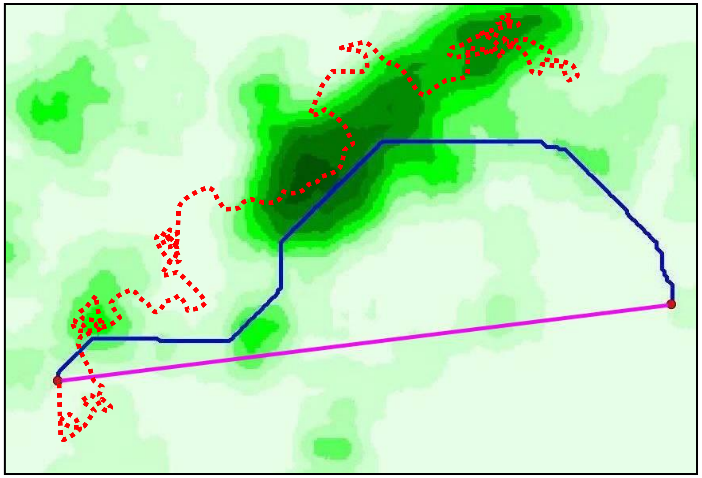
The use of a stochastic movement simulator improves estimates of landscape connectivity



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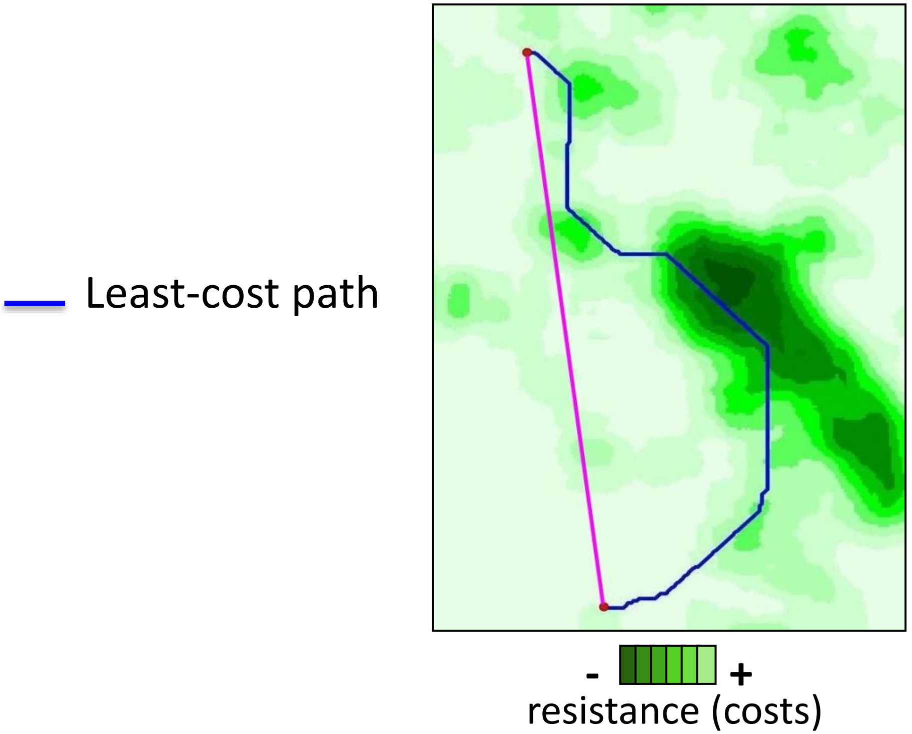
Estimating connectivity: still a challenge…

« Connectivity: the degree to which a landscape facilitates or impedes movements among resource patches » (Taylor et al. 1993)

- **Most used estimators:**
  - Least-cost paths: "easy" but several limiting assumptions (omniscience, optimality)



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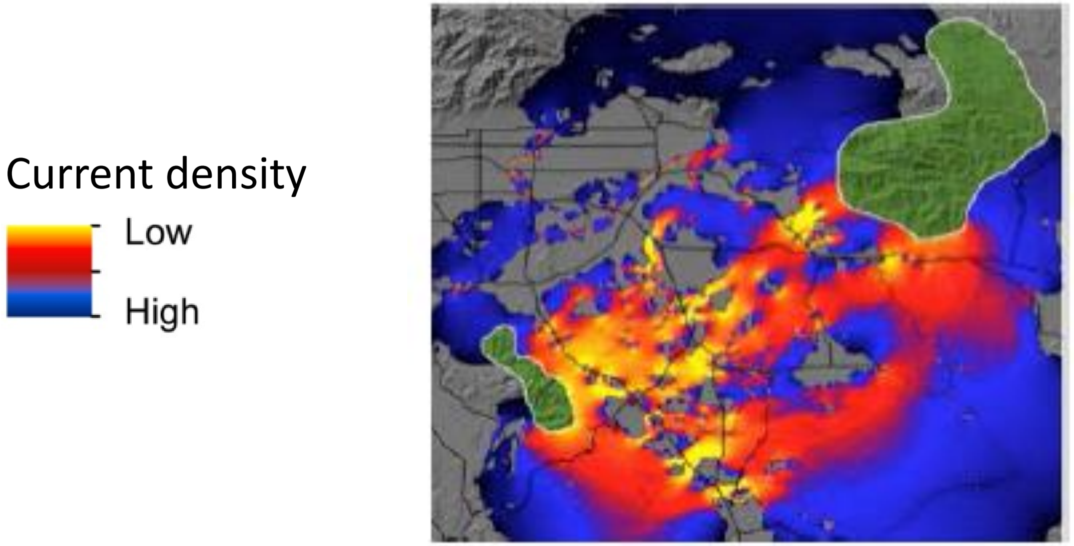

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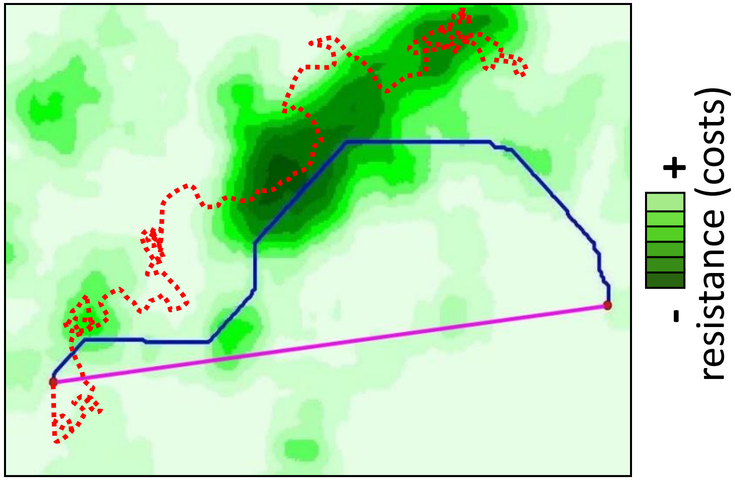
- **An alternative:**
  - individual-based modelling, e.g. SMS (Stochastic Movement Simulator):
    - rule-based, stochastic simulations (C++)
    - animals have limited perceptual range
    - routes taken may be sub-optimal

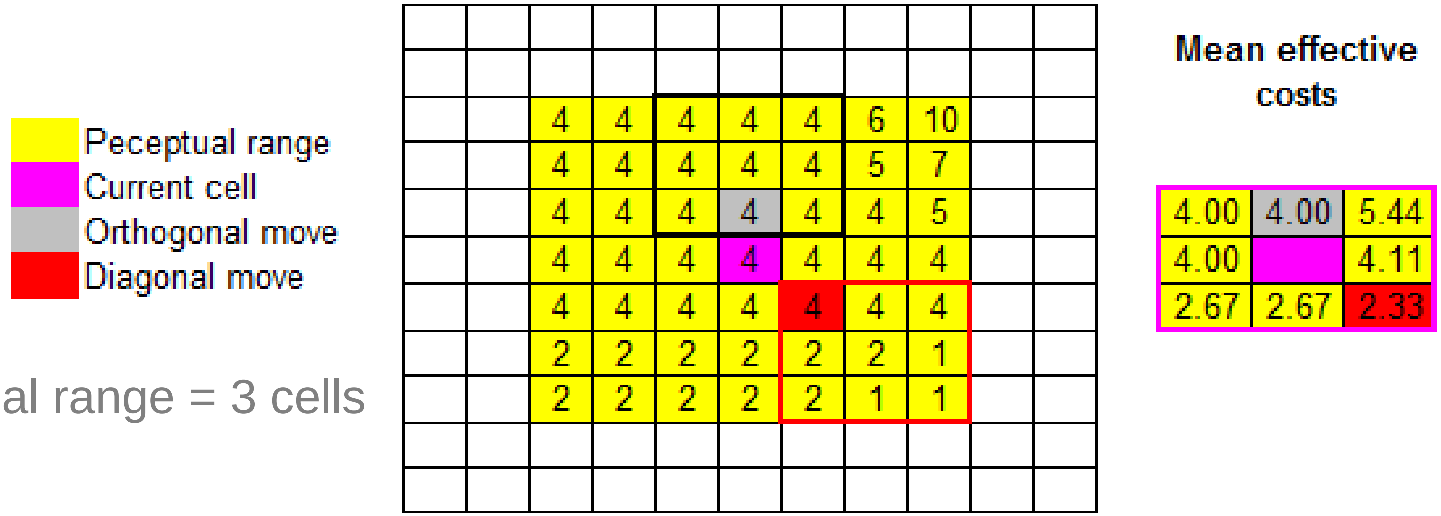
Palmer, Coulon, Travis MEE 2011

SMS-simulated movement



SMS movement rules

Landscape assessment within Perceptual Range



ex: perceptual range = 3 cells

Palmer, Coulon, Travis MEE 2011

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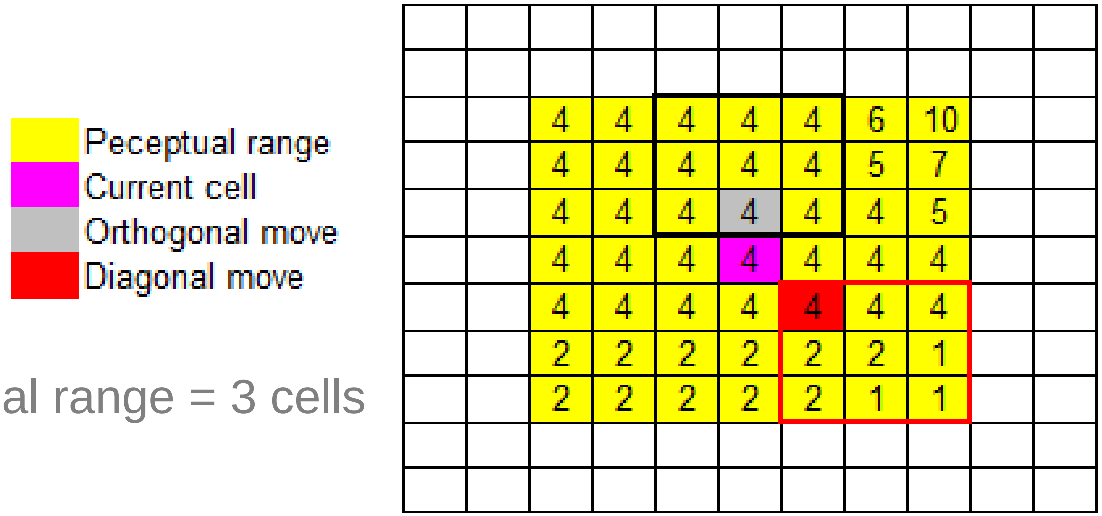

ex: perceptual range = 3 cells

Mean effective costs

4.00	4.00	5.44
4.00		4.11
2.67	2.67	2.33

$$\text{movement probability} = \frac{1}{\text{weighted mean effective cost}}$$

Palmer, Coulon, Travis MEE 2011

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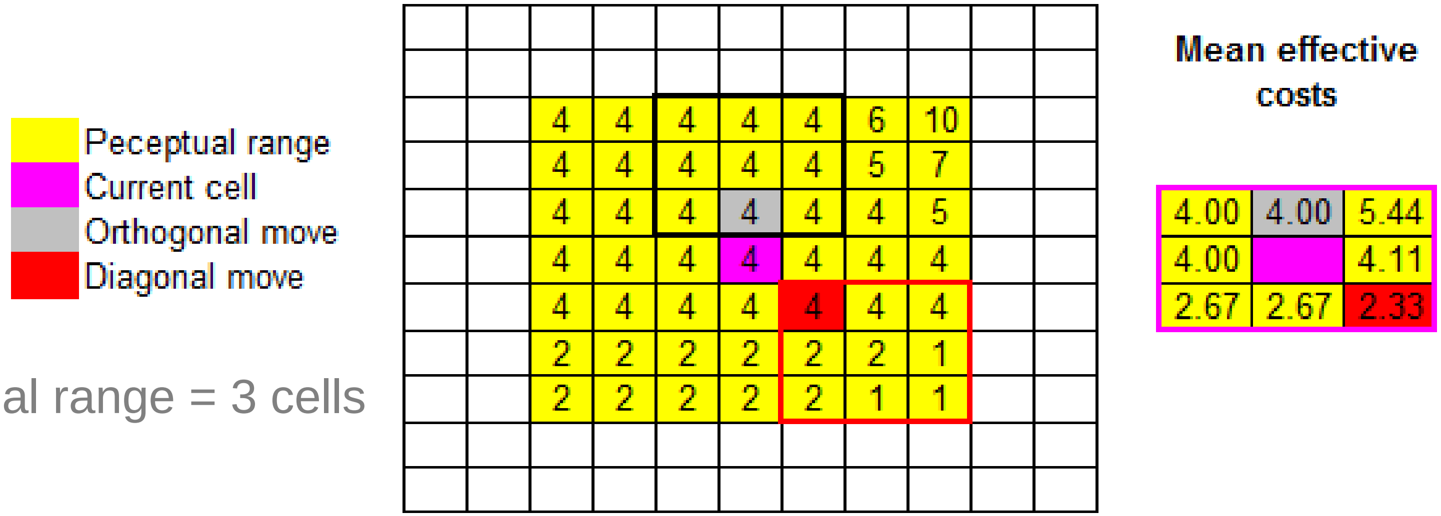

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1. mean of cost of cells within perceptual range

Palmer, Coulon, Travis MEE 2011

SMS movement rules

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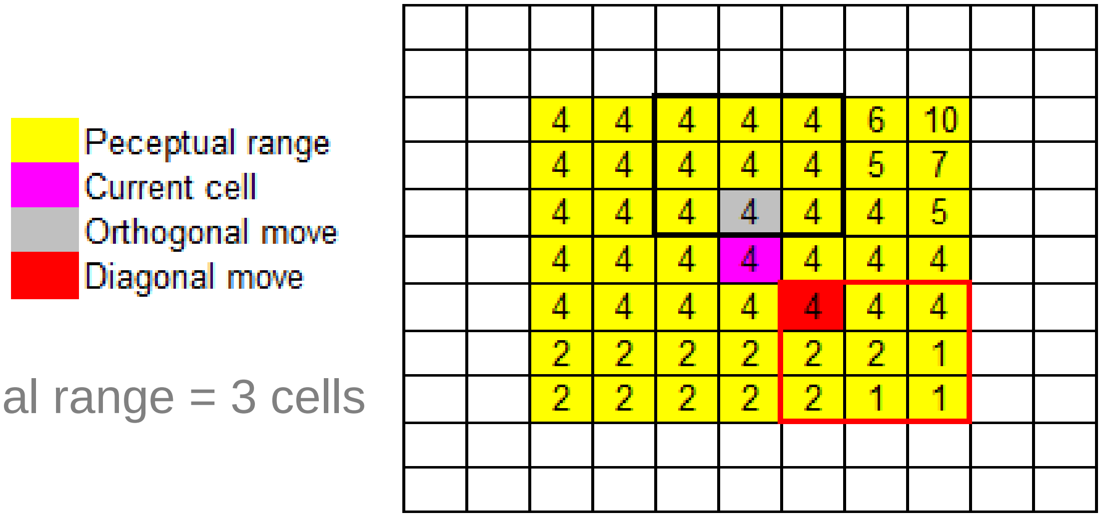

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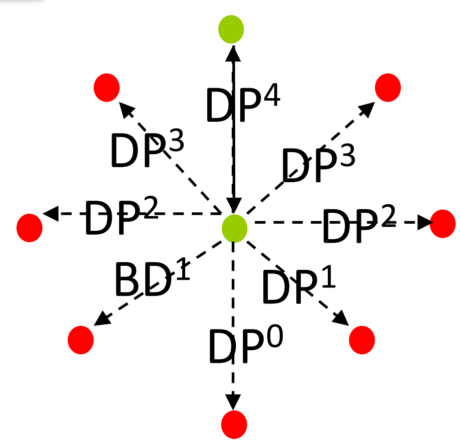
2. weighting by directional persistence

→ higher probability for cells in the same direction as the previous move



Palmer, Coulon, Travis MEE 2011

SMS movement rules

- **Movement decisions depend on:**
  - perceptual range (*n* cells)
  - directional persistence

- **Connectivity estimate from patch A to patch B**

= nb of dispersers from patch A to patch B

Palmer, Coulon, Travis MEE 2011

Aims of the study

- **Compare performance of connectivity estimates based on:**
  - Least Cost Paths
  - Circuit theory (Circuitscape)
  - SMS

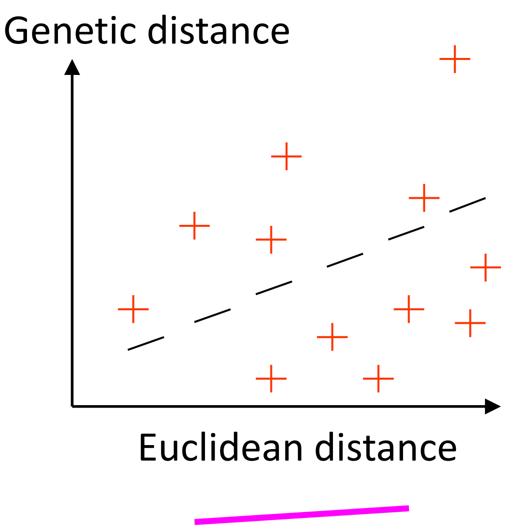
- **2 case studies**

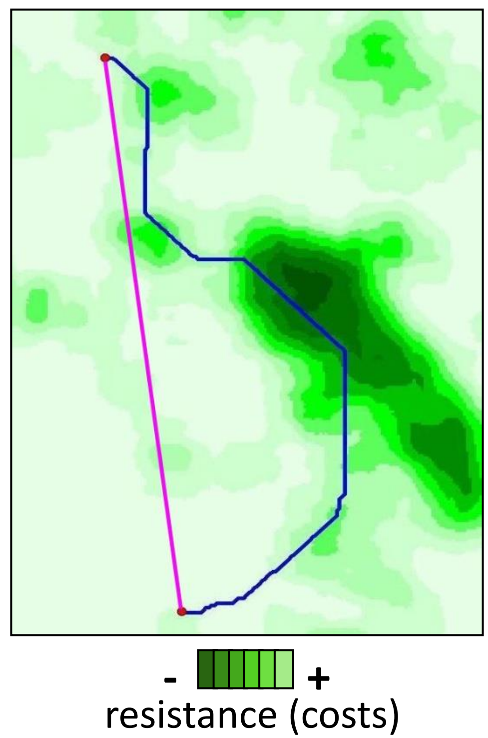
Natterjack toad
Bufo calamita

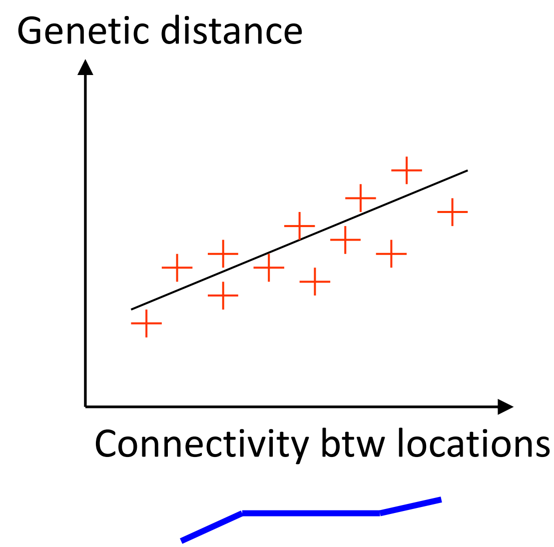
Cabanis's greenbul
Phyllastrephus cabanisi

SMS / LCP / Circuitscape – How do they compare?

Correlation of genetic estimates of inter-patch connectivity with Euclidean, LCP, Circuitscape and SMS estimates of connectivity





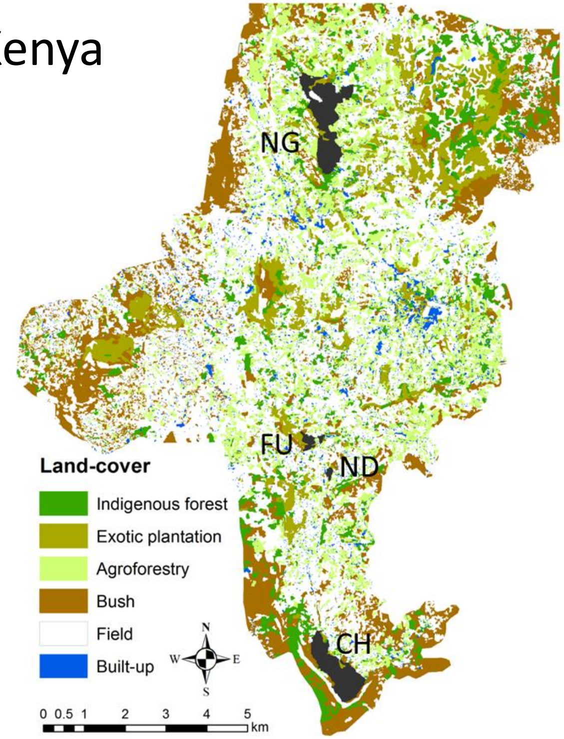


→Larger r with better estimates of connectivity

SMS / LCP / Circuitscape – How do they compare?

1st case study: the Cabanis' greenbul in the Taita hills, Kenya

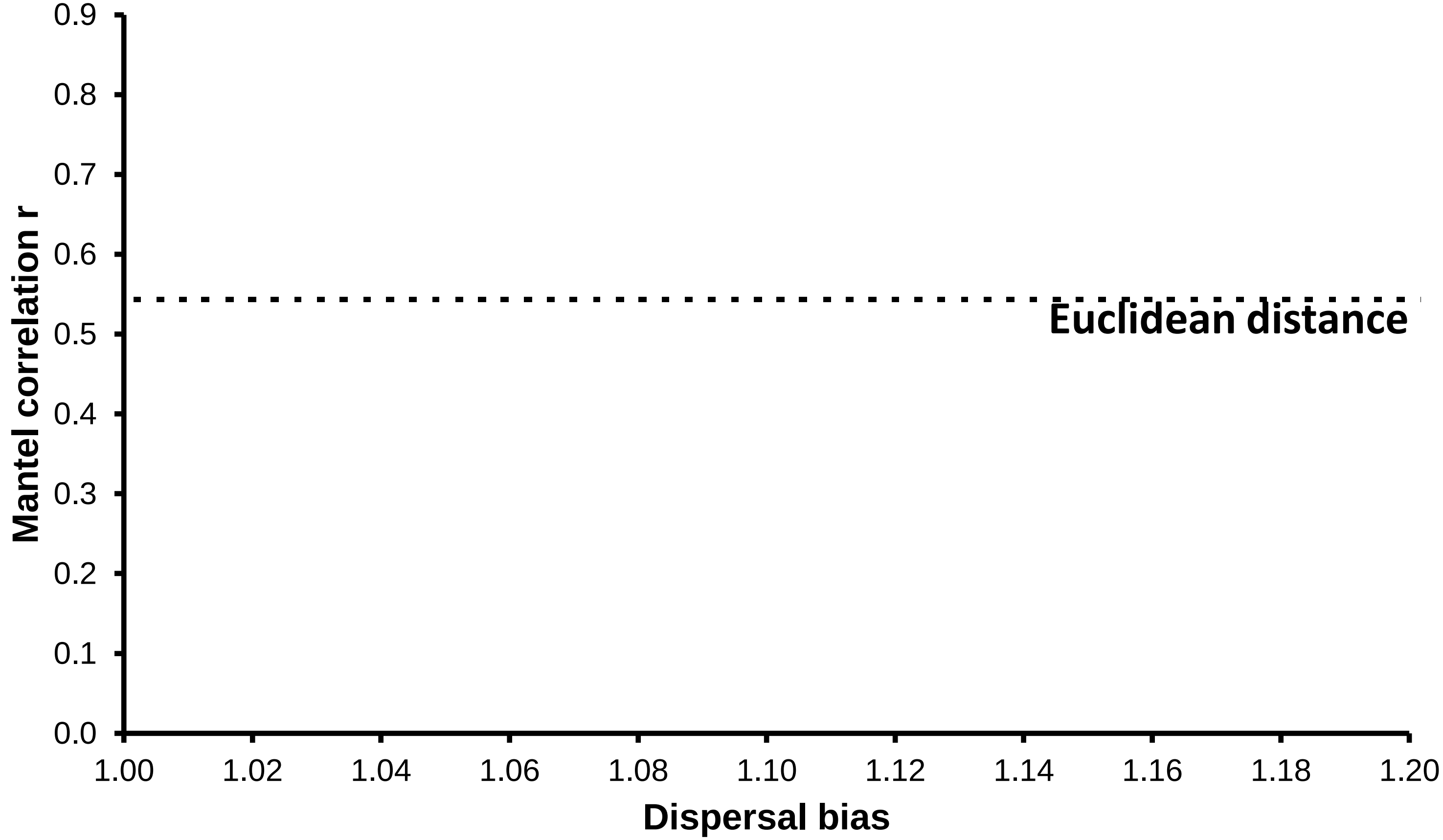
Cabanis's greenbul
Phyllastrephus cabanisi



- Forest-dwelling passerine species
- Birds captured, released ~1km away & tracked back to home forest block → analysis of trajectories → resistance values
- SMS parameters set by congruence assessment of simulated trajectories to actual movements
- Dispersal bias added to SMS
- Microsatellites → genetic distance estimated among the four forest patches (migration rates, MLNE)

SMS / LCP / Circuitscape – How do they compare? (Greenbuls)

Correlation of genetic estimates of inter-patch connectivity with Euclidean, LCP, Circuitscape and SMS estimates of connectivity



Coulon, Aben et al. Ecology 2015

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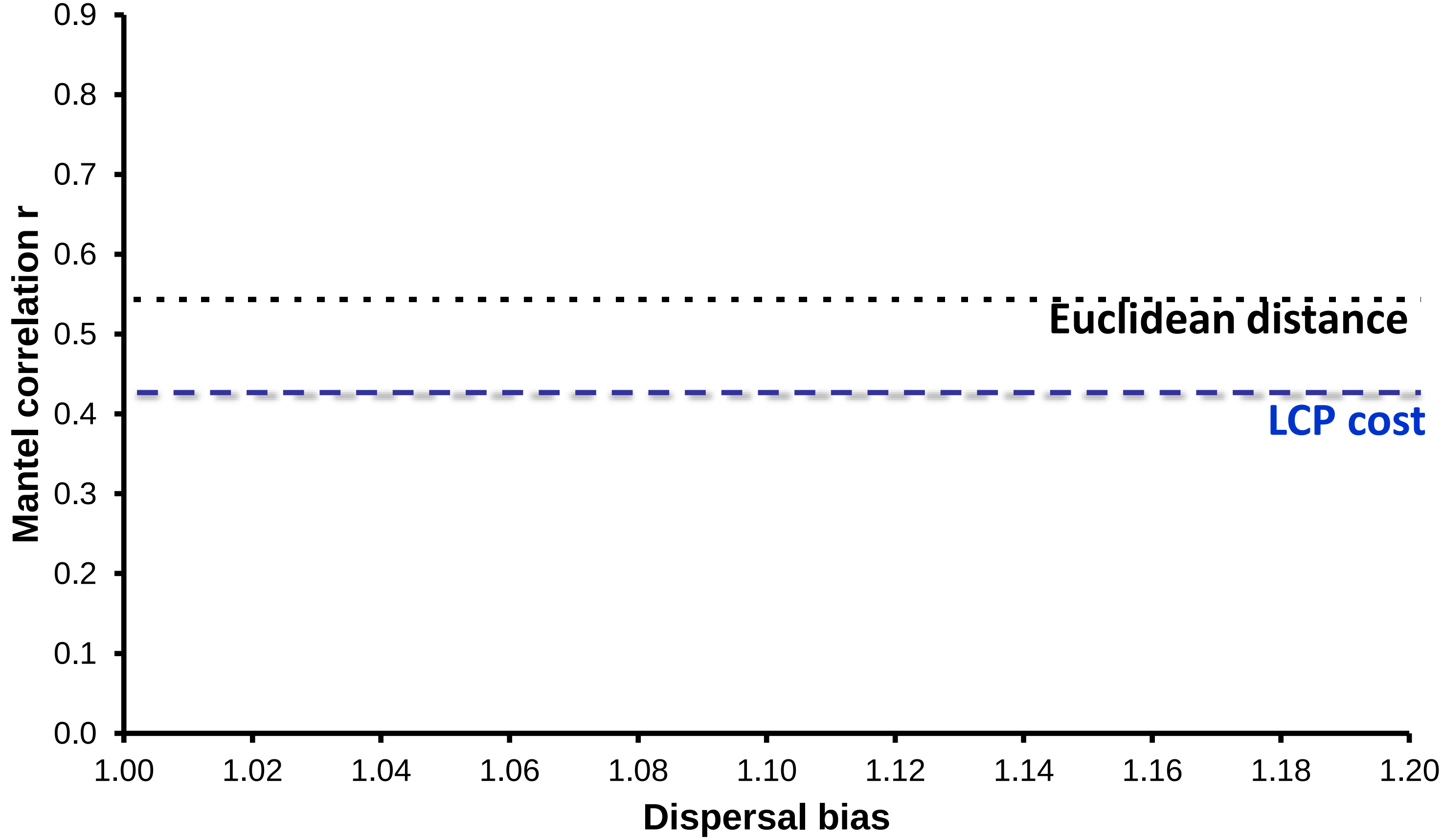

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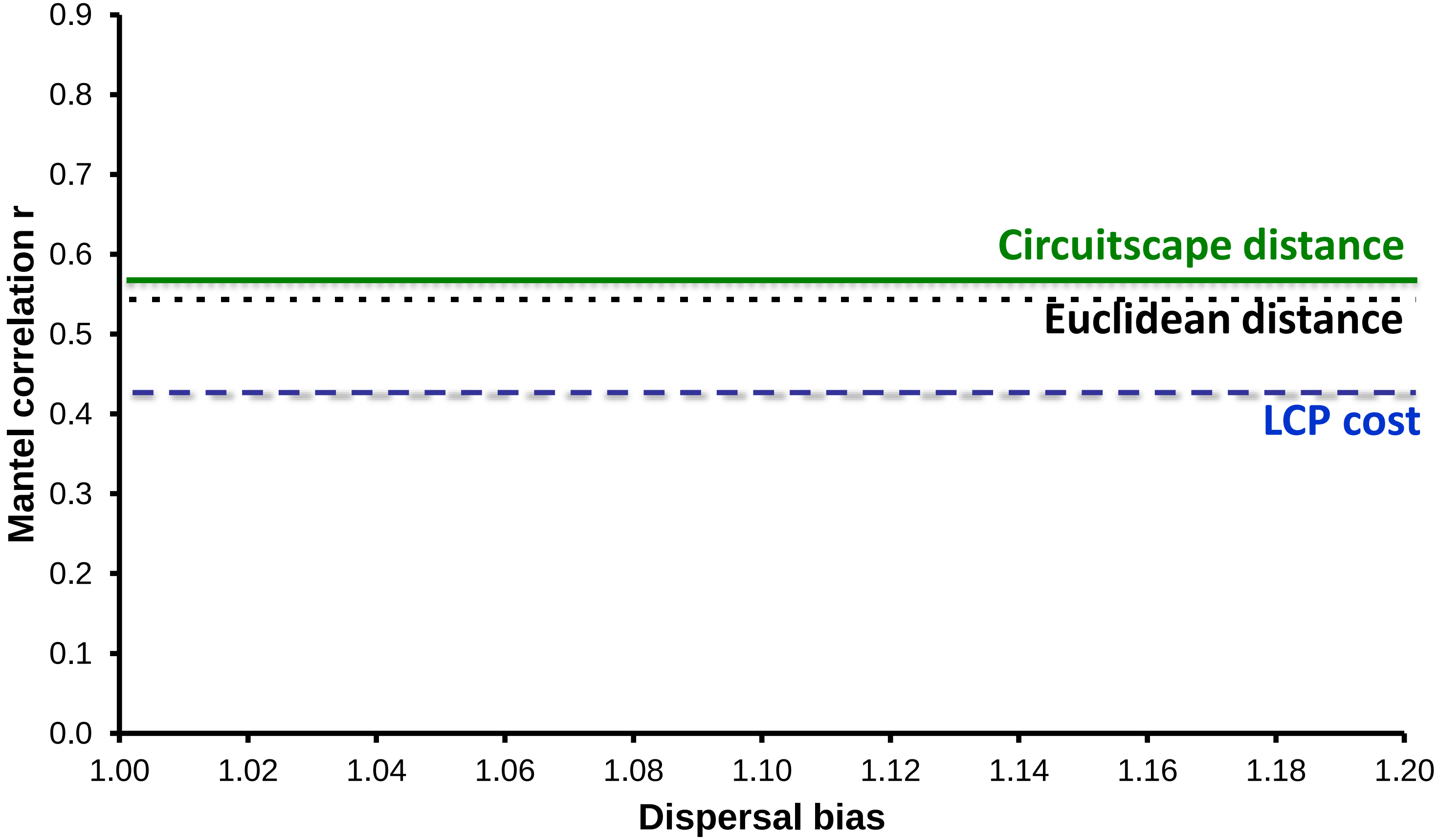

Coulon, Aben et al. Ecology 2015

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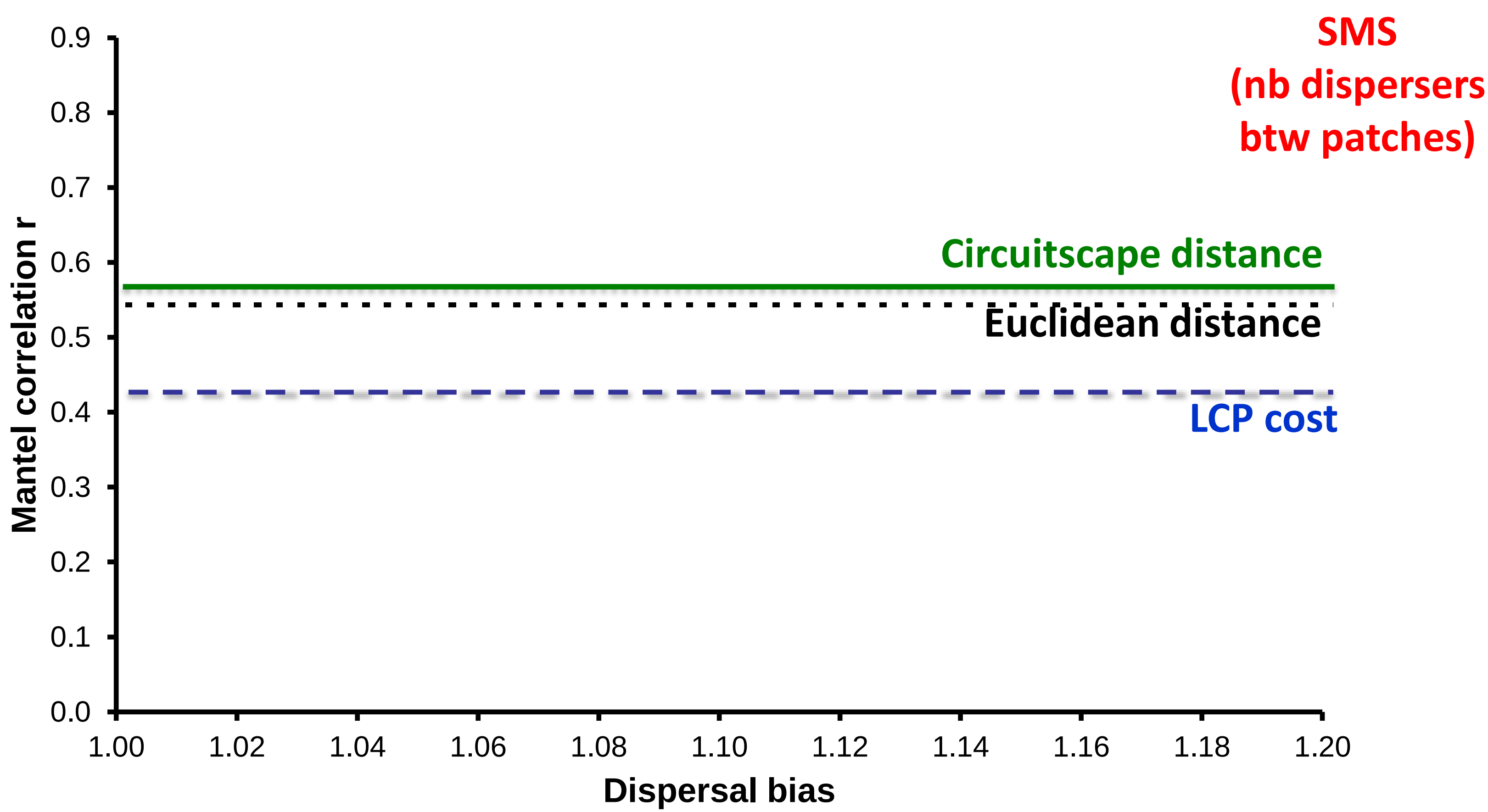
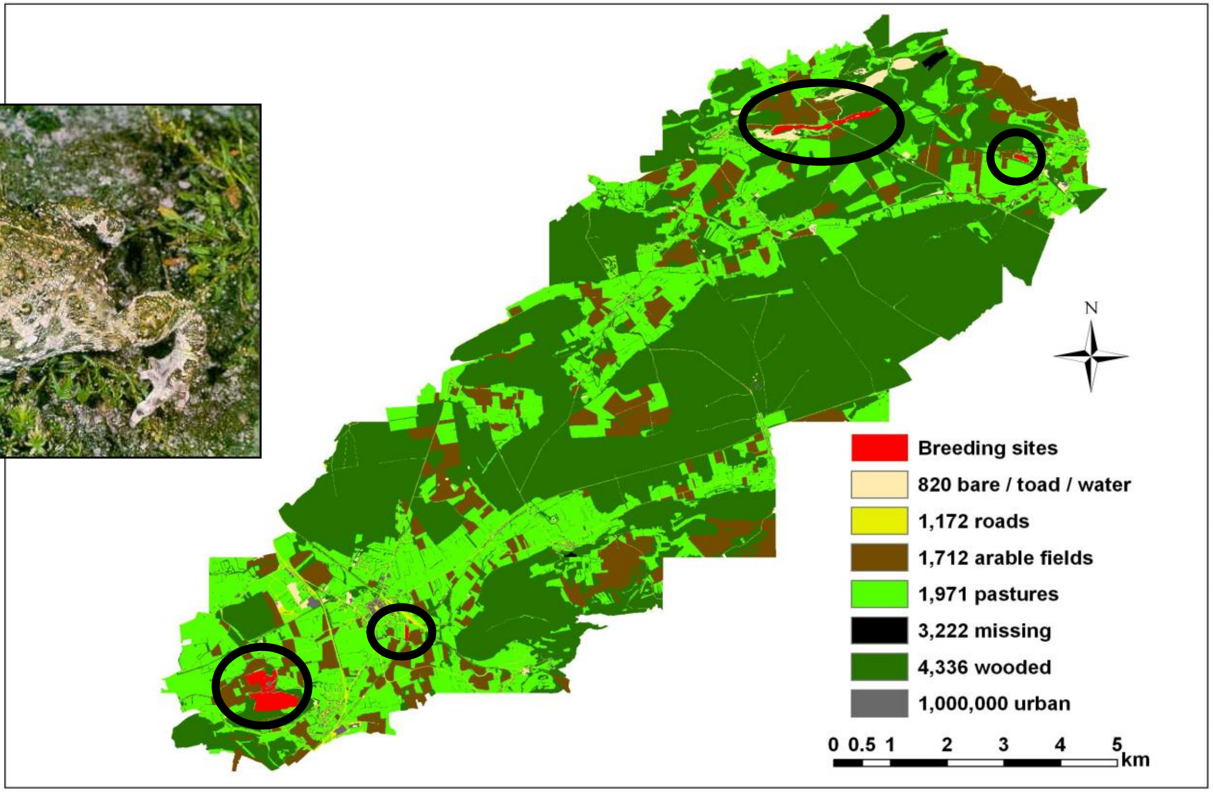


Coulon, Aben et al. Ecology 2015

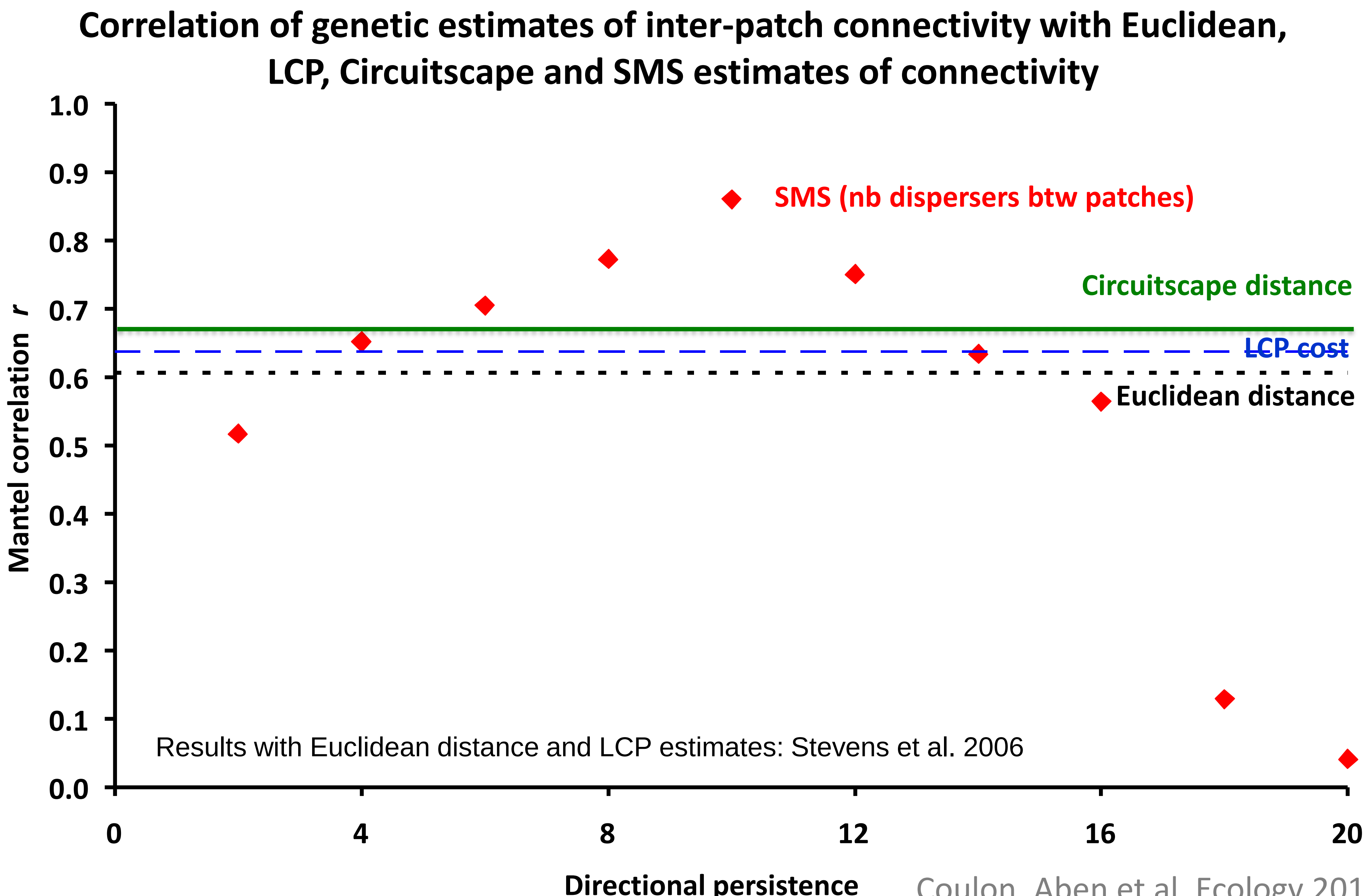
SMS / LCP / Circuitscape – How do they compare? (Natterjack toad)

2nd case study: the Natterjack toad (*Bufo calamita*) in Sambre-Meuse valley, Belgium



- Terrestrial toad, favours open vegetation or bare ground
- Movement costs estimated experimentally (Stevens et al. 2004, 2006)
- 1km buffer around ponds added to SMS
- Microsatellites → genetic distances among the four patches (migration rates, MIGRATE)

SMS / LCP / Circuitscape – How do they compare? (Natterjack toad)



Coulon, Aben et al. Ecology 2015

Conclusions

- A spatially-explicit IBM appears to be a better predictor of habitat connectivity than LCP or Circuitscape
  - verified for 2 species (one landscape in each case)
  - requires certain species-specific assumptions (auditory attraction) …
  - will this be prohibitive in general?
- SMS robust to the choice of spatial grain and perceptual range
- Is it robust to relative costs of habitat types?
- SMS is potentially a suitable tool to help conservationists and policy makers

Acknowledgements

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fwo Research Foundation Flanders Opening new horizons

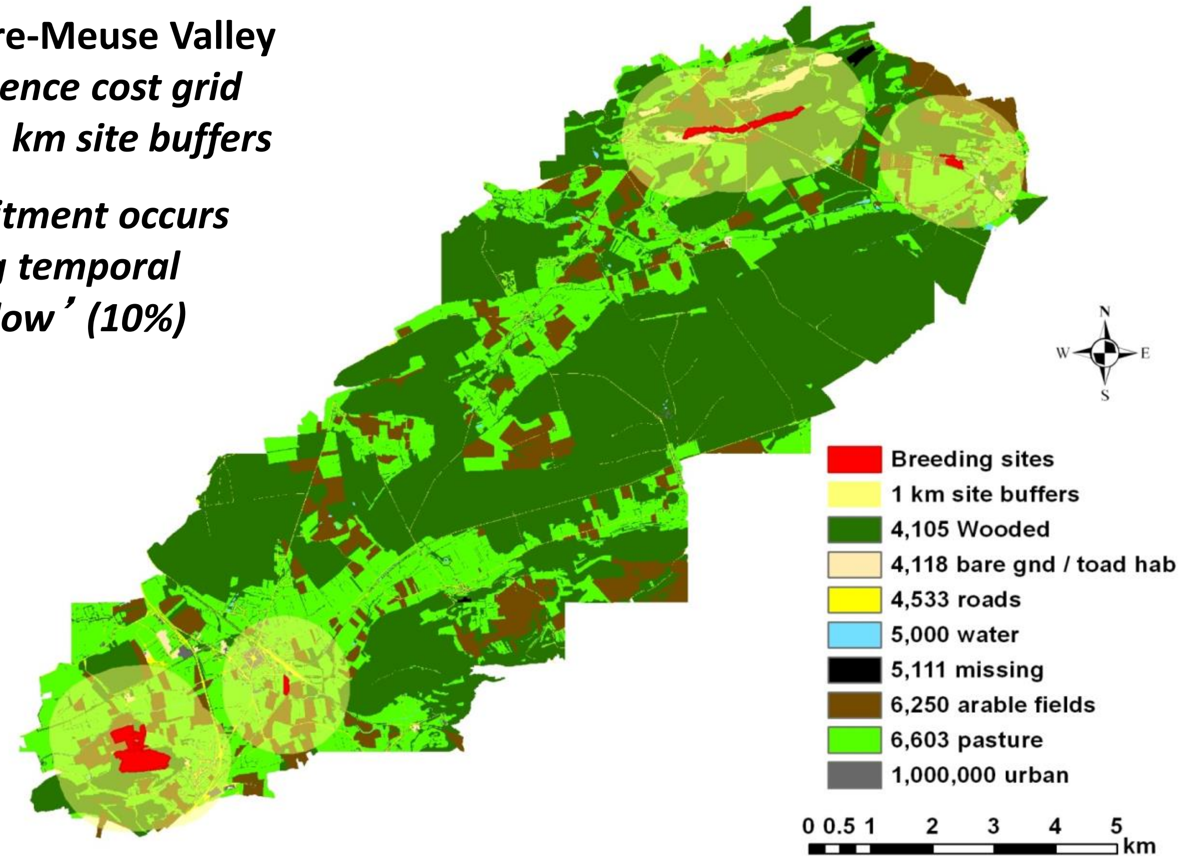
VLIR-VLADOC scholarship

SMS / LCP / Circuitscape – How do they compare? (Natterjack toad)

Does SMS need species-explicit ecology?

Sambre-Meuse Valley
Preference cost grid with 1 km site buffers

Recruitment occurs during temporal 'window' (10%)



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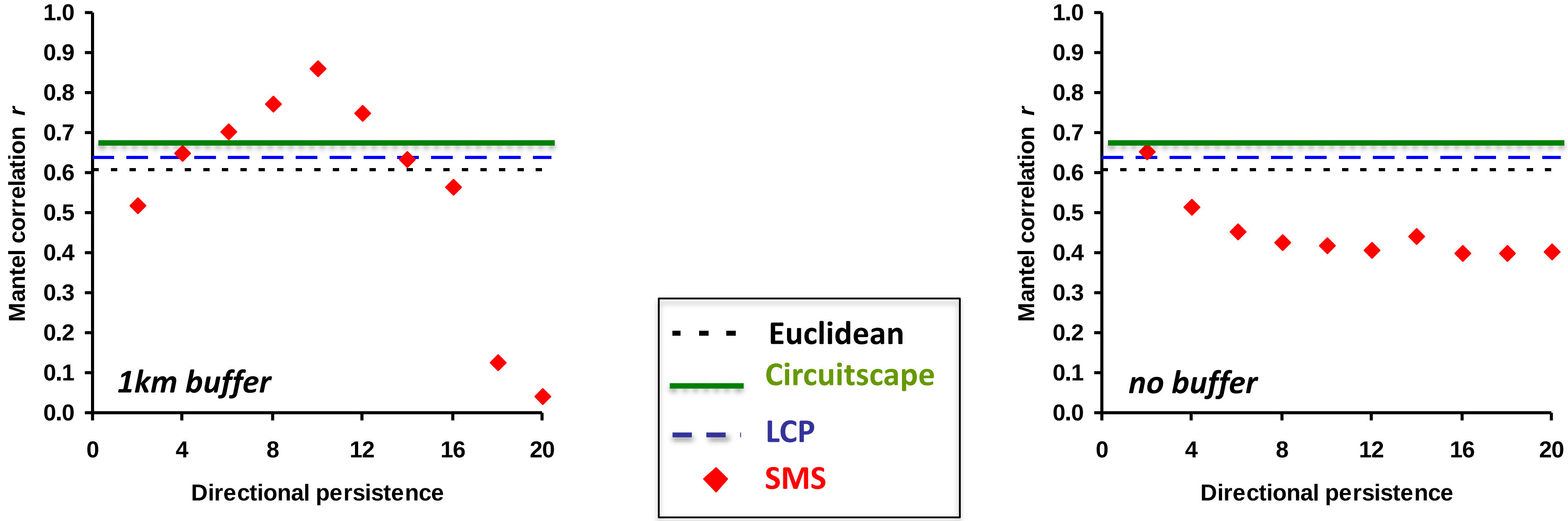
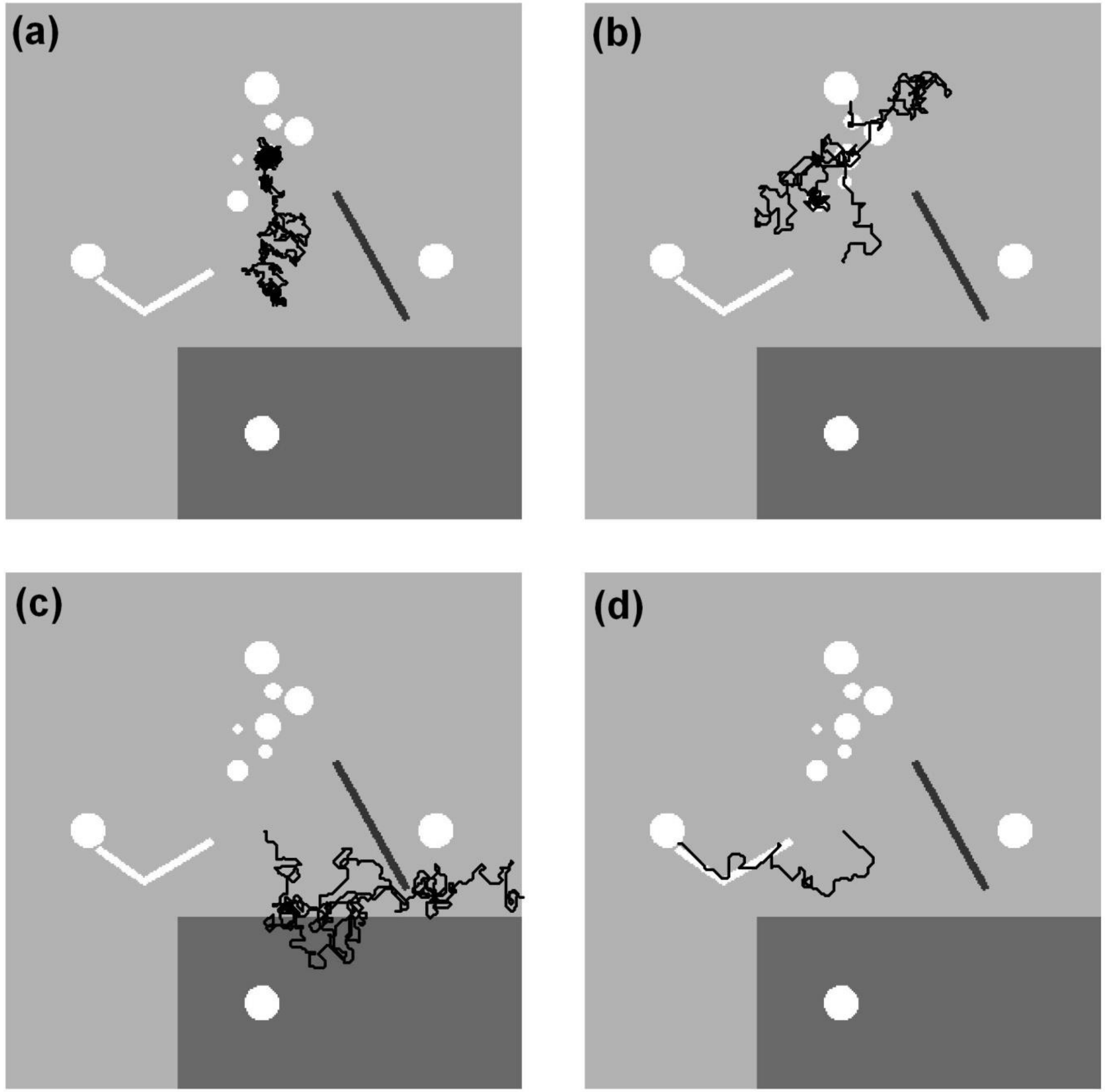


...in this case yes...

Example paths

Low PR
Low DP
Harm. method

Low PR
High DP
Harm. method



Low PR
High DP
Arith. method

High PR
High DP
Harm. method

PR = perceptual range; DP = directional persistence

Sensitivity analysis of SMS performance (Natterjacks)

Is SMS robust to assumed perceptual range?

Preference costs
10m grain size
PR = 3 cells (30m)