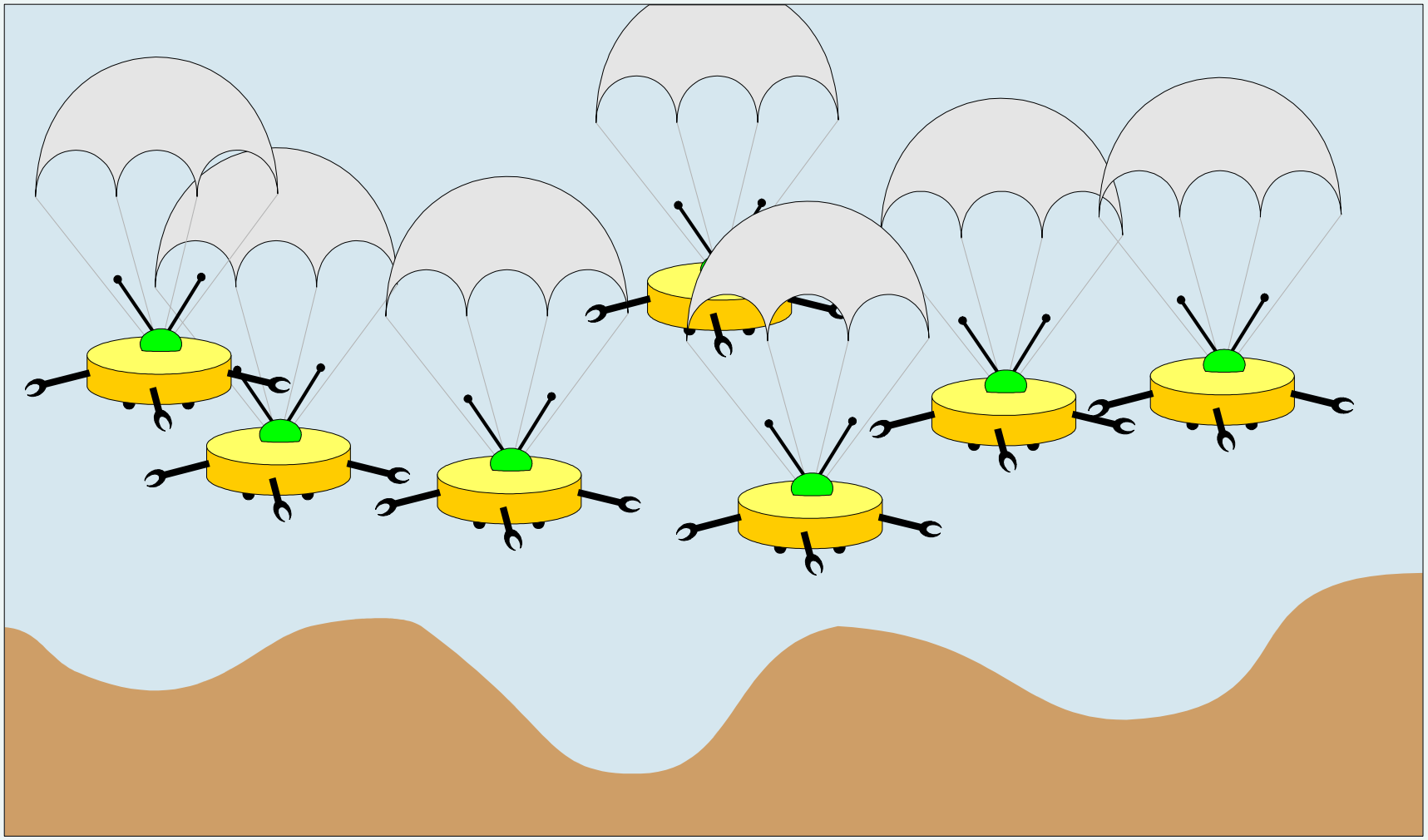
Random backward steps

- Moves up a slope to try to move into neighbouring, lower-lying valleys
- Backward steps are more common at the beginning of the simulated annealing process



Source: Bob Smith (DICE)

Repetition



Source: Bob Smith (DICE)

Elevation on Mars ~ Score

Combined planning unit cost

+

Combined boundary cost * BLM

+

Combined species penalty factors

The combined planning unit cost

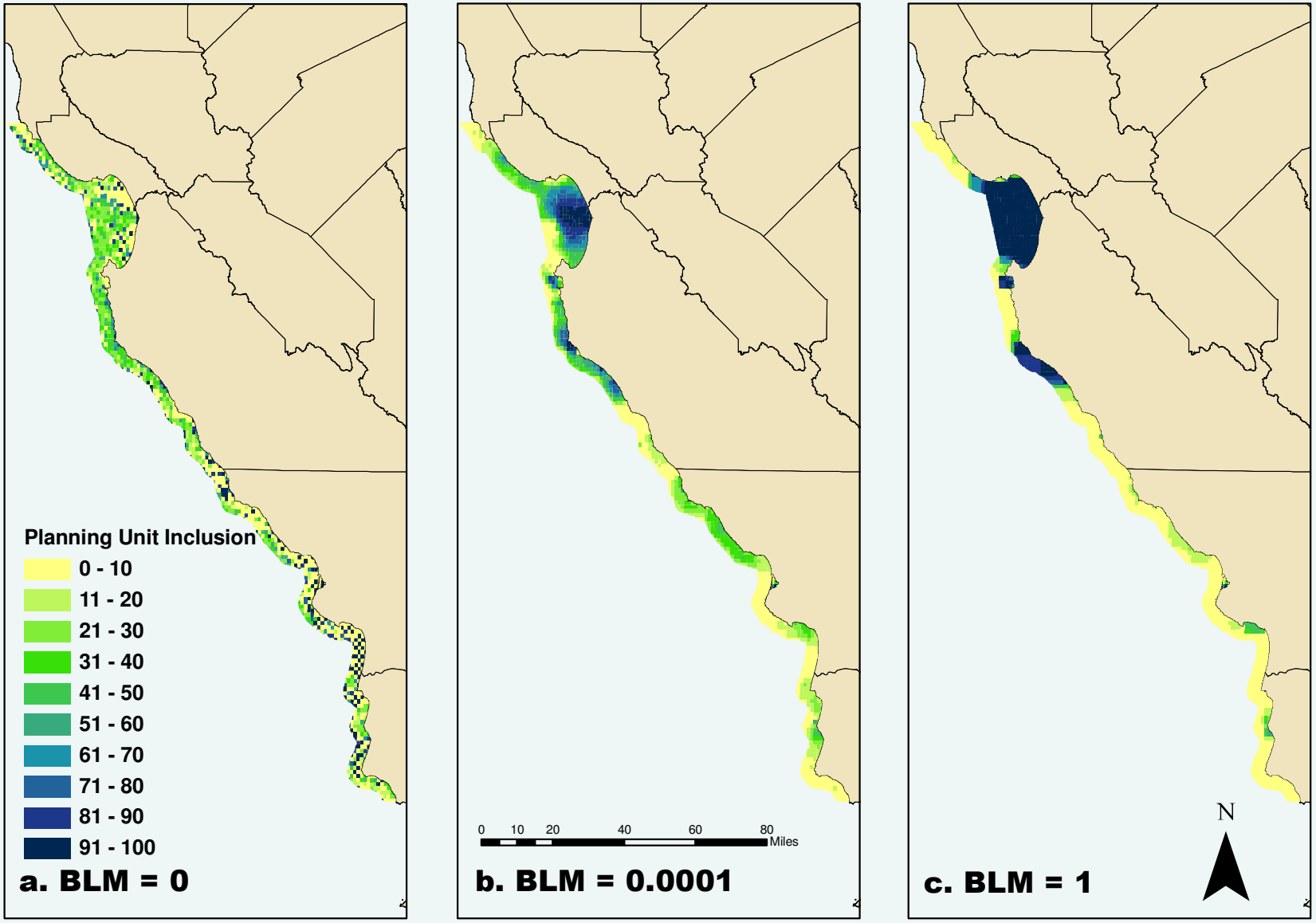
Each planning unit is assigned a cost and MARXAN calculates the combined cost of all the planning units

- Area (of planning unit or of available habitat)
- Financial value
- Opportunity costs
- Potential profitability

The boundary cost

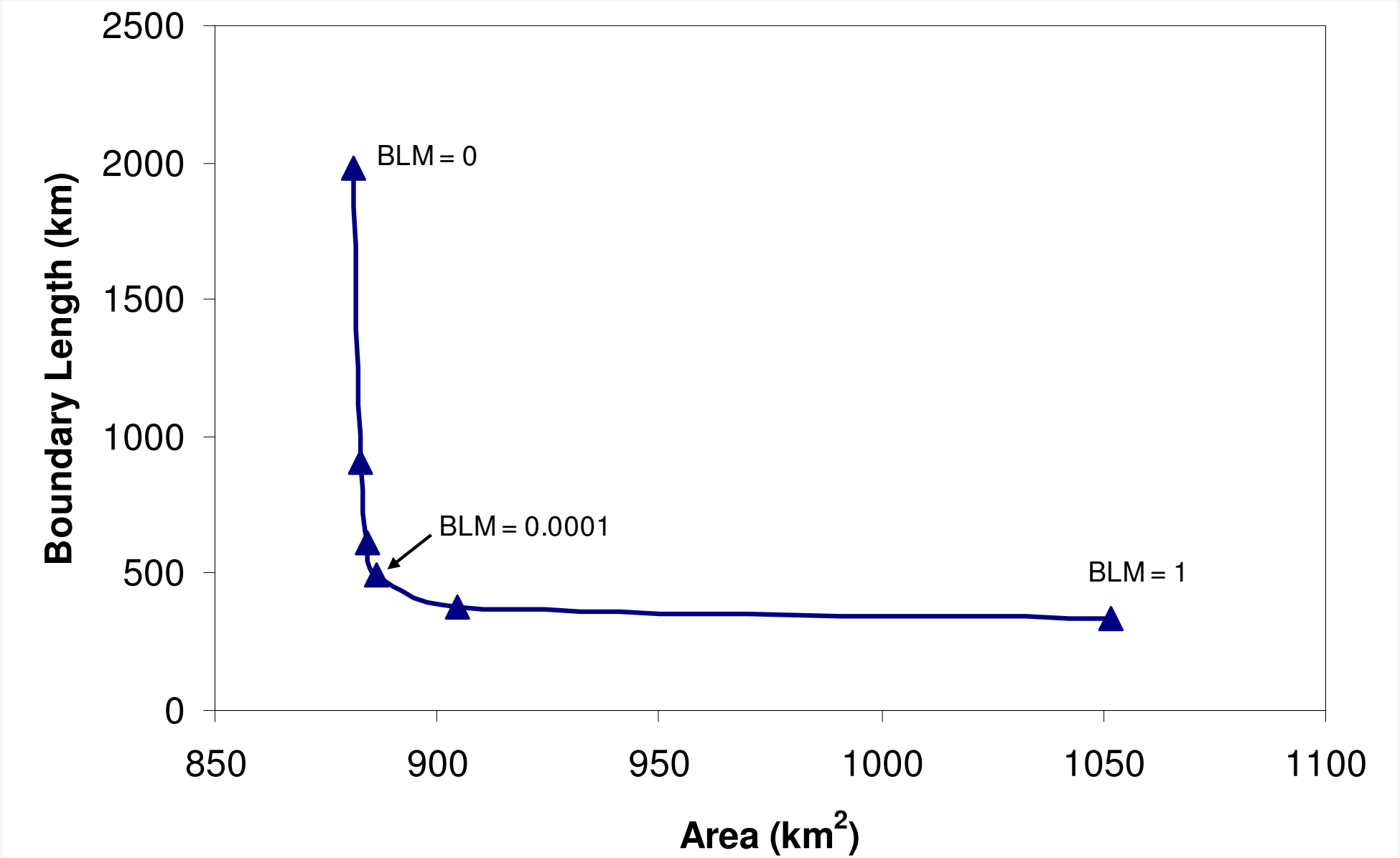
- The total amount of edge that the planning units share with unprotected units [scattered, unconnected planning units will have a large cost].
- The cost is quantified as the length of edge or dollars.
- MARXAN then multiplies this value by the Boundary Length Modifier (BLM), which is a user-defined number.
- Increasing the BLM increases the cost of having a fragmented set of conservation areas.

Spatial Compactness of Reserves



BLM = Boundary Length Modifier

Tradeoffs – Area/Cost vs Boundary



Species penalty factor

- MARXAN calculates whether the target for each conservation feature is met and includes a cost for any target that has not been meet (as specified by the species penalty factor).

- These penalty factors can be generic or species-specific.

Elevation on Mars ~ Score

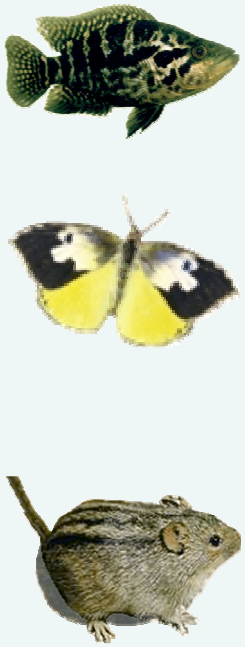
Combined planning unit cost

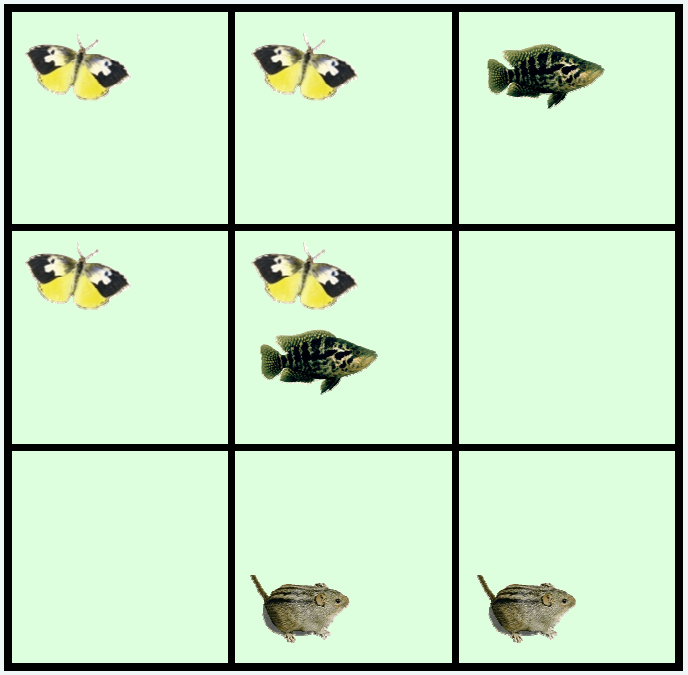
+

Combined boundary cost * BLM

+

Combined species penalty factors





Each planning unit costs 1

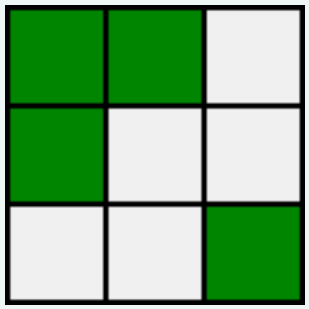
Boundary length modifier value = 1.5.

The species penalty factor for all three species is 10.

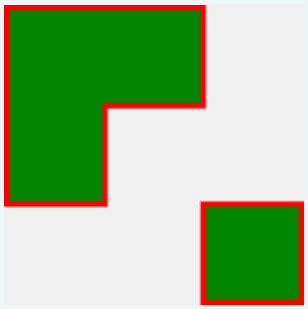
Illustrations by Bob Smith (DICE)

Measuring overall score

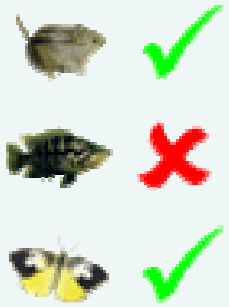
Total score



Total PU cost = 4

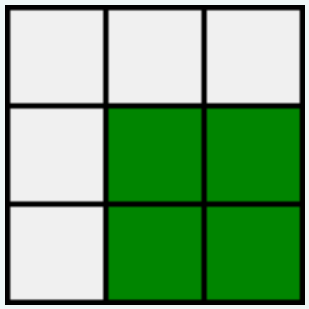


Boundary = 12 * 1.5

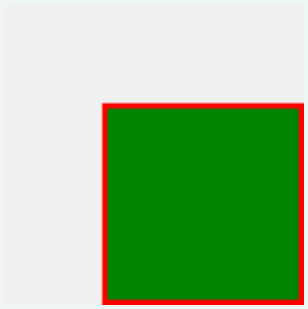


SPF = 10

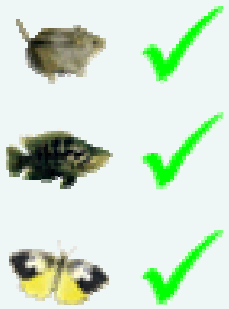
32



Total PU cost = 4



Boundary = 8 * 1.5



SPF = 0

16

Illustrations by Bob Smith (DICE)

Simulated Annealing

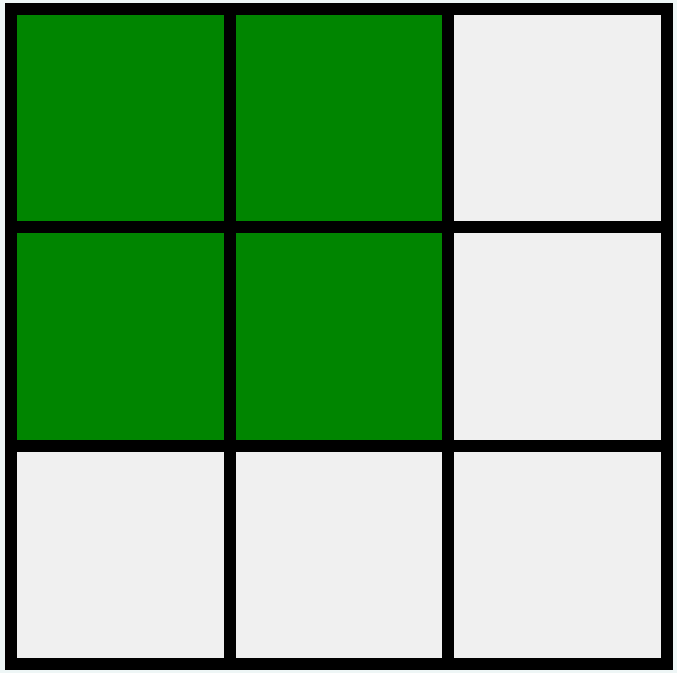
1. Calculate the overall score of a set of planning units chosen at random (cost, boundary, species penalty factors)

2. Choose a planning unit at random and temporarily change its protection status.

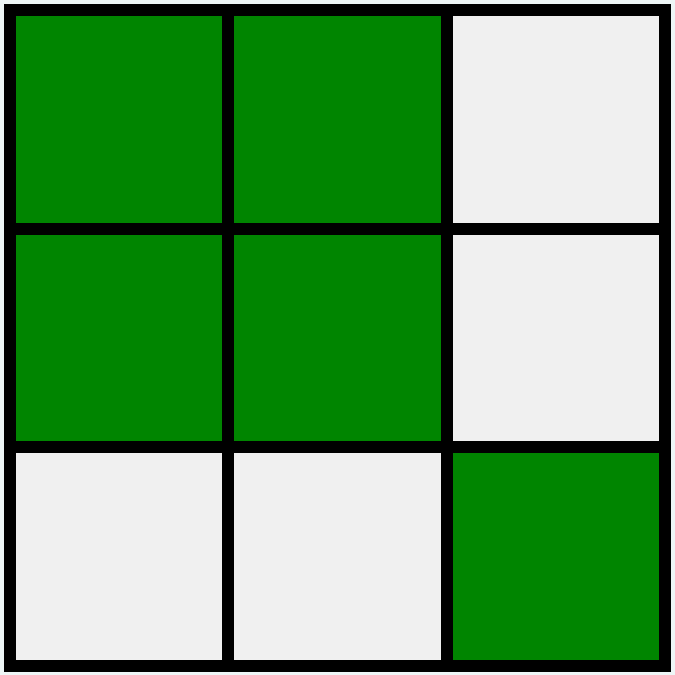
3. Calculate the score of the temporarily changed set. If the change reduces the score then make the change permanent, otherwise, do not make the change [The criteria for a good change becomes more stringent as time progresses].

4. After pre-specified number of iterations, iterative improvement commences but only good changes are accepted.

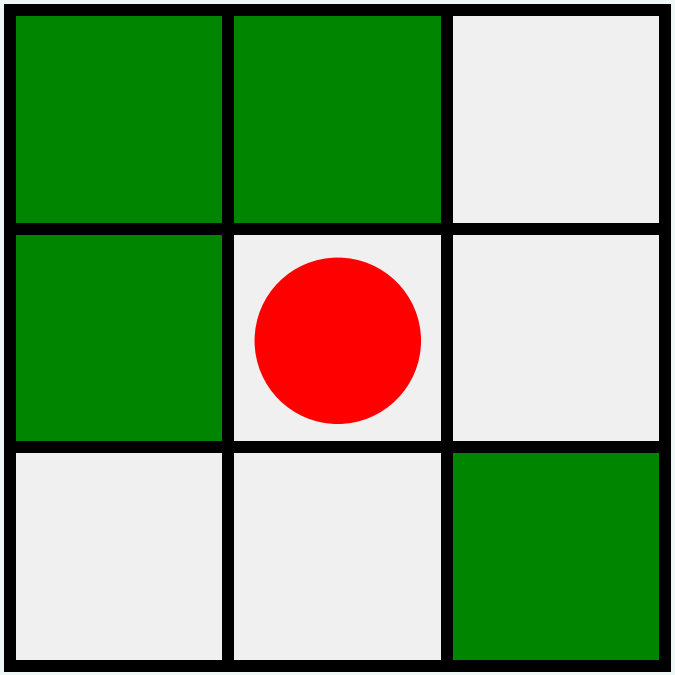
5. Repeat for pre-specified number of runs.



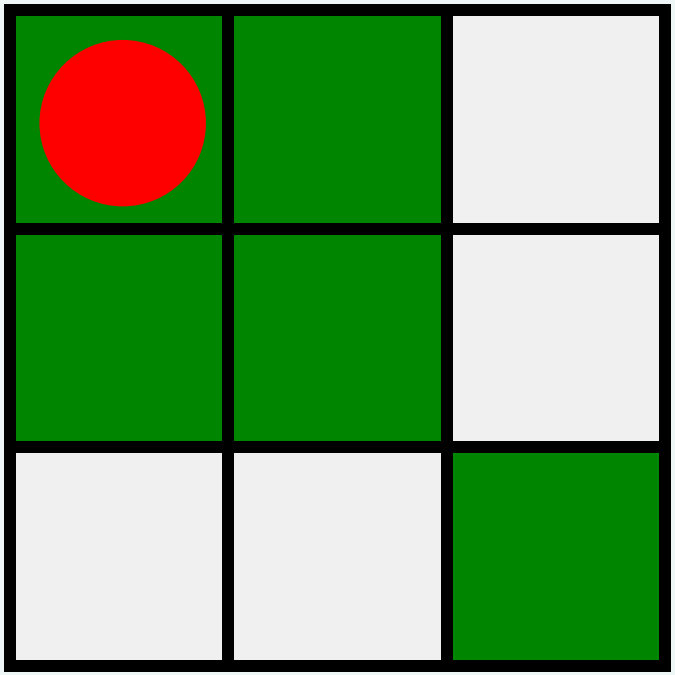
Total score =
26



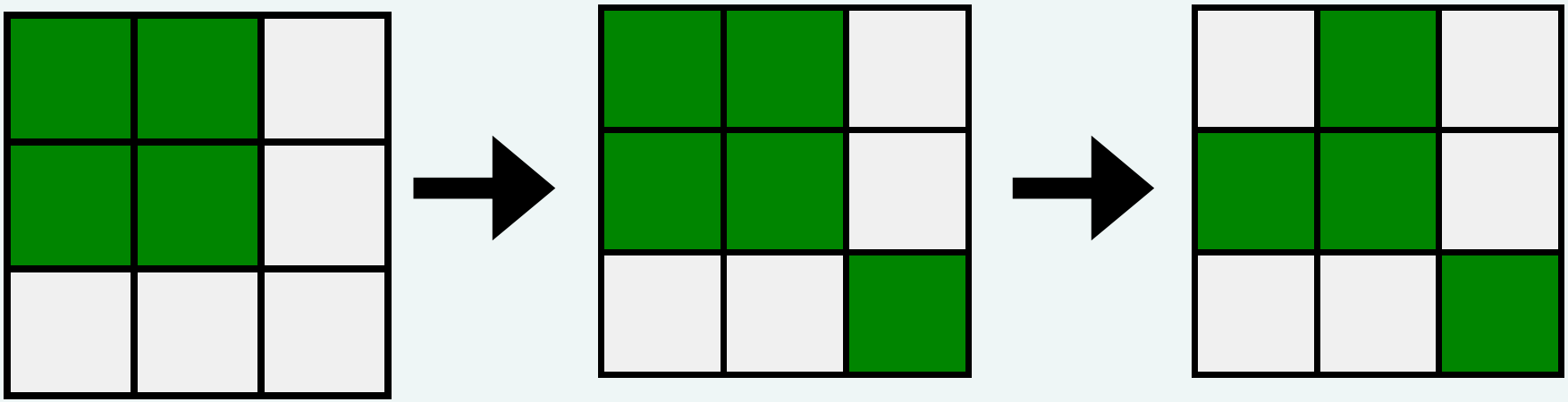
Total score =
23



Total score =
32



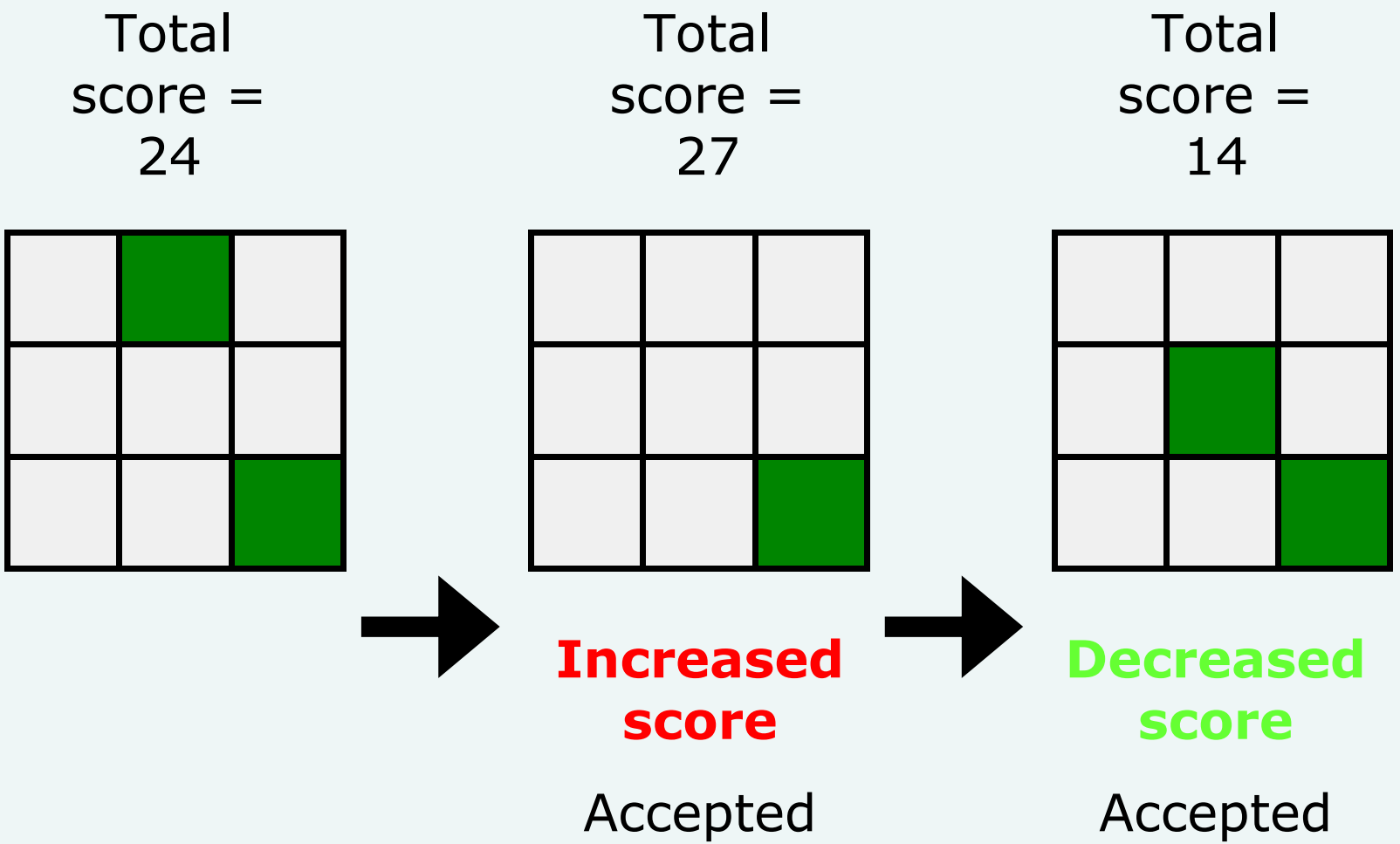
Total score =
20



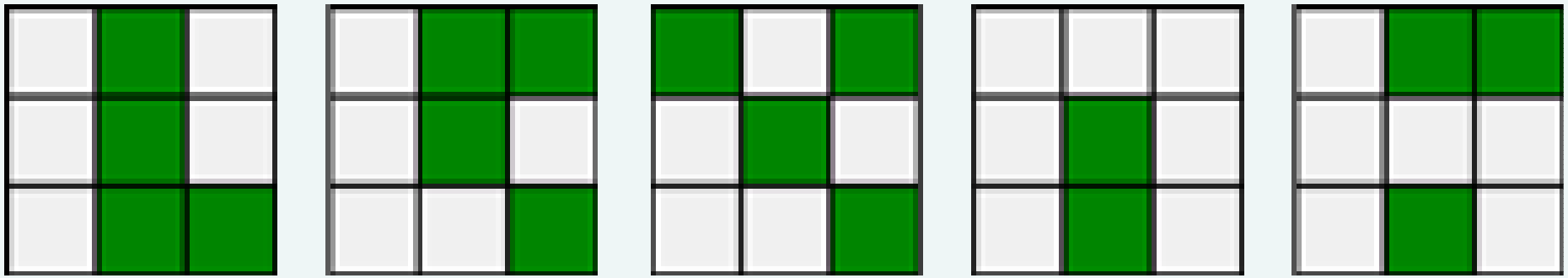
Backward steps

- Short term loss for overall improvement

- MARXAN is more likely to accept these changes at the beginning of the process.

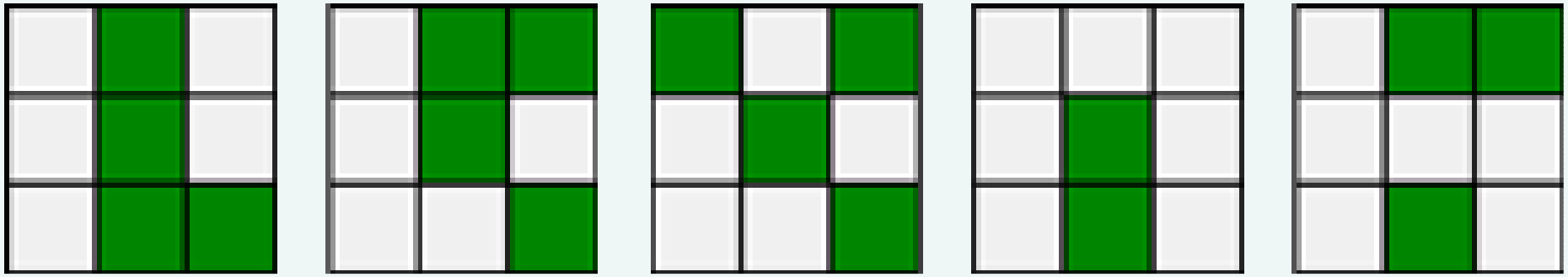

Total score = 24
Total score = 27
Total score = 14
Increased score
Decreased score
Accepted
Accepted

Repetition



MARXAN then identifies the best of the five, based on score.

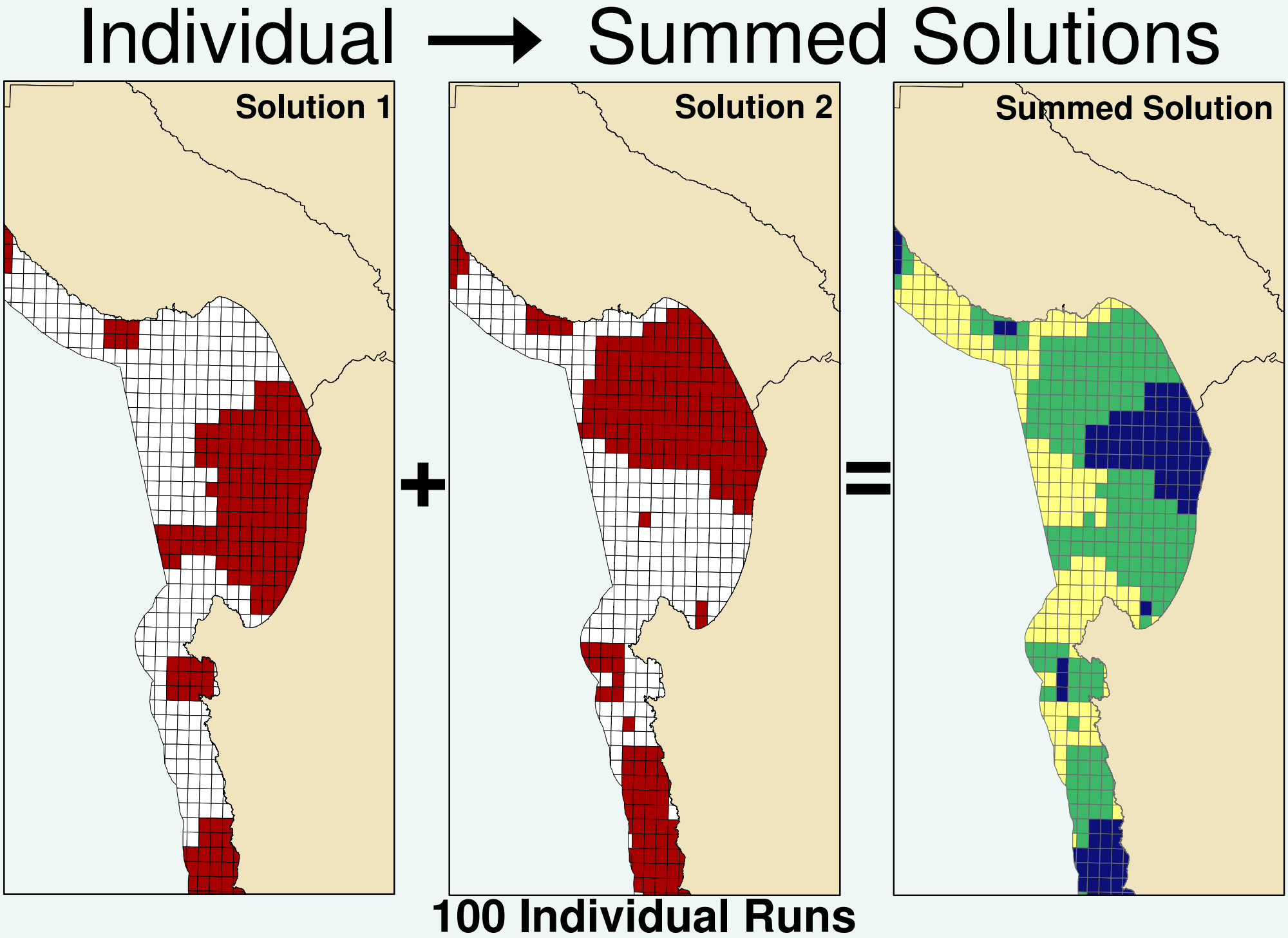
Repetition and selection frequency



1	3	3
0	4	0
0	3	3

The numbers represent the number times the planning unit was selected.

Illustrations by Bob Smith (DICE)


Individual → Summed Solutions
Solution 1
Solution 2
Summed Solution
+
=
100 Individual Runs

Reserve design game

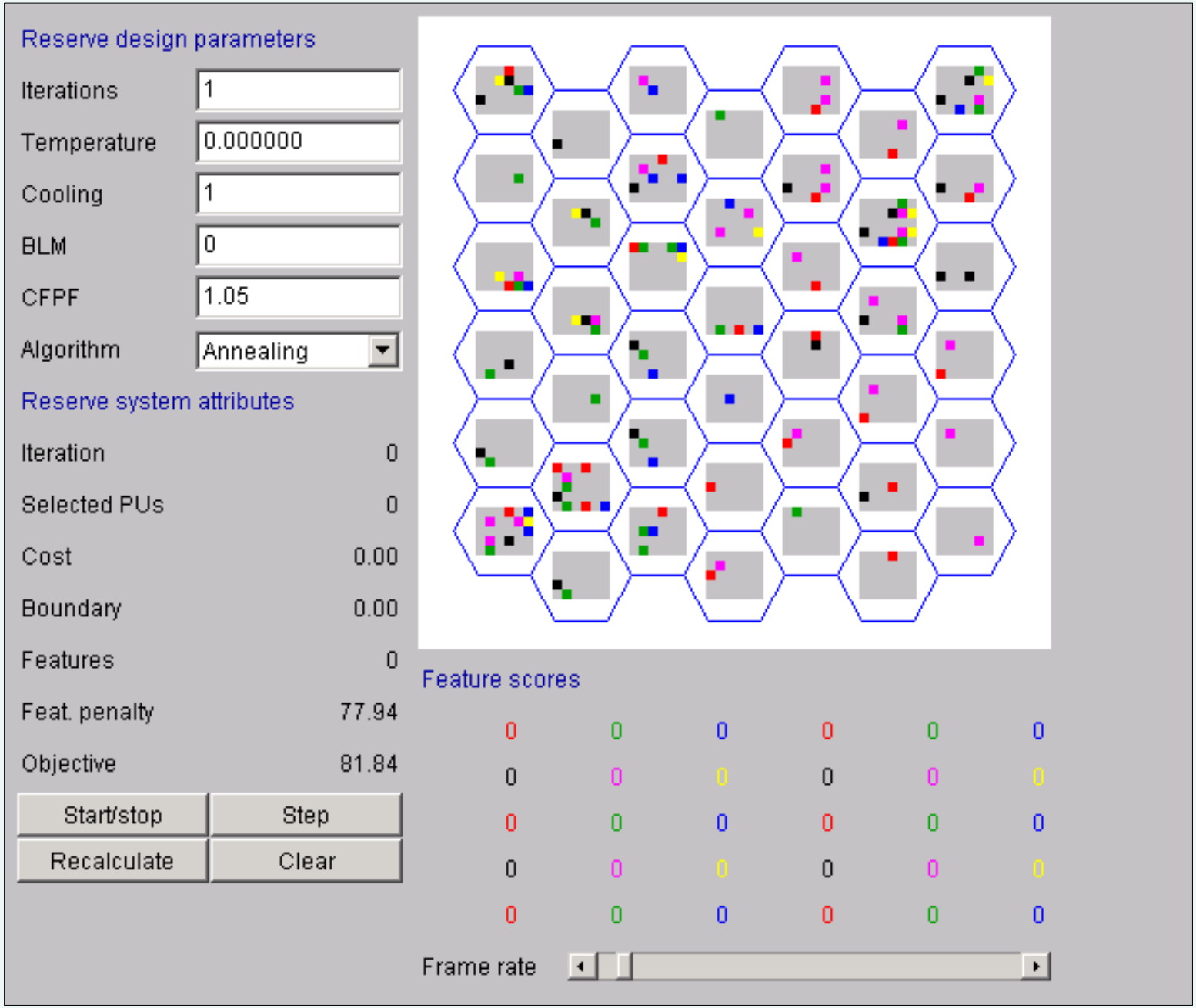
This game illustrates the process that MARXAN uses and understand the effects of changing the parameters. Key elements are:

Temperature – this determines the likelihood of accepting backward steps

Cooling – the rate at which the temperature drops

BLM – boundary length modifier

SPF – penalty for missing targets for species



http://www.uq.edu.au/~uqwroche/resgame/