“Everything Disperses to Miami”

Linking Individual Movements and Population Patterns in Dynamic Landscapes

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Linking Individual Movements and Population Patterns in Dynamic Landscapes

Part 1: Conceptual

Framework for animal movements and population distributions

Part 2: Emprical

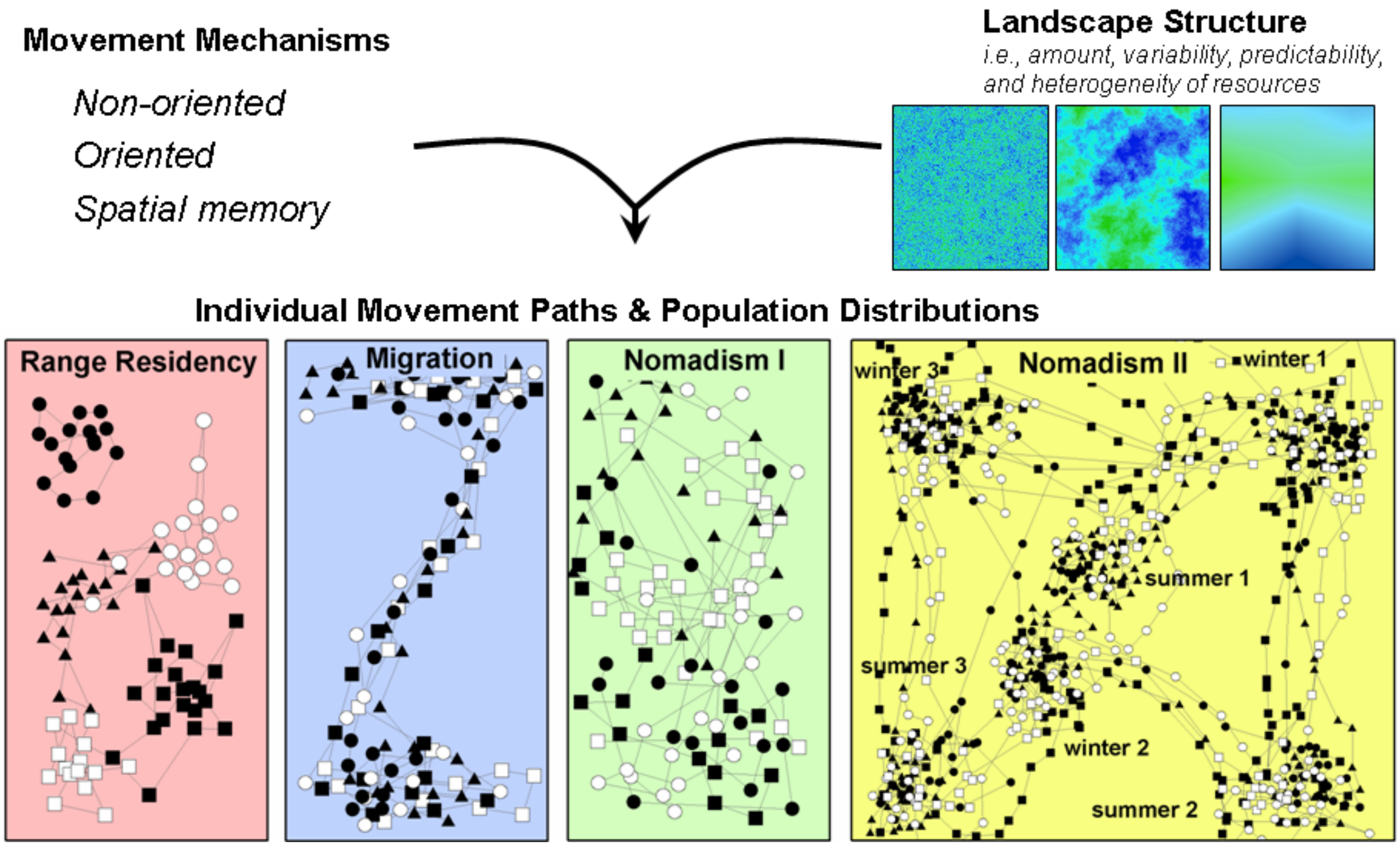
> Nomadism in Mongolian gazelles

> Multispecies comparison

Part 3: Theoretical

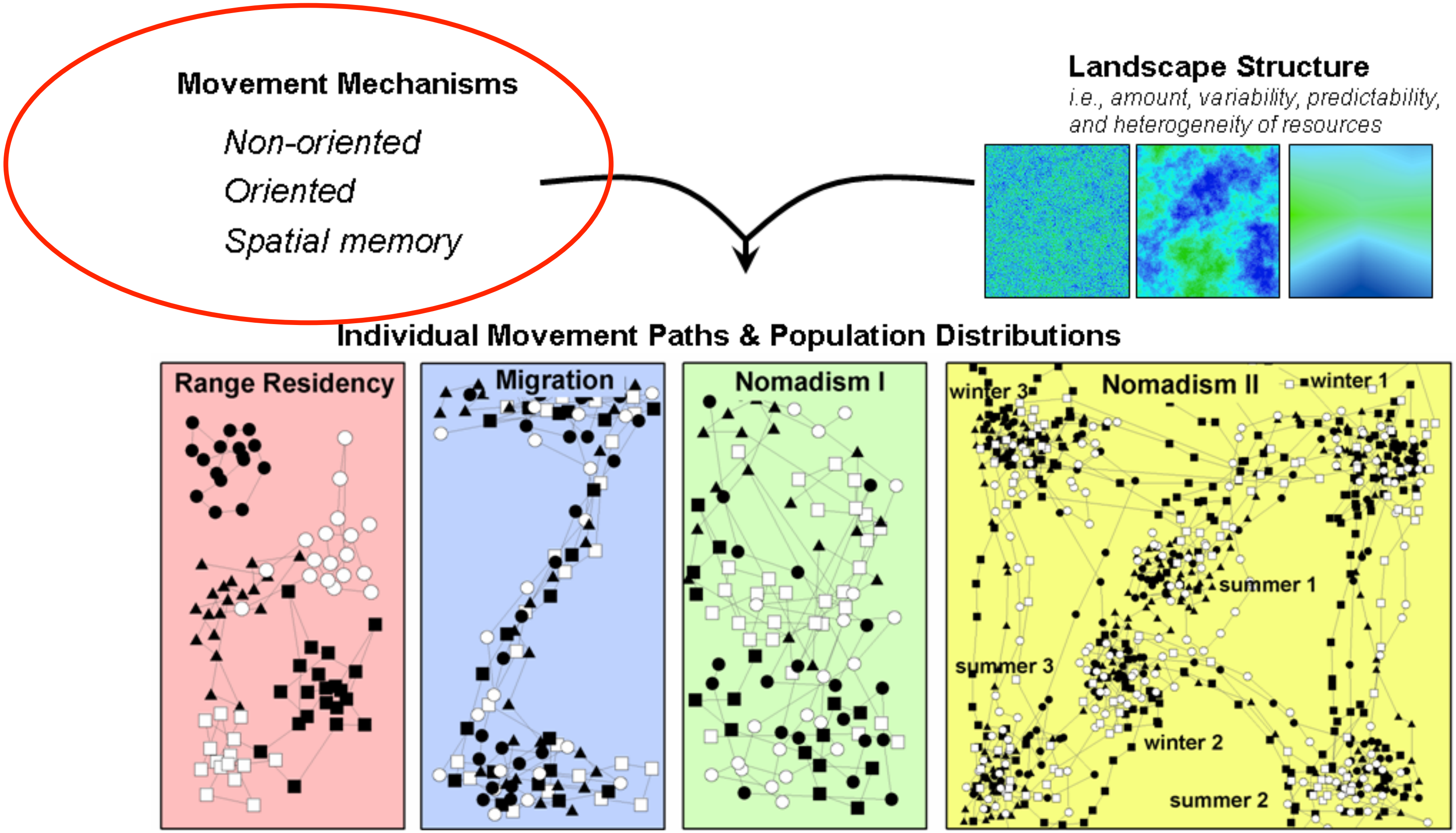
Simulating movement behaviors using artificial life approaches

Part 1: Conceptual framework for resources, population distributions and movement mechanisms



Mueller and Fagan, Oikos 2008

Part 1: Conceptual framework for resources, population distributions and movement mechanisms



Mueller and Fagan, Oikos 2008

<u>Individual level movement mechanisms:</u>

(1) ***Non-oriented,*** based on kinesis and bio-diffusion

- sensory stimuli such as stomach fullness

- <u>*stimuli coming from an animal's current location*</u>

- cause an alteration in an individual's movement parameters (speed, turning angle)

- movement decision with <u>*random direction*</u>

Individual level movement mechanisms:

(1) ***Non-oriented,*** based on kinesis and bio-diffusion

(2) ***Oriented,*** based on taxis and perceptual range

- e.g. visual detection of food good habitats
- stimuli *stem from a location beyond the animal's current position*
- movement in a *predictable direction*.



Individual level movement mechanisms:

(1) ***Non-oriented,*** based on kinesis and bio-diffusion

(2) ***Oriented,*** based on taxis and perceptual range

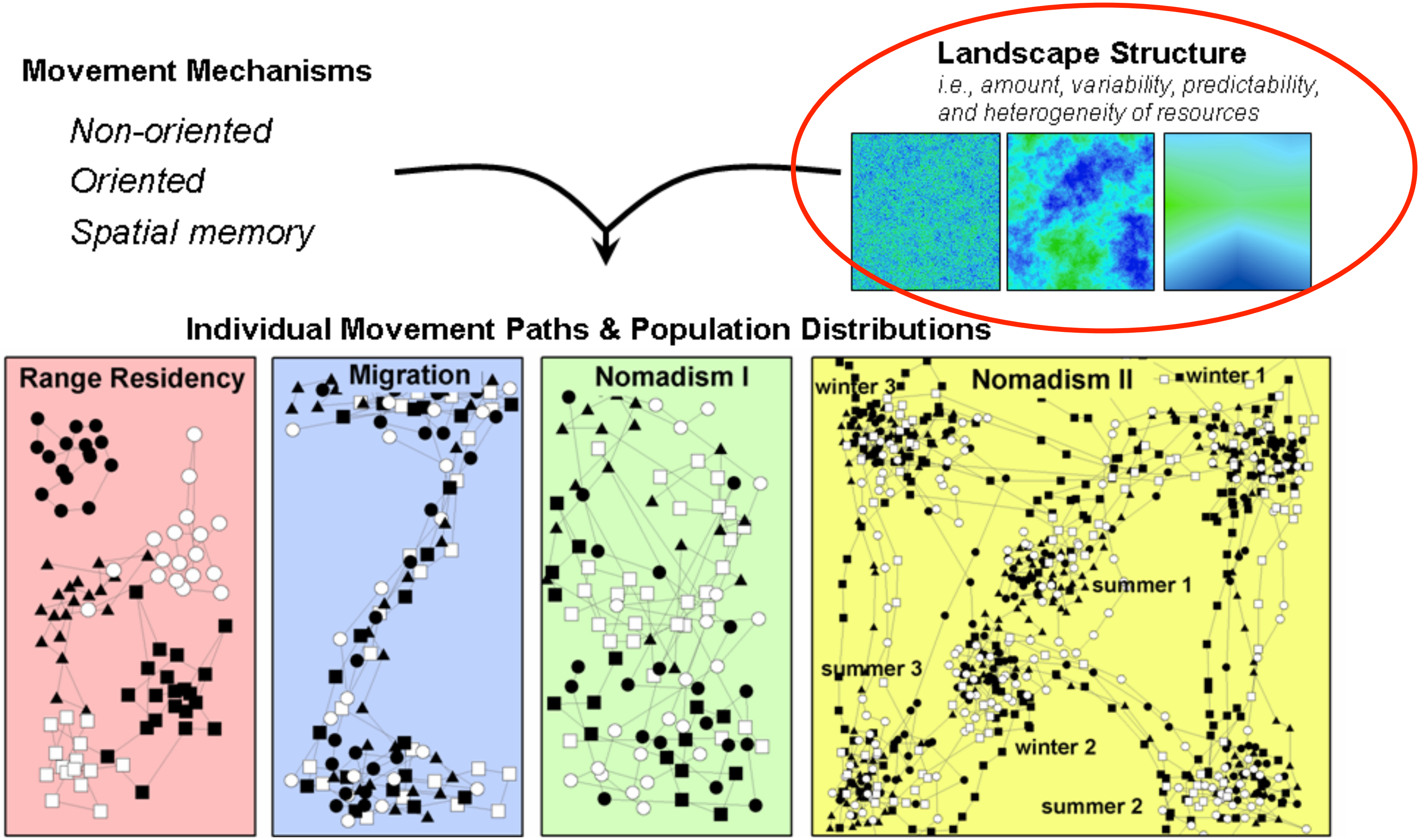
(3) ***Spatial memory,*** based on previous information derived from the recollection of

- an *individual's own history*,
- *communication with conspecifics*,
- or as a *genetic inheritance* from its ancestors

➢ *path integration* (e.g., waggle dance in bees or magnetic compasses in birds)

➢ *cognitive maps* (e.g., geomagnetic coordinates and use of landmarks)

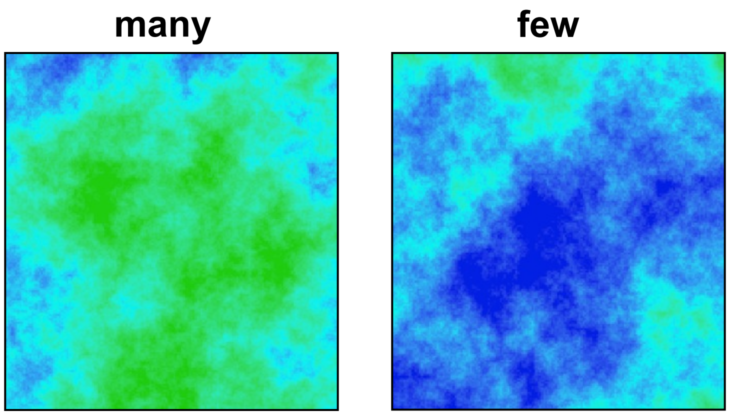
Part 1: Conceptual framework for resources, population distributions and movement mechanisms



Mueller and Fagan, Oikos 2008

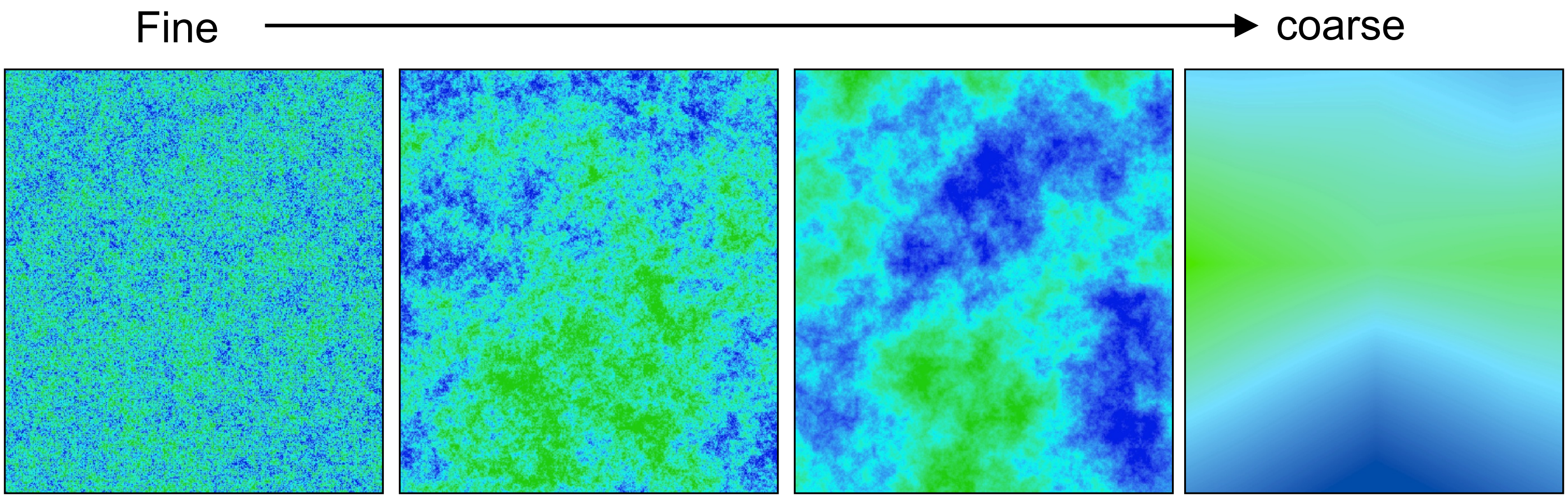
Resources…variability across **4 gradients:**

a) Amount



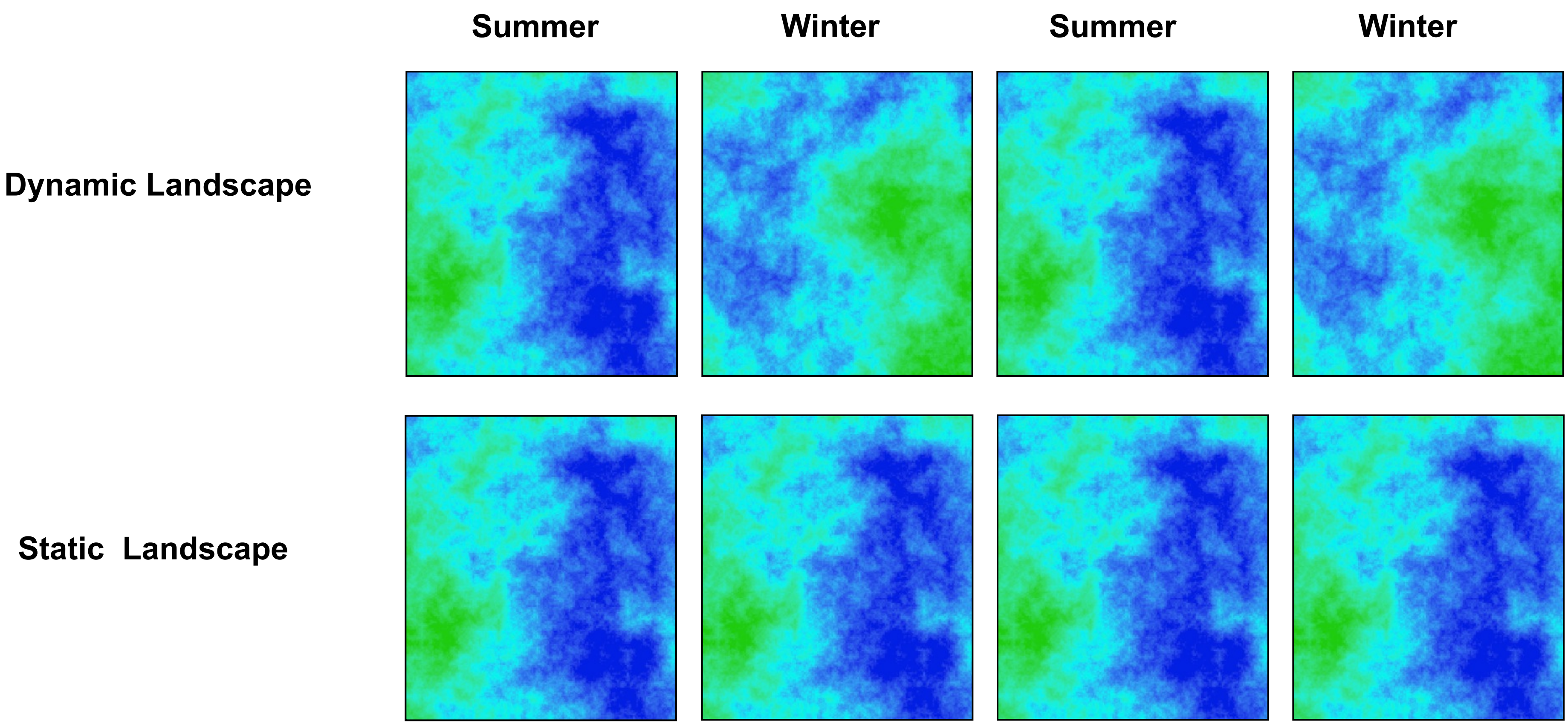
Resources…variability across **4 gradients:**

a) Amount
b) Spatial configuration



Resources…variability across **4 gradients:**

a) Amount
b) Spatial configuration
c) Temporal variation



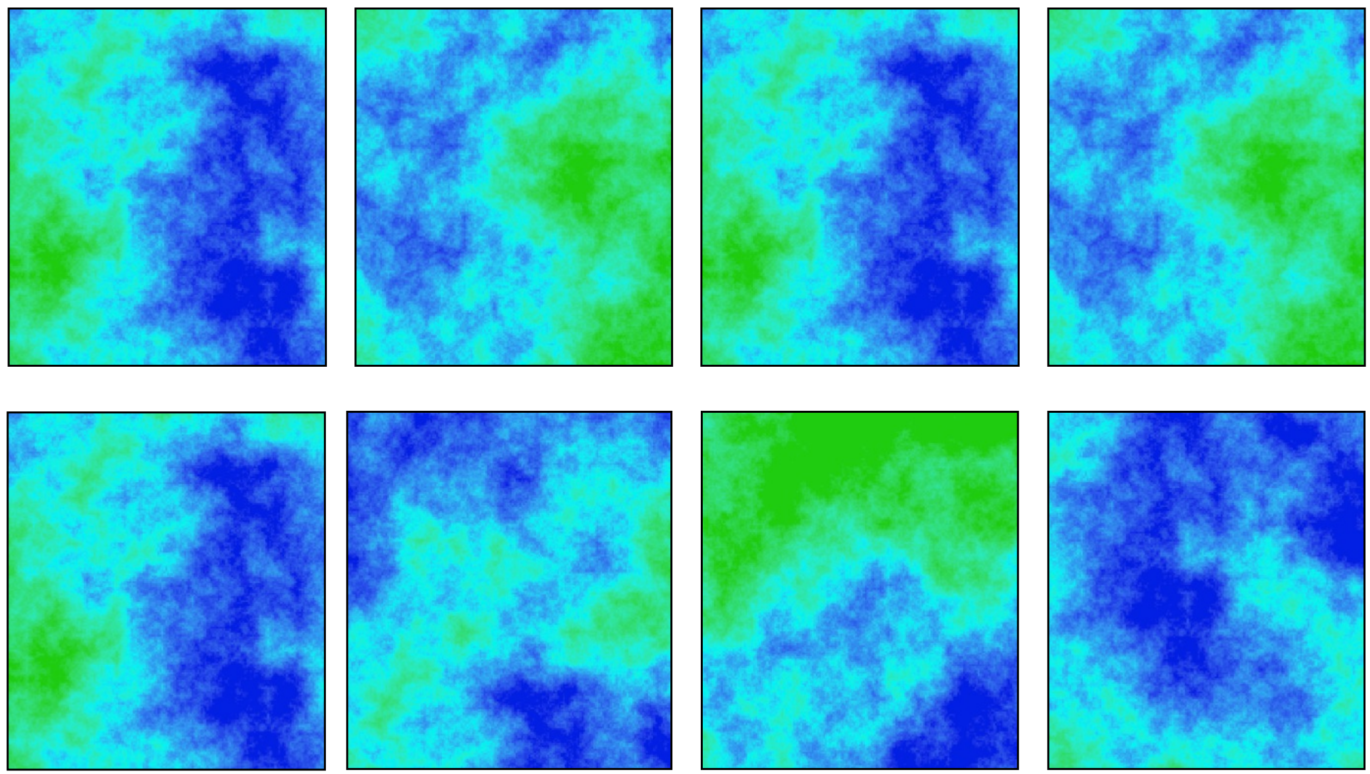
Resources…variability across **4 gradients:**

a) Amount
b) Spatial configuration
c) Temporal variation
d) Predictability

Summer **Winter** **Summer** **Winter**

Dynamic Landscape:
variable but predictable

Dynamic Landscape:
variable and unpredictable



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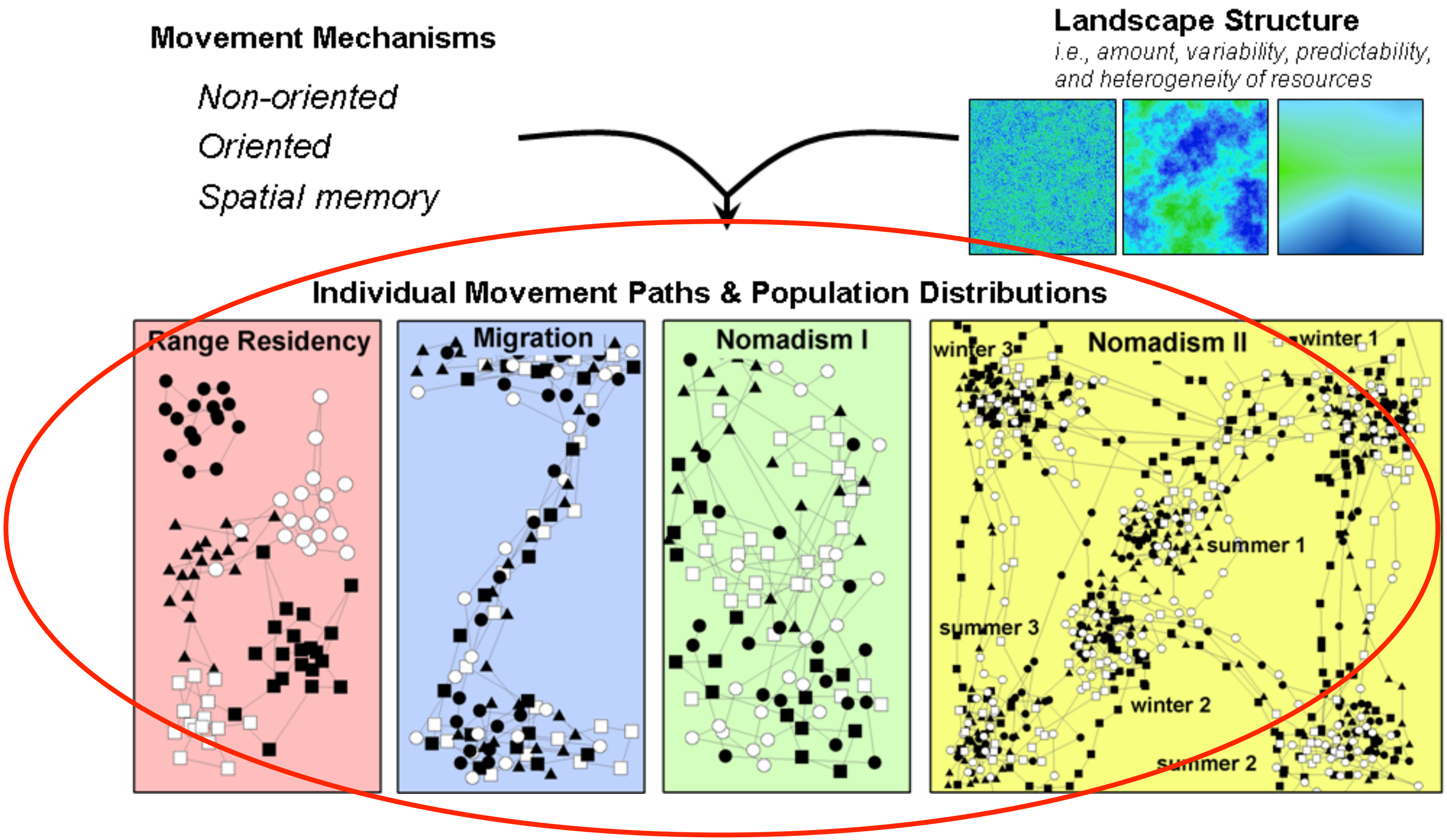
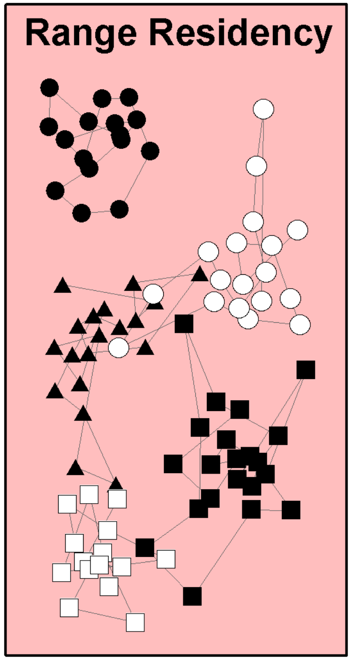
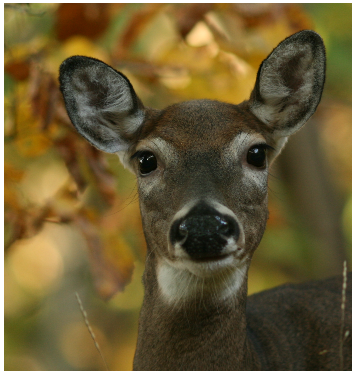


Population distributions





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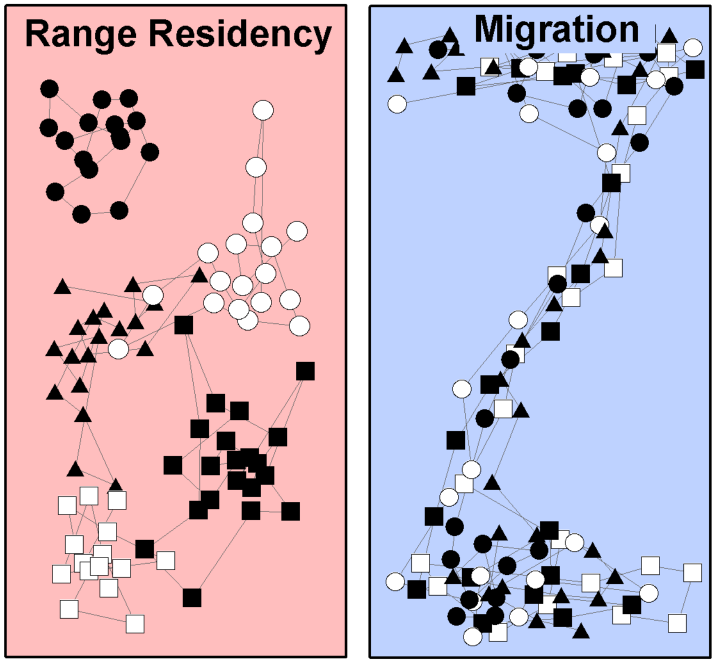

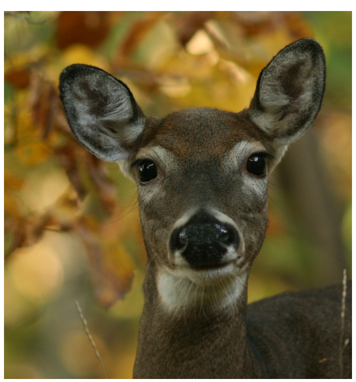

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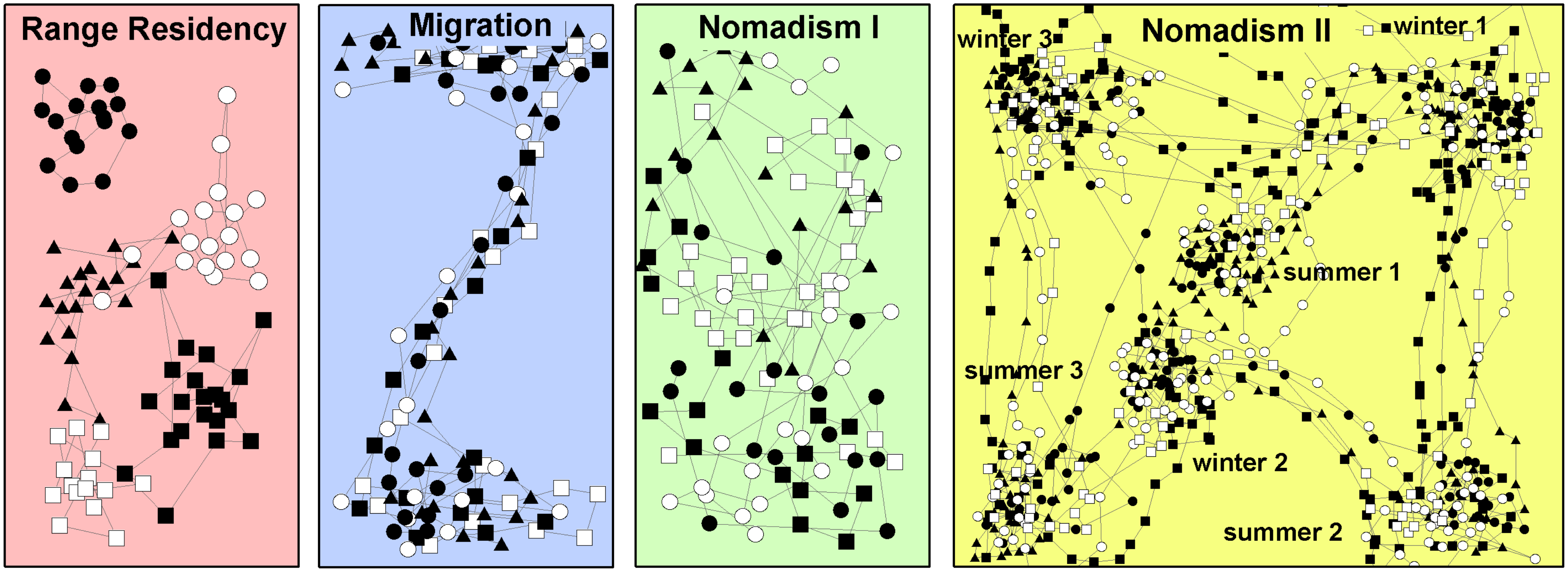
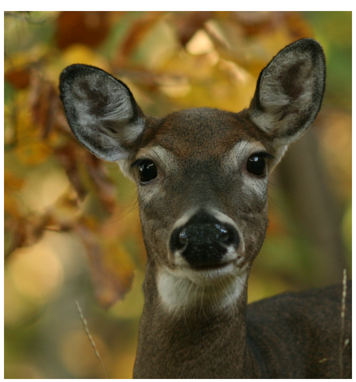
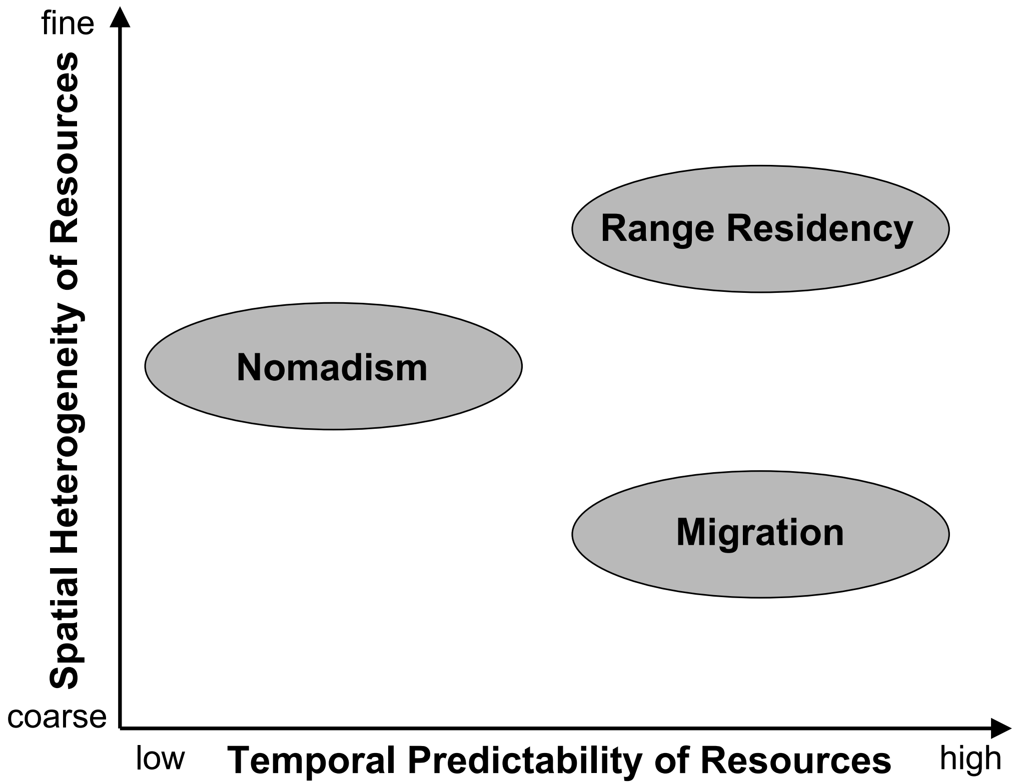




Resource landscapes and Population-level patterns



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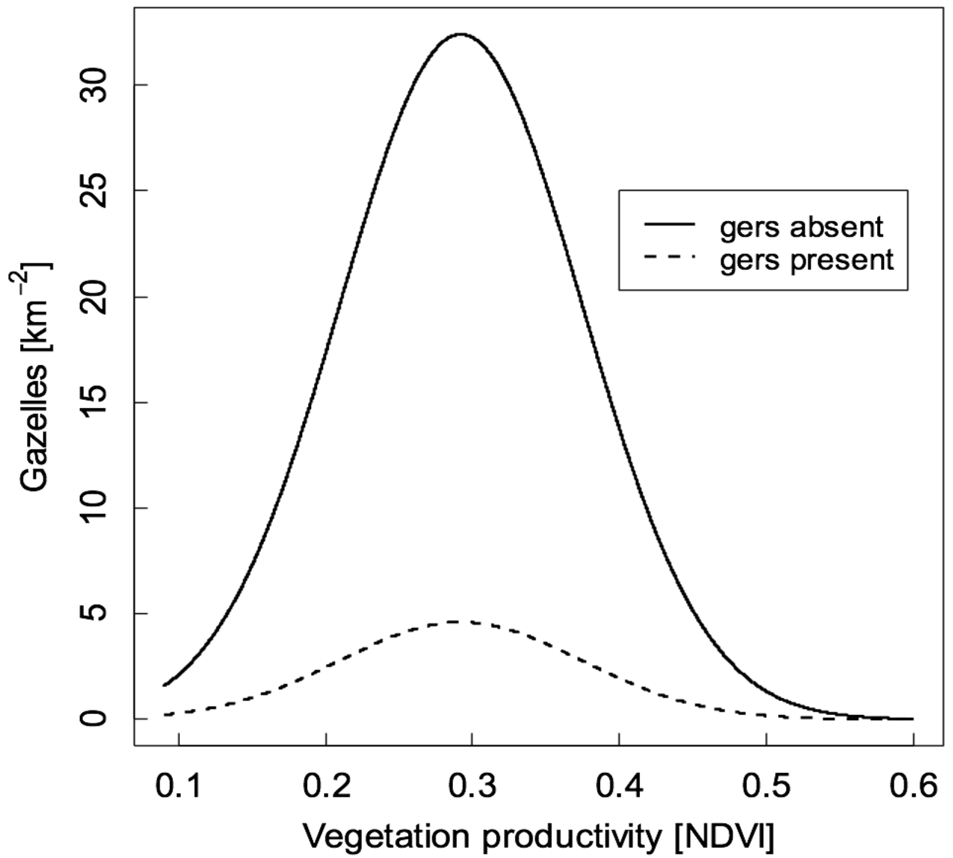
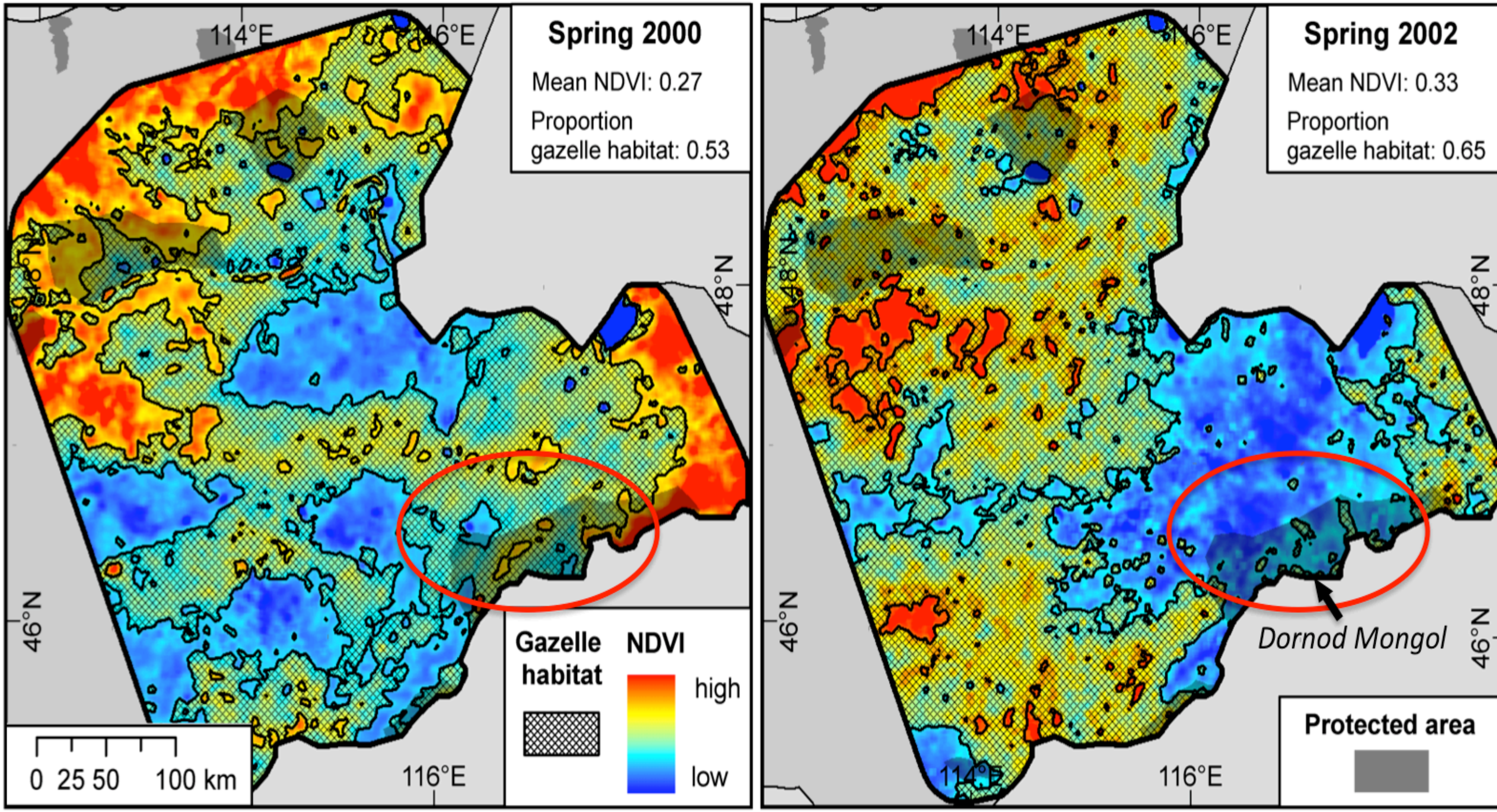
Simulating movements using artificial life approaches

The Eastern Steppe of Mongolia

Dynamic Habitat Models using Remote Sensing Data



Olson et al. Cons. Letters 2011



Mueller et al., J. Appl. Ecol. 2008

Comparison of relocation patterns among individuals

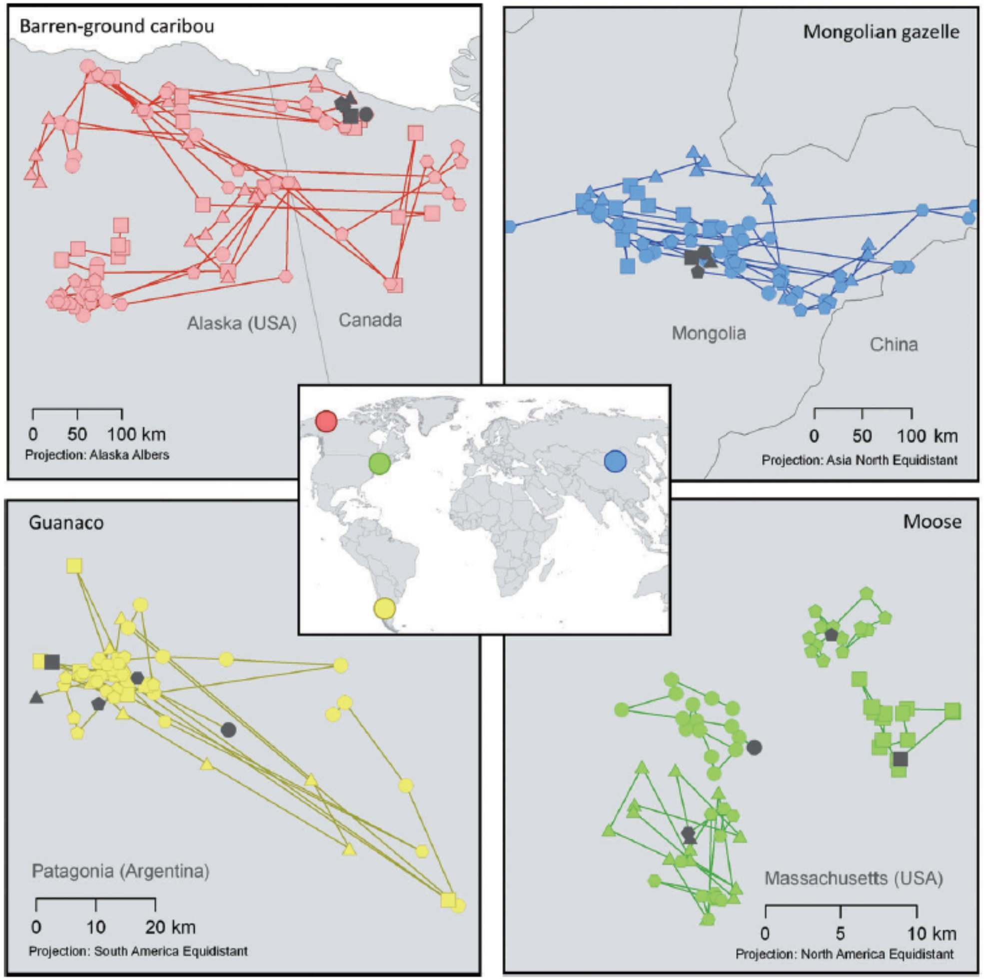
<u>Data: 1 year of relocations in 16 day intervals of</u>

- 5 Caribou of the Porcupine caribo

- 5 Mongolian gazelle

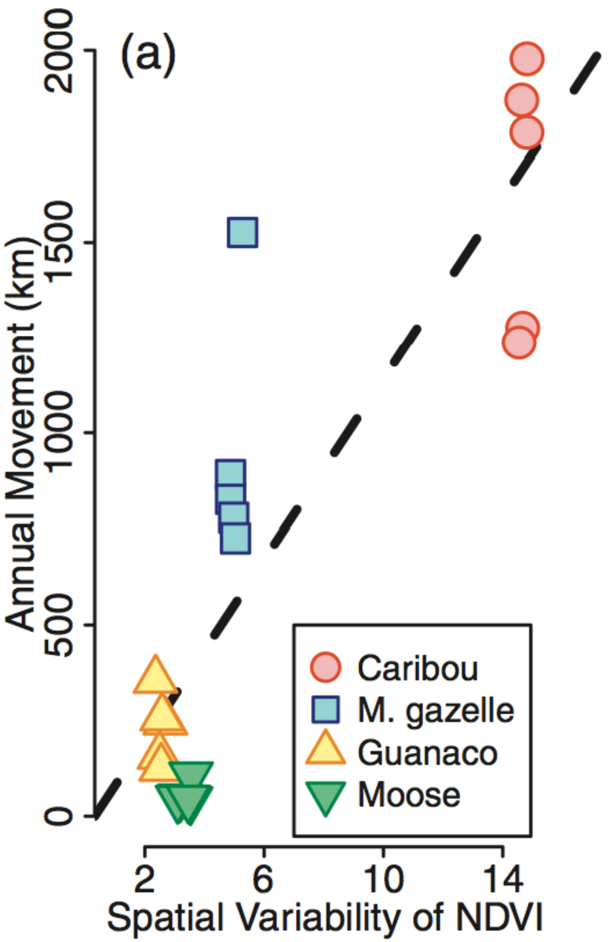
- 5 Patagonian guanaco

- 5 Moose of Massachusetts



Drivers of population-level movement

Landscape dynamics in relation to movement



Mueller et. al., Global Ecol. Biog. 2011

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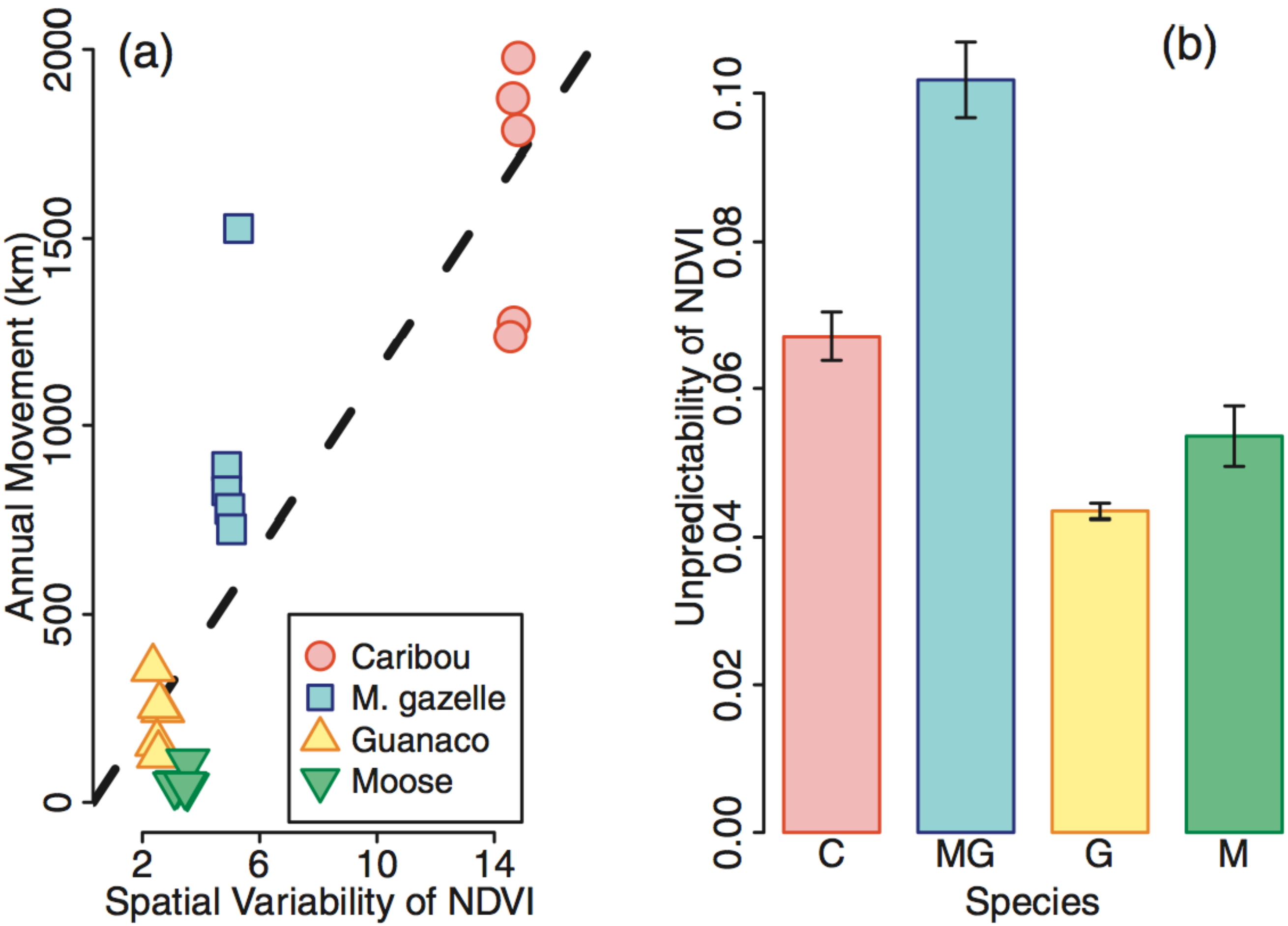

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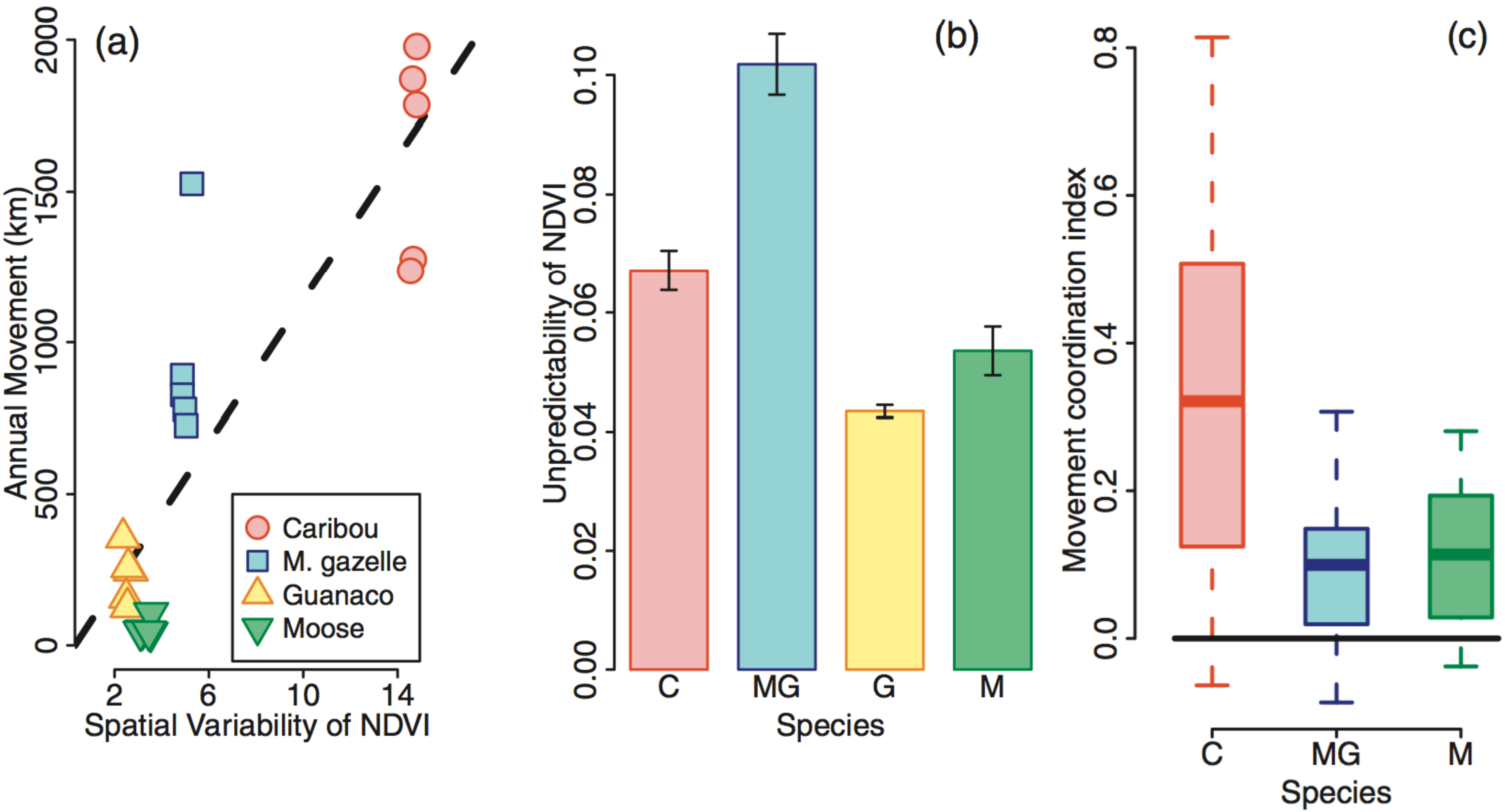

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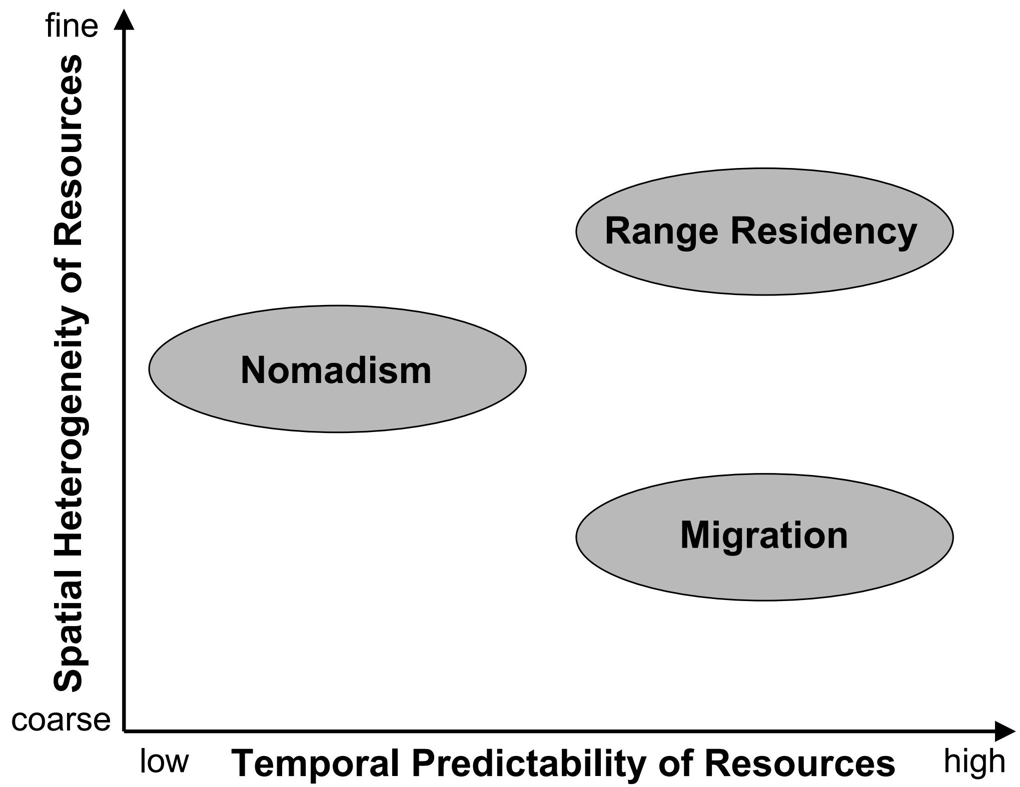
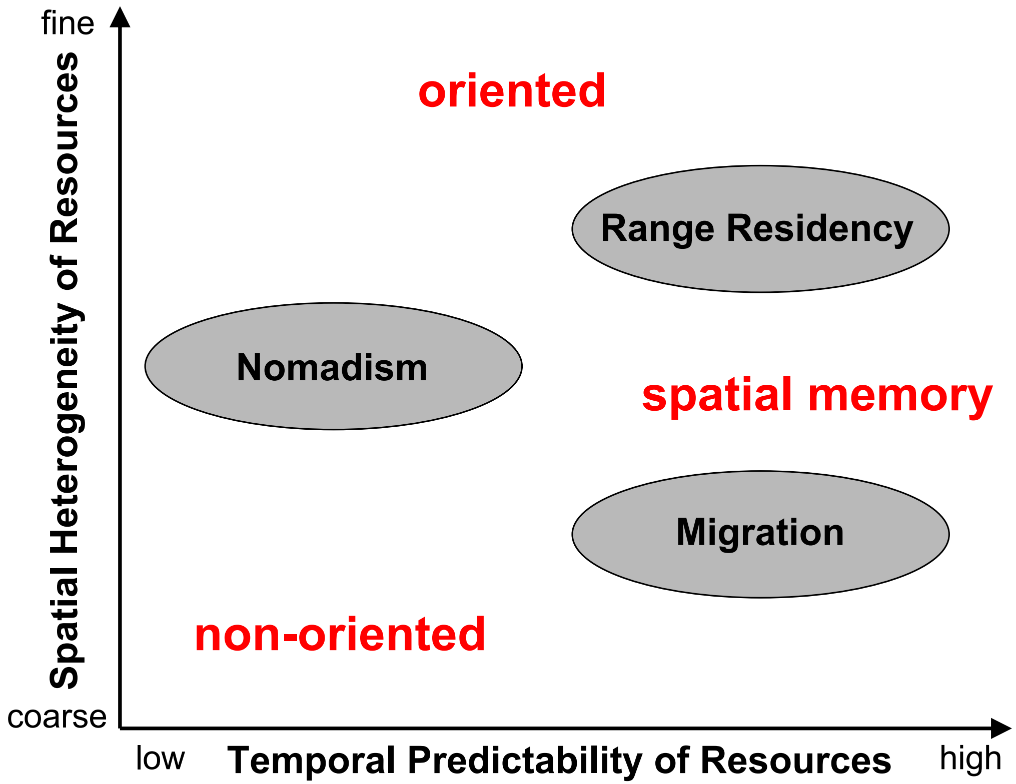
Resource landscapes and Population-level patterns



Resource landscapes and Individual movement



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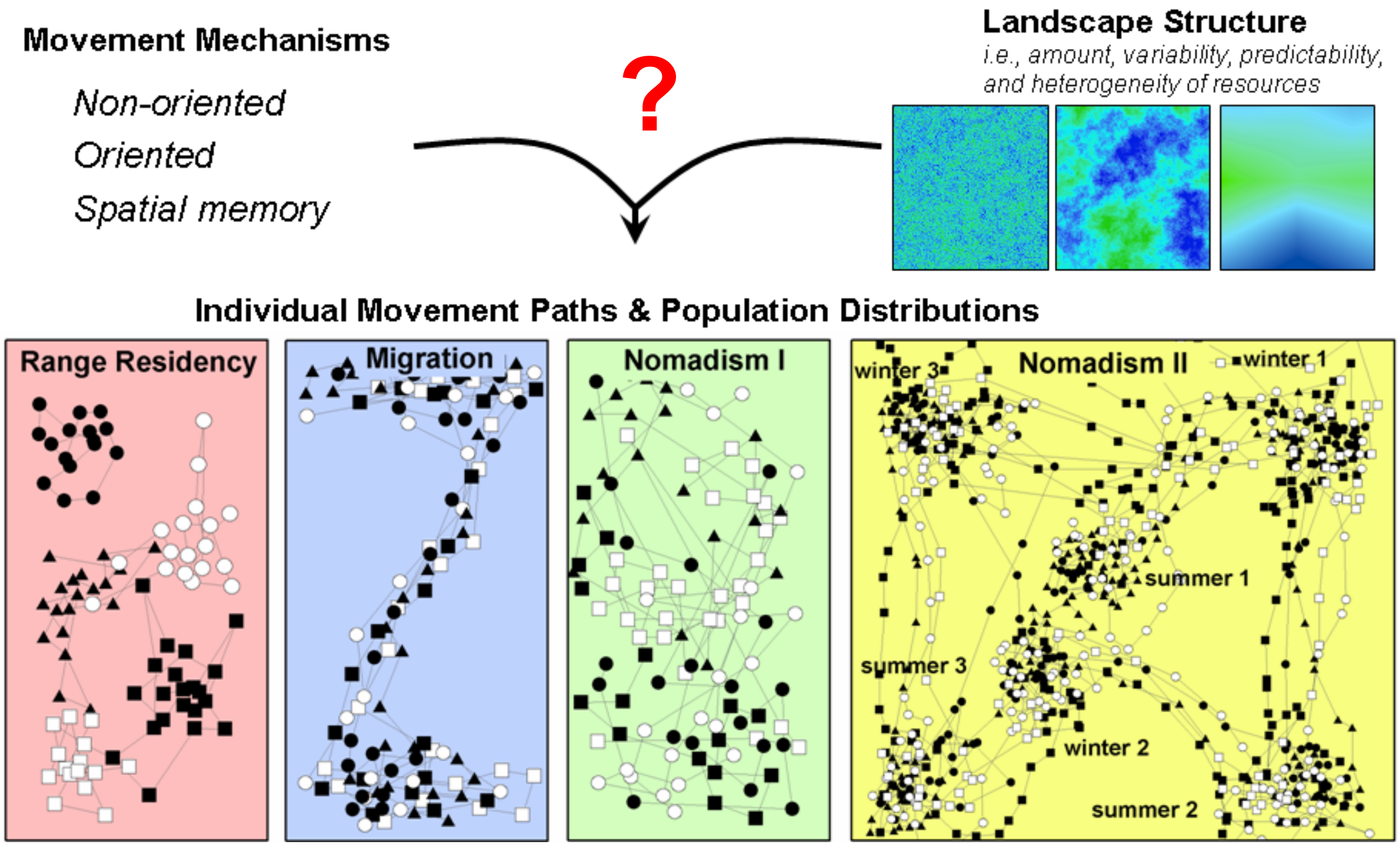
Part 3: Artificial life techniques to model movement



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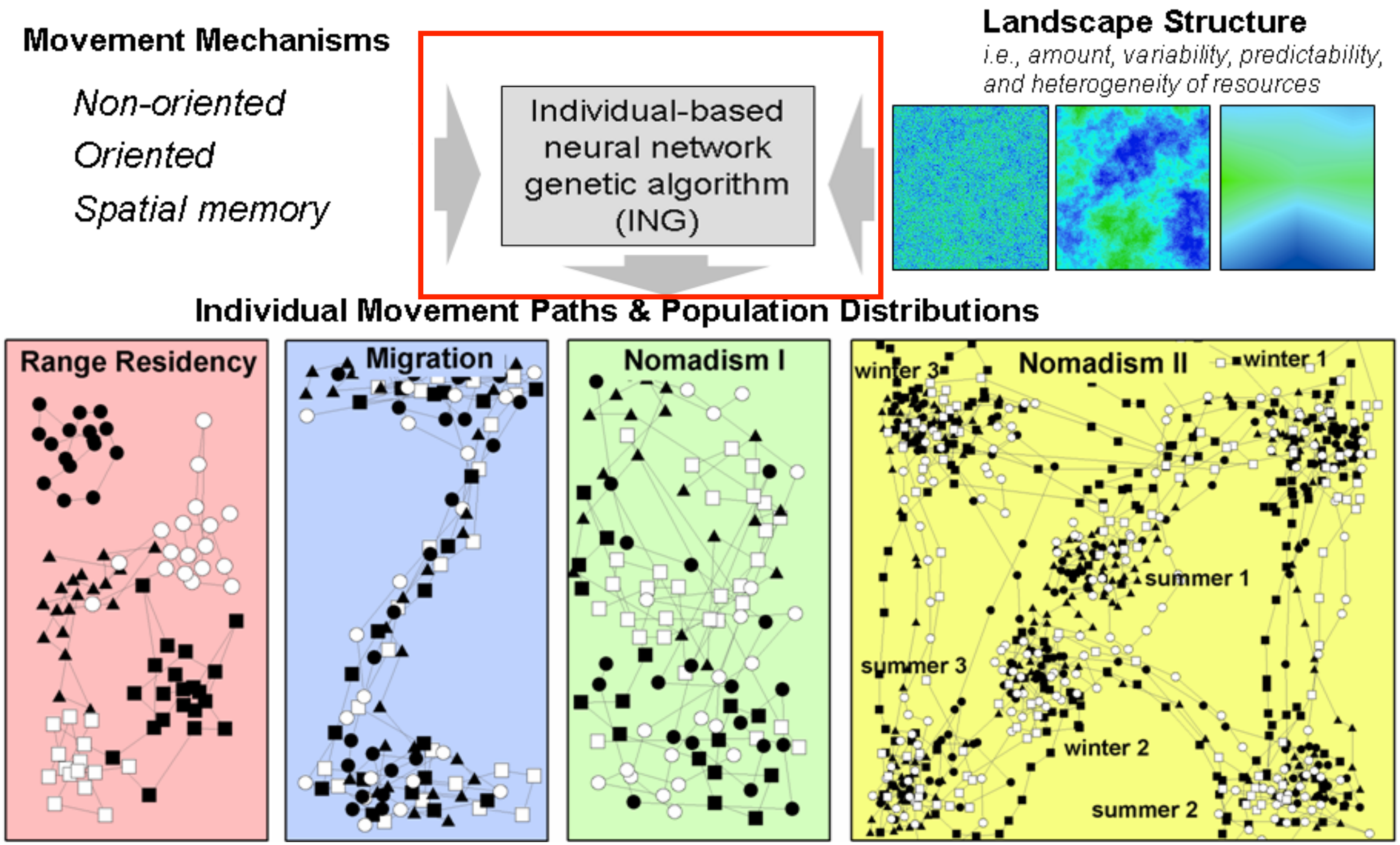
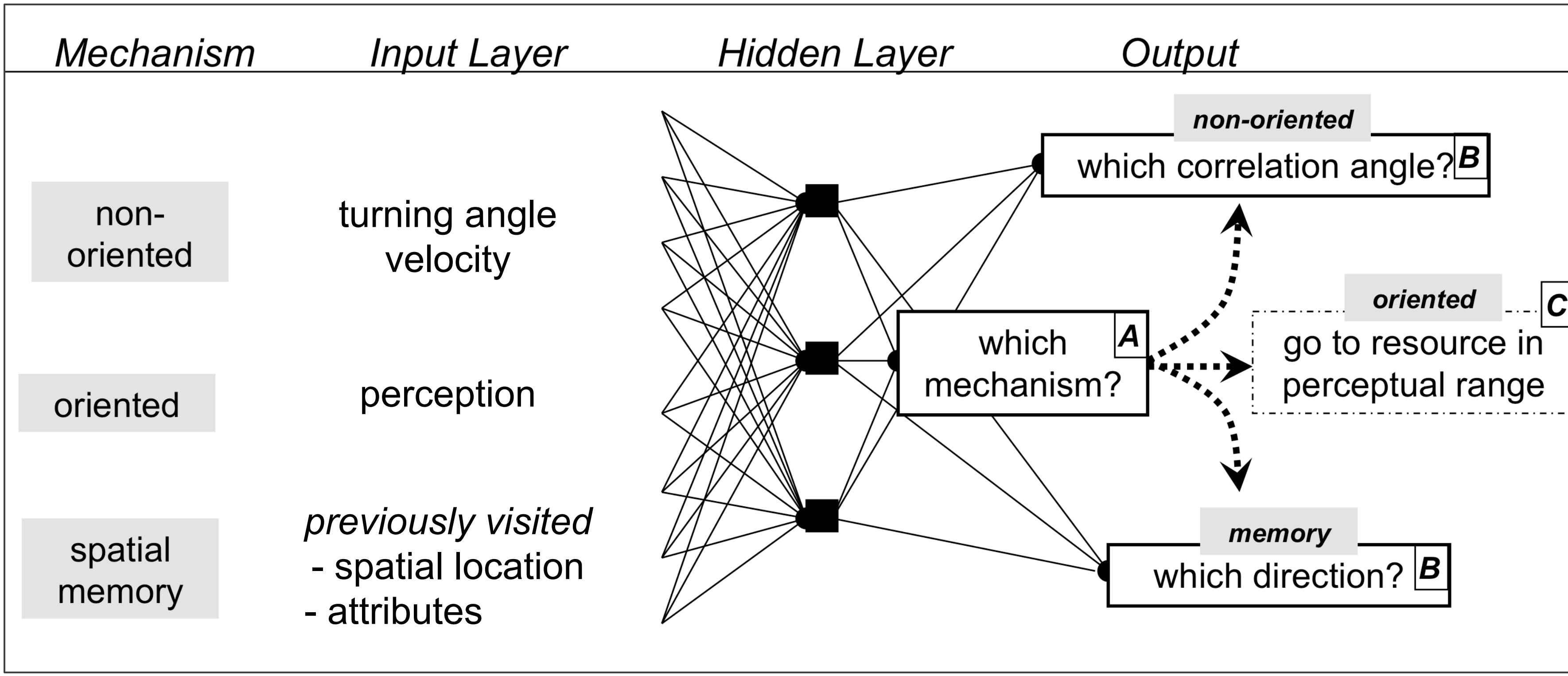


Individual-based Neural Net Genetic Algorithm (ING) Model



Mueller, Fagan & Grimm, Theoretical Ecology 2011

$$HiddenNode_j = \frac{\exp\left(\sum_{i=1}^{InputNodes} InputNode_i * weight_{ij}\right)}{1+\exp\left(\sum_{i=1}^{InputNodes} InputNode_i * weight_{ij}\right)}$$

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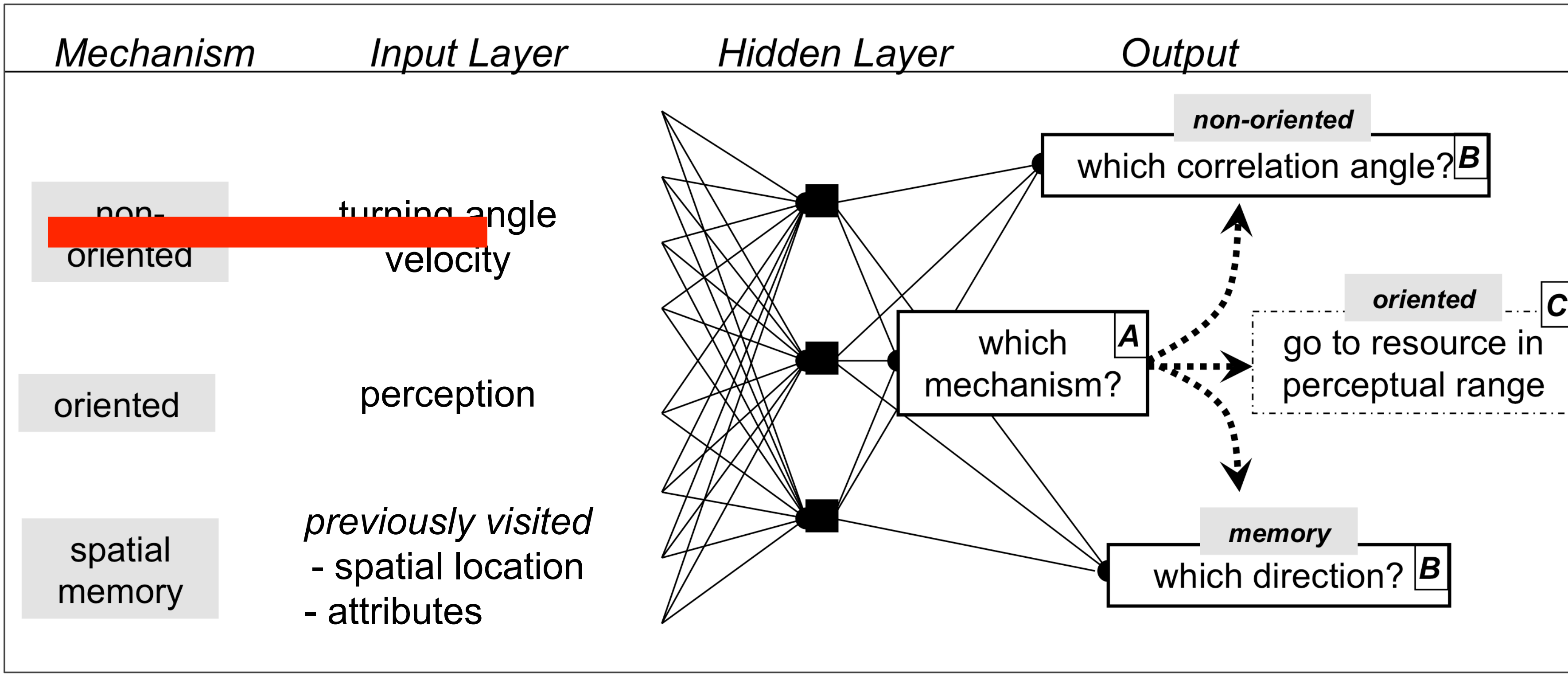

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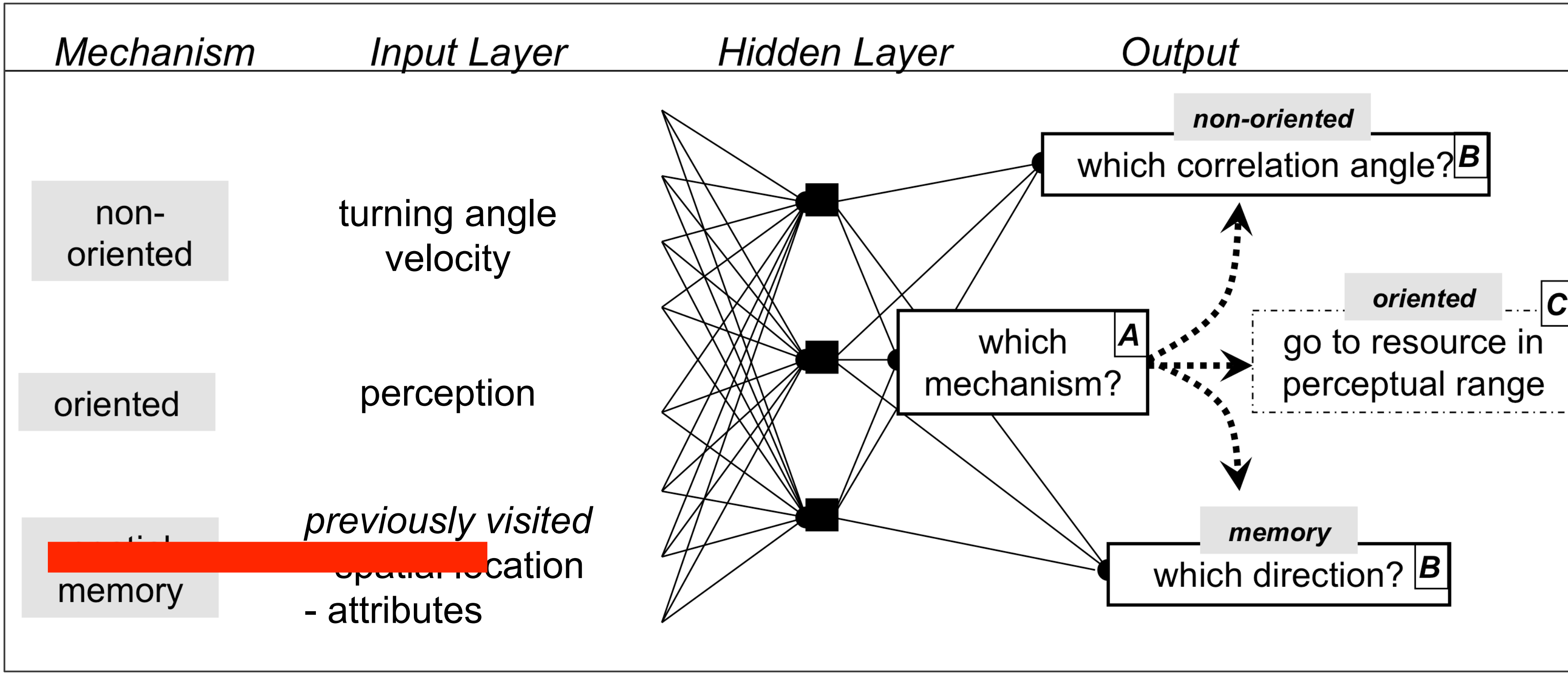

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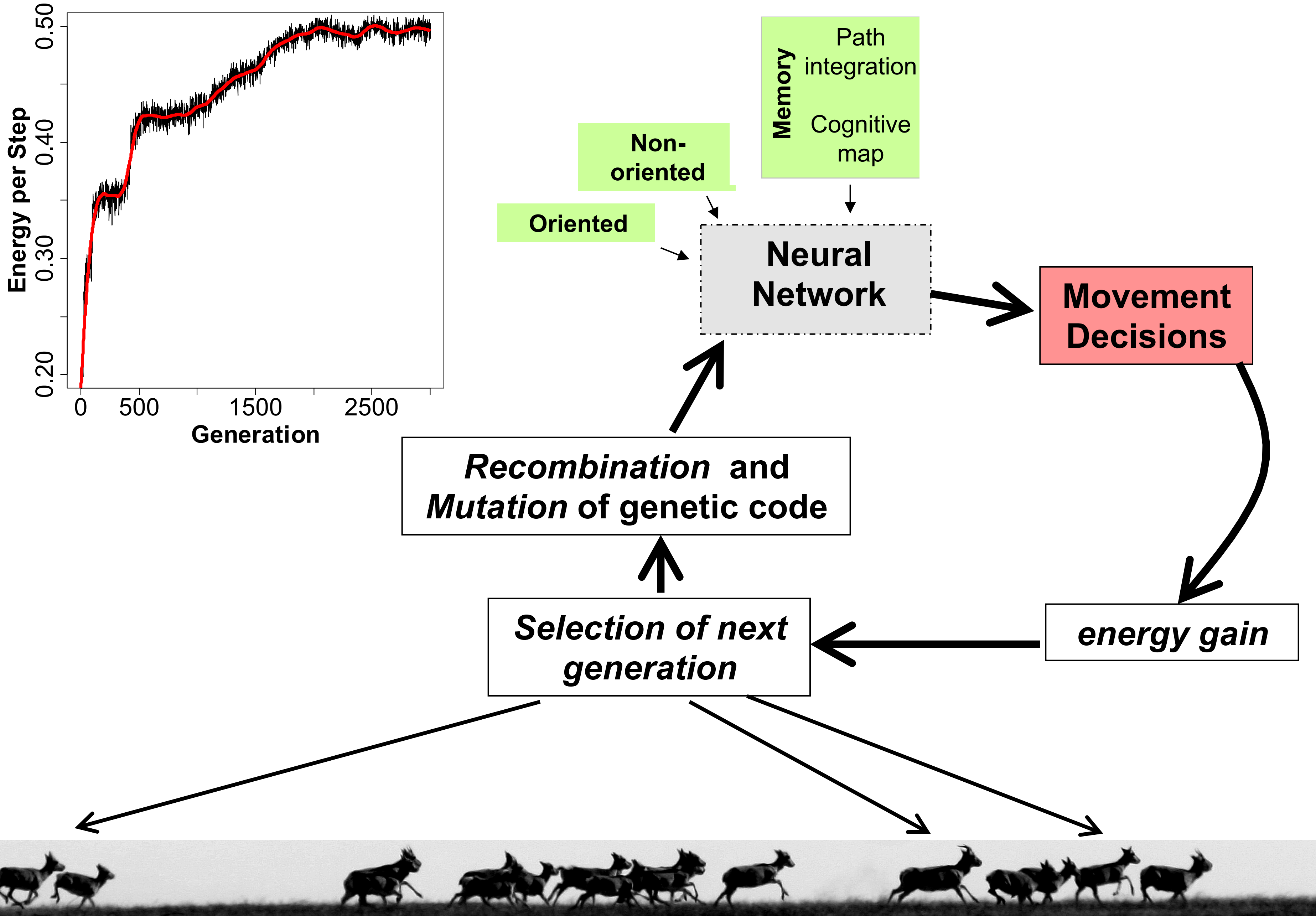
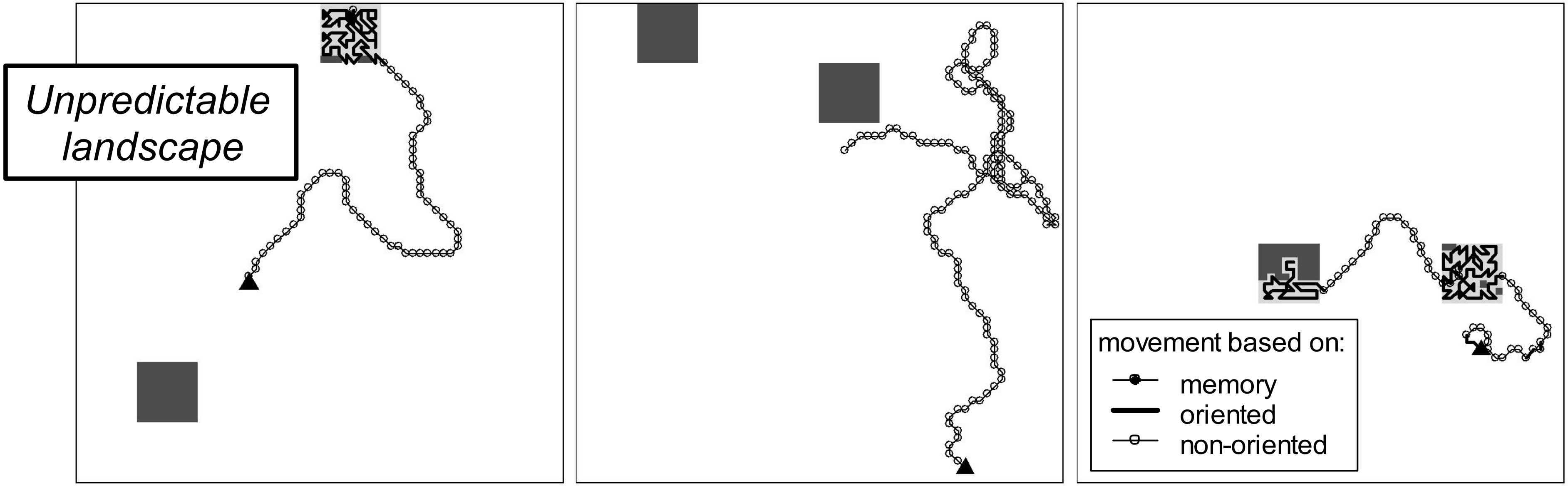
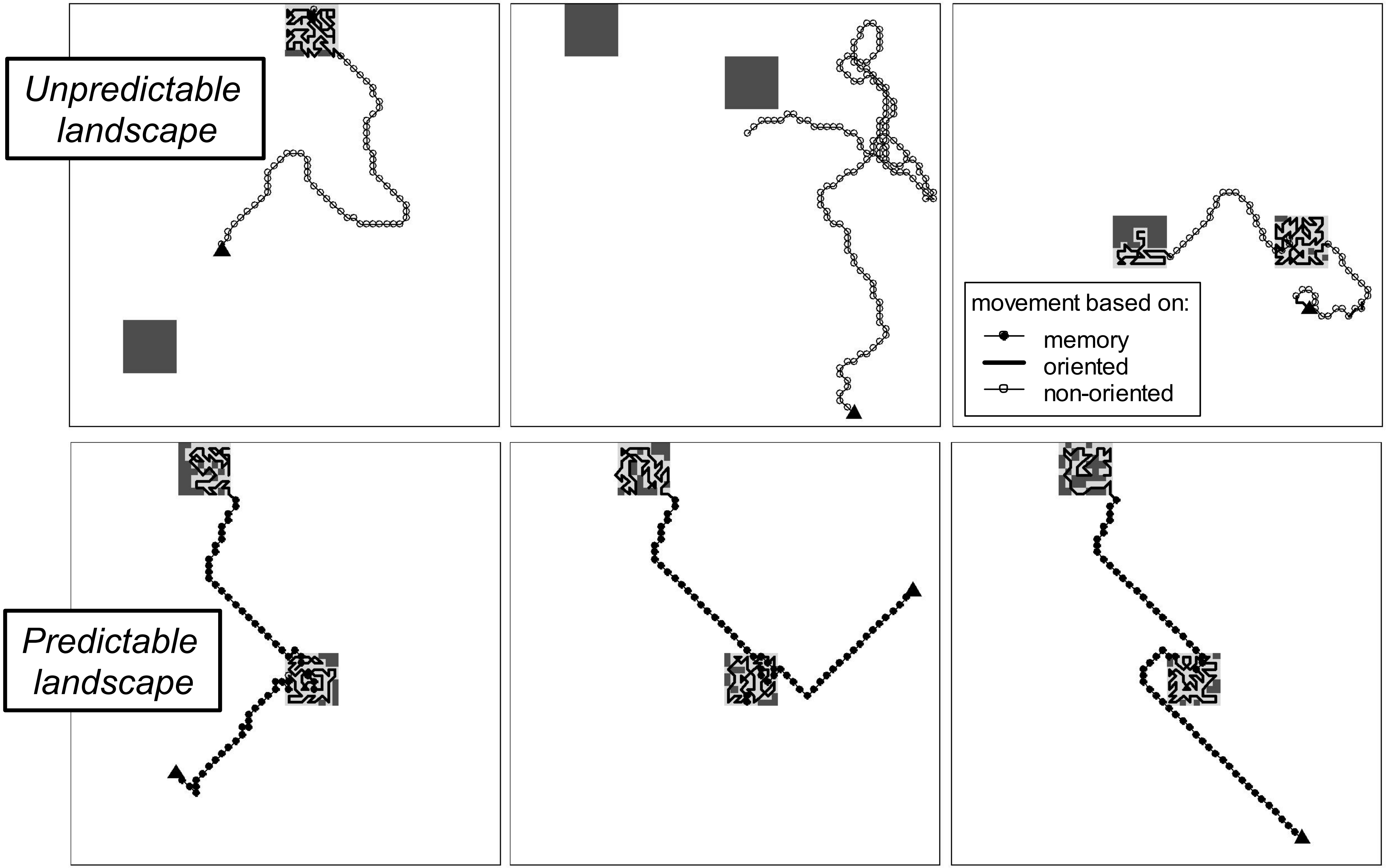
Individual-based neural network genetic algorithm





Unpredictable landscape
movement based on:
memory
oriented
non-oriented



Mueller et al., Theor. Ecol. 2011

Individual-based Neural Net Genetic Algorithm (ING) Model

Two key landscape features:

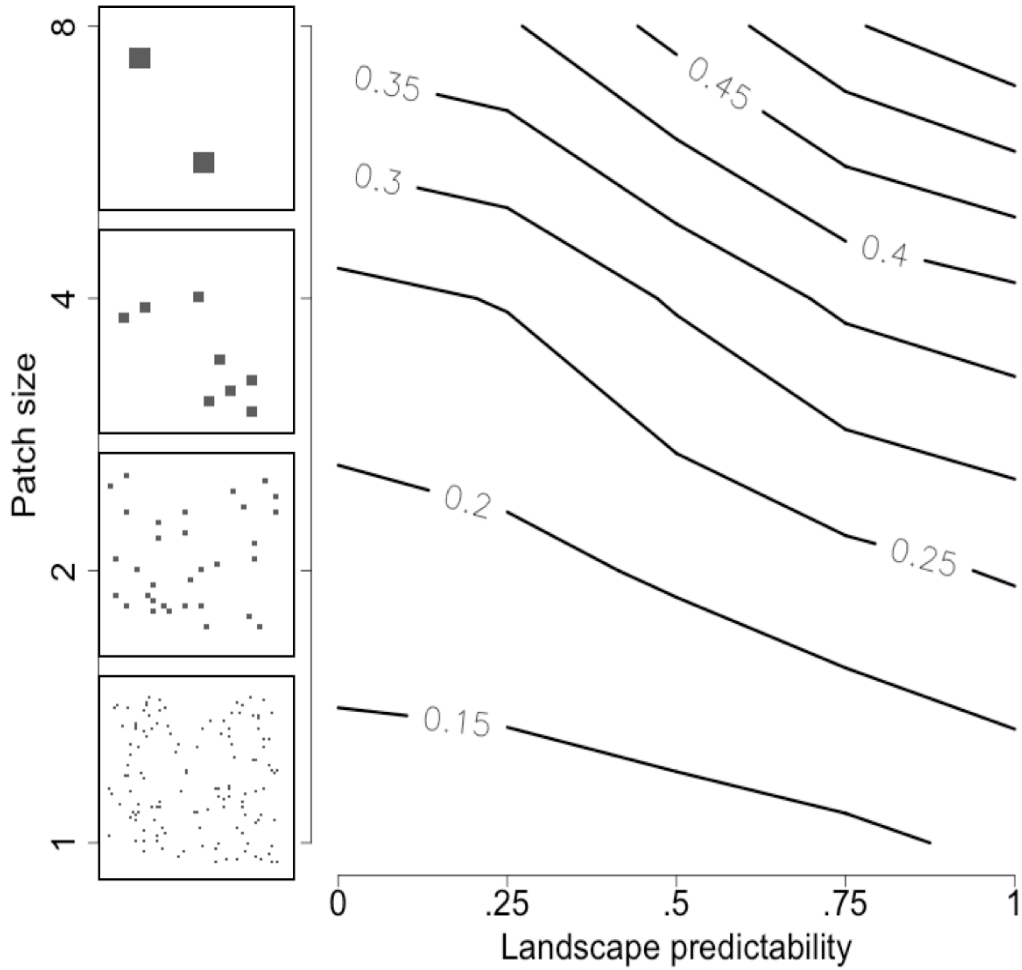
1) Patch Size
2) Resource Predictability

Foci:

1) Frequency
2) Context of use
3) “Relevance” of different movement mechanisms

$$\text{Relevance} = 1 - \left[\frac{\text{efficiency}_{\text{reduced network}}}{\text{efficiency}_{\text{full network}}}\right]$$

Efficiency is greatest in predictable landscapes with large patch sizes

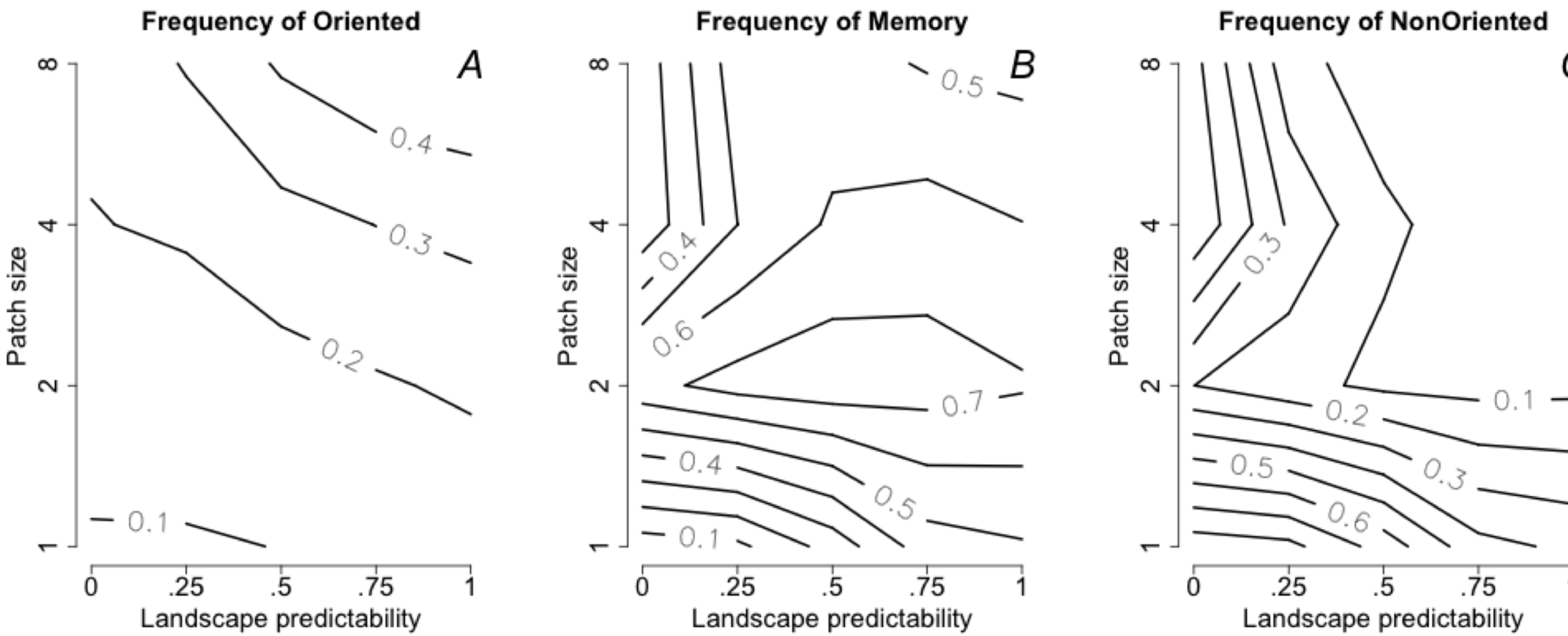


Contours are efficiency of movement

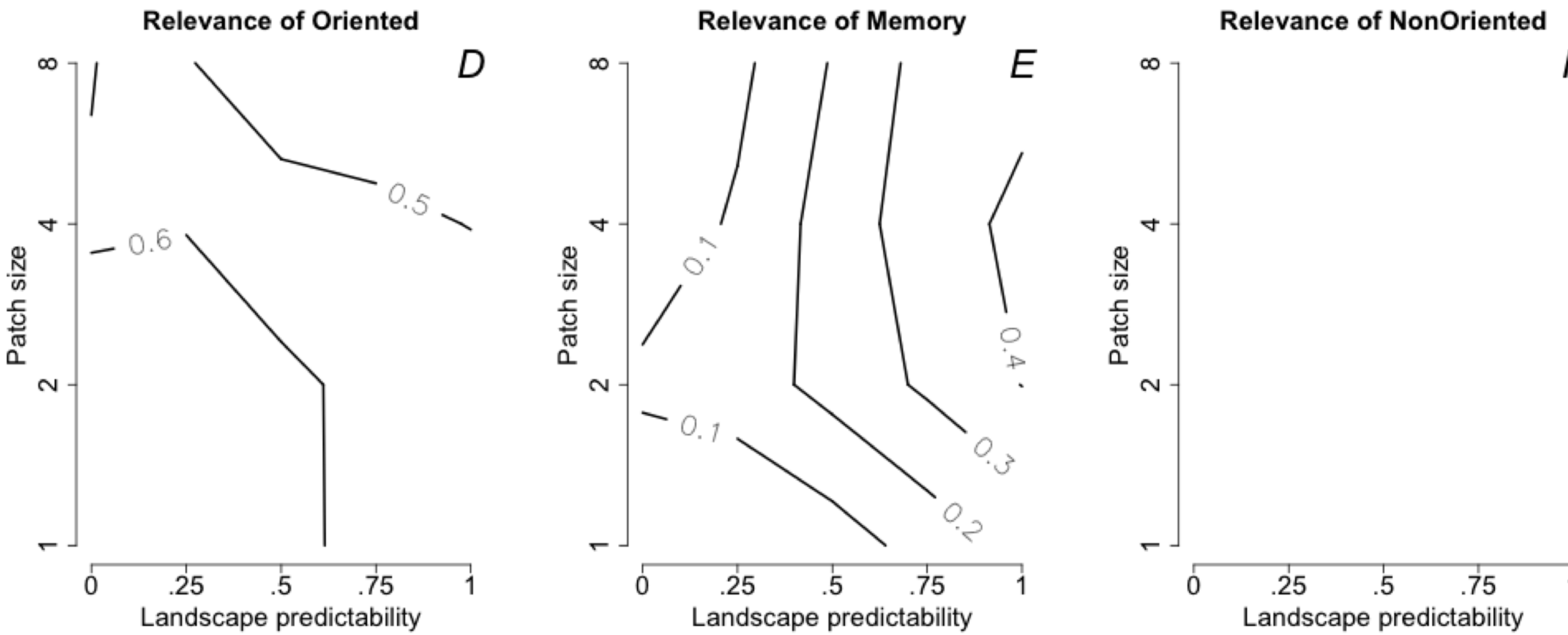
(Avg. resources per movement step)

Mueller, Fagan, & Grimm. Theoretical Ecology. 2011.

Frequency of behaviors

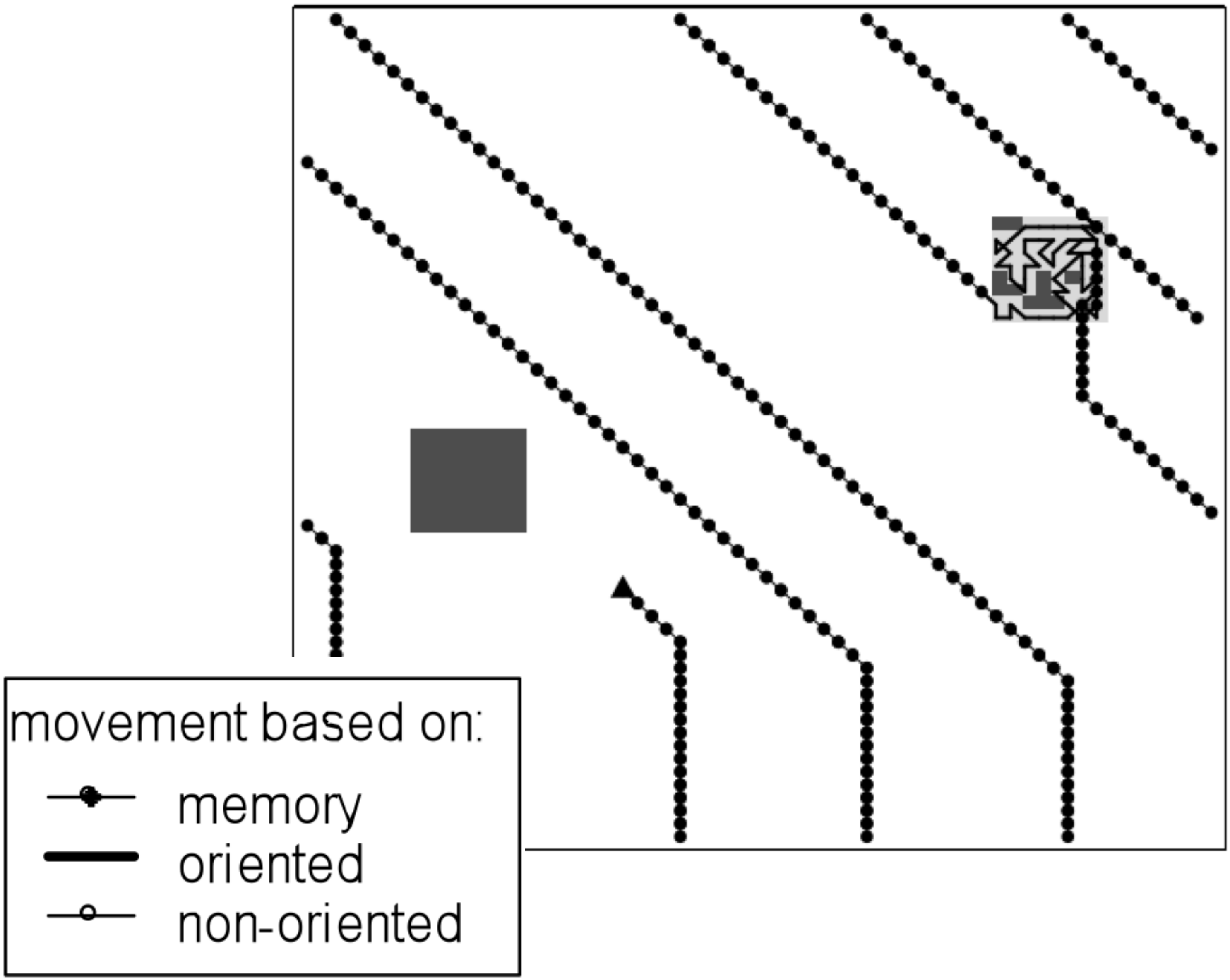


Relevance of behaviors



$$\text{Relevance} = 1 - \left[\frac{efficiency_{reduced\ network}}{efficiency_{full\ network}} \right]$$

Unpredictable landscapes (no non-oriented)



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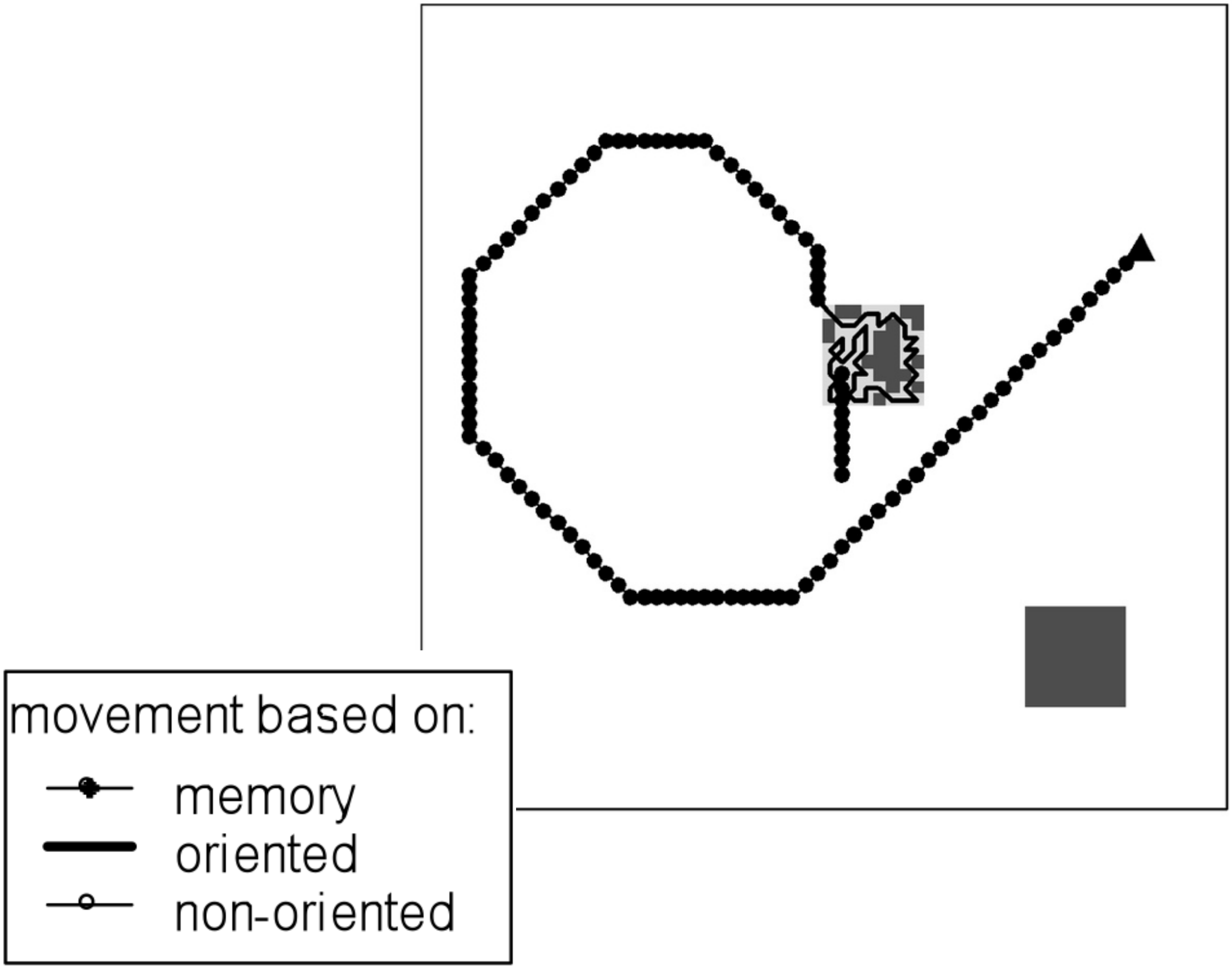

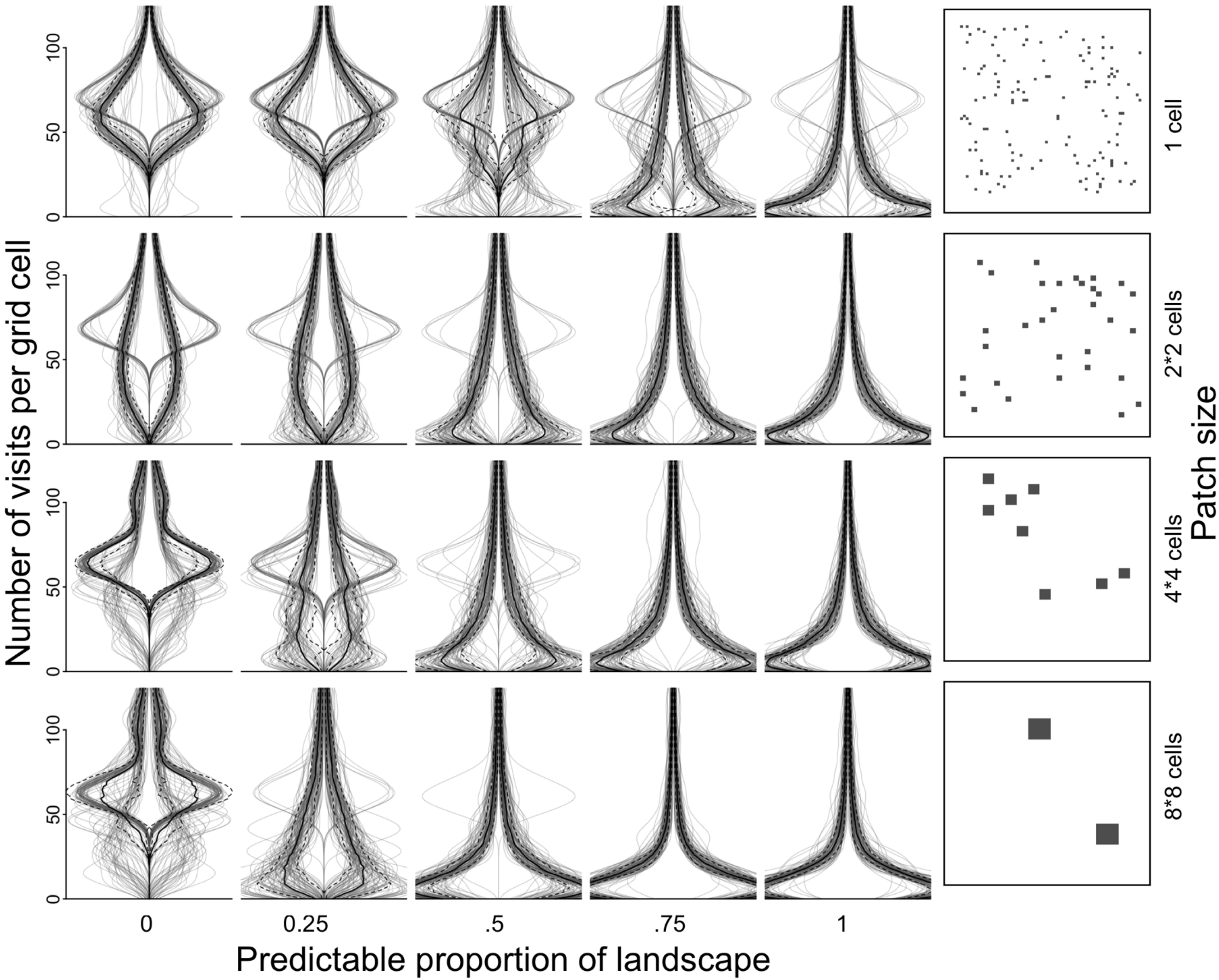
Number of visits per grid cell
0
50
100
1 cell
2*2 cells
4*4 cells
8*8 cells
Patch size
0
0.25
.5
.75
1
Predictable proportion of landscape

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Collaborators

William F. Fagan (University of Maryland, USA)
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Kirk Olson (Smithsonian,USA)
Justin Calabrese (Smithsonian, USA)
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Petra Kaczensky (Vet. U. Vienna, Austria)
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George Schaller (Panthera, USA)
David Wattles (Univ. Mass., USGS)
Steven DeStefano (Univ. Mass., USGS)
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Craig Nicolson (Univ. Mass.)
Andres Novaro (Argentine Research Council)

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