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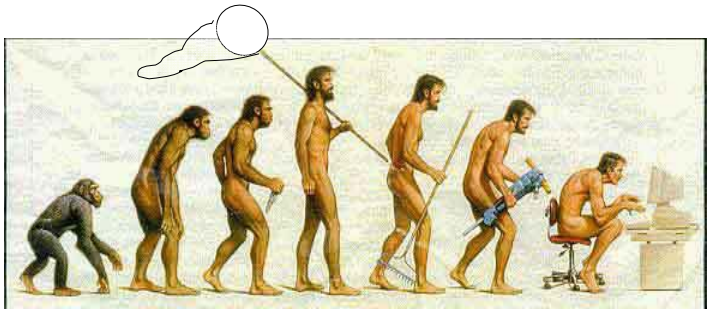
Linking Individual-based models with observed animal behaviour



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Helmholtz Centre for Environmental Research – UFZ, Leipzig
Department of Ecological Modeling

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Overview

- Why link models and empirical data - and how?
- The basis: a simple model of hilltopping behaviour
- Testing the model to predict patterns
- What do we do in the case of uncertainties?
- An example from another model
- Conclusions and tips

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Why link models and empirical data and how

- Ecological models can be used to **understand** or **predict** patterns
- To predict patterns requires identifying realistic parameter ranges
- Often: realism is associated with model complexity
- Can we combine generality and simplicity?
- Should we?

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A simple model on hilltopping

Hilltopping: "Where males and virgin or multiple-mating females seek a topographic summit to mate" (Shields 1967)

An Individual-based model

Spatially explicit

Assumption: Animals respond only to topography

For start: Males and virgin females move upward

Per-step probability to take the steepest slope (q = 0-1)

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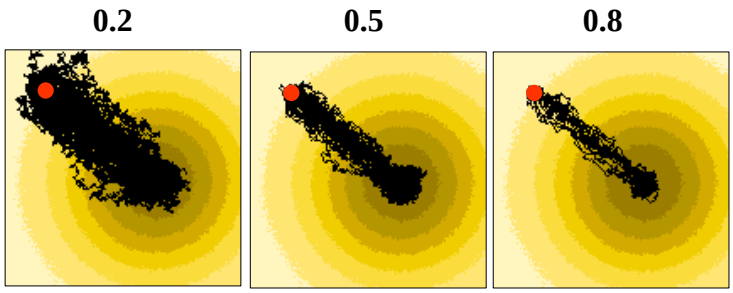
Simulation results

Some representative paths

50 individuals, 1000 movement-steps each



➔ Virtual corridors are formed (Pe'er, Saltz and Frank 2005)

➔ Slight response to topography is sufficient for their formation (Pe'er, Heinz & Frank 2006)

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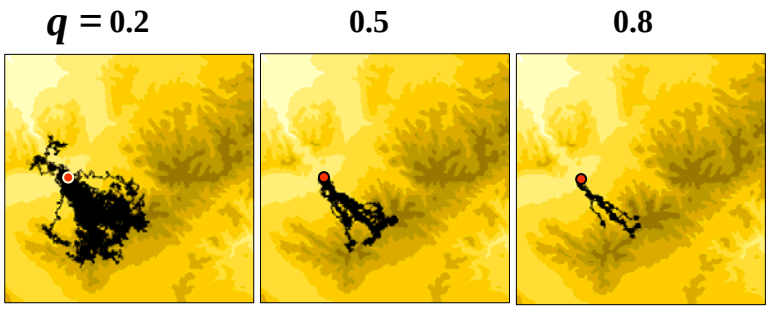

➔ The structure of Virtual Corridors may be complex and unintuitive

But what are the biologically-realistic parameter values?

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A simple conversion:

- For q = 1: real individuals should move upward 100% of time
- For q = 0: real individuals should move upward 50% of time

Therefore

$$q_{model} = q_{observed} \cdot 2 - 1$$

In reality:

males moved 0.77 of time upward ➔ q_{model} = 0.54
virgin females = 0.82 of time upward ➔ q_{model} = 0.64 (Pe'er et al. 2004)

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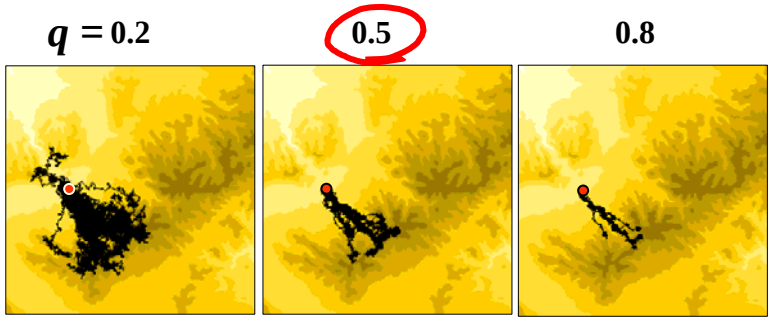
Take back into simulated patterns:



➔ The structure of Virtual Corridors may be complex and unintuitive
especially for biologically-realistic parameter values!

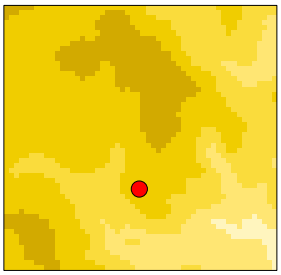
➔ **IBMs may be useful for predicting such complex patterns**

But can such a simple model do so?

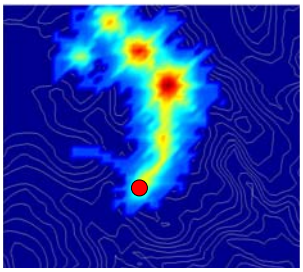
Field validation of the model

A release-recapture experiment

Realistic landscape map

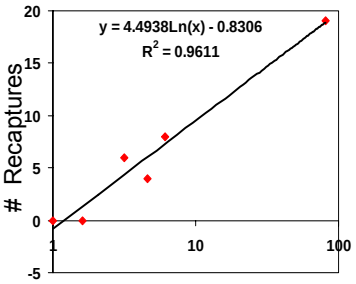


Model prediction



q = 0.9, p = 0.2, 100 inds.

Field validation



The pattern is neither distance-dependent nor simple

But it is still predictable using this simple IBM!

What do we do in the case of uncertainties?

We may know the behaviour of a species and be able to model it -

But many factors affecting animals' decisions remain are unknown.

For instance: we often don't know animals' **perceptual distance.**

Why should we care?

Animals may "perceive" some elements from large distances, by responding to spatial gradients associated with them, e.g. topography, habitat quality, pheromones, pollutants (chemicals, noise, light).

Therefore the perceptual range may affect connectivity patterns.

Does it ?

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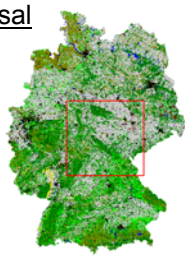
Altering an existing IBM for the Eurasian Lynx

An existing PVA:

- Individual-based
- Spatially-realistic
- Based on well-established knowledge
- Includes Population dynamics and Dispersal

Alteration of the original model: (Pe'er and Kramer-Schadt 2008)

Varying the perceptual range of animals during dispersal



Response to cities, rivers or local forest patches

With various values of

- perceptual range (0 - 3km) and
- intensity of response (probability = 0 - 1)

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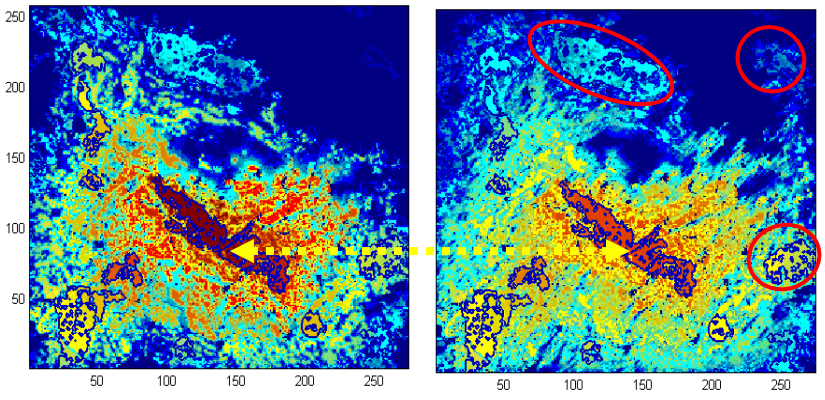
Results



Original model (no gradients)

Response to forests (0.9, 2000m)

Animals disperse more readily

Movement patterns and connectivity patterns are altered

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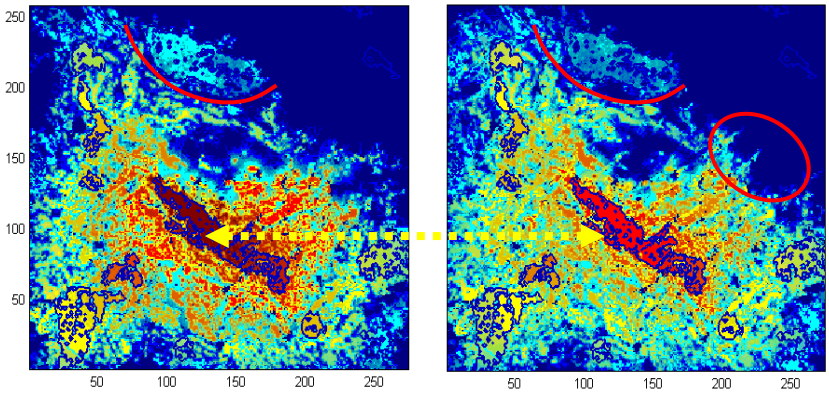

Original model (no gradients)

Response to rivers (0.9, 2000m)

Movements are often concentrated into specific routes

Barrier to the Harz is maintained by all models

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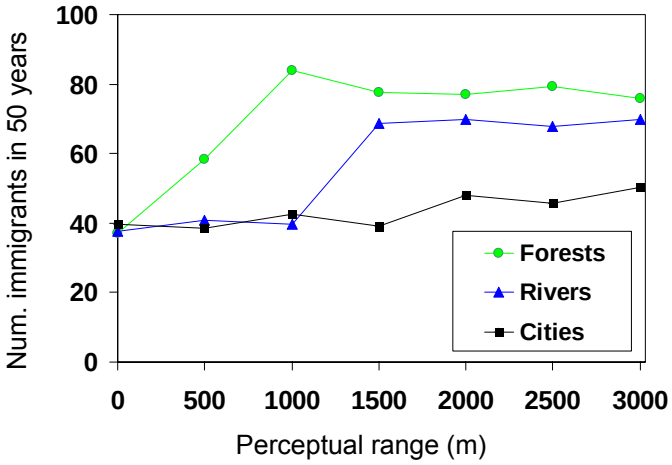
Results

Enhanced perceptual range can double immigration success!



Intensity of response = 0.9

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Conclusions

- Linking ecological models and empirical data does not necessary require complexity: try to grasp simple mechanisms
- Mimicking known ecological patterns can be used as first stage to understand new patterns emerging from models
- This interaction between model and reality can enhance
- Thinking (e.g. recognizing virtual corridors and importance of gradients)
- Directing field-work (e.g. planning field experiments on hilltopping; pinpointing the need to study perceptual ranges)
- The development of decision-support tools (e.g. recognizing dispersal barriers despite uncertainty).

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Tips?

- Before you start modelling, make sure you know THE QUESTION.
- Don't try to mimic nature – try to identify simple mechanisms (perhaps: think as an animal?)
- Ask yourself: what field-data **exists**, **might exist**, or is unlikely to become available in the near future. The first can be used for parameterization; the second for validation; and guessing is where you can really gain from a good model!
- Plan ahead: what field-tests would allow you to differentiate between models (= scenarios) or parameters?

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Tips?

- Bear in mind: models allow you to play with "would-be" cases and are perhaps the best tool to deal with β errors!

Reject H_0?	Yes (model)	No (model)
True (reality)	Correct	β (Type-2 error)
False (reality)	α (Type-1 error)	Correct

- Think of the biological meaning of your parameters: use what you have, or think how to ensure that you CAN extract them.

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Thank you!

Hilltopping model (PhD):

Supervisors: David Saltz, Uzi Motro
Cooperation: Karin Frank, Hans-Hermann Thulke, Simone Heinz.

Funding: Ben-Gurion Uni. of the Negev, Marie-Curie, Mitrani Grant-In-Aid of Research.

Modelling Lynx dispersal:

cooperation with Stephanie Kramer-Schadt.

Funding: Dept. of Ecological Modelling (Visiting Scientist)

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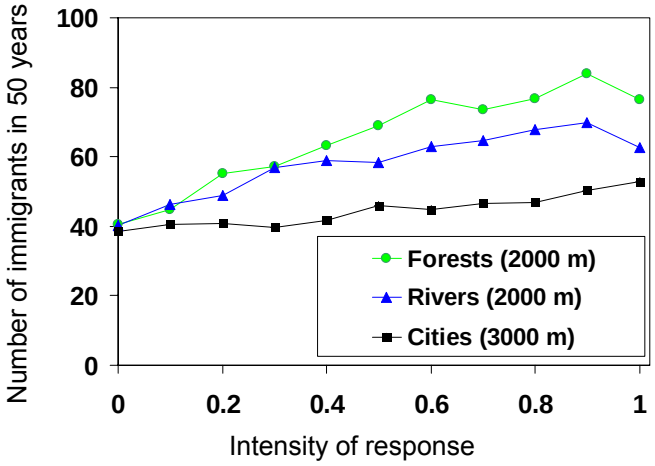

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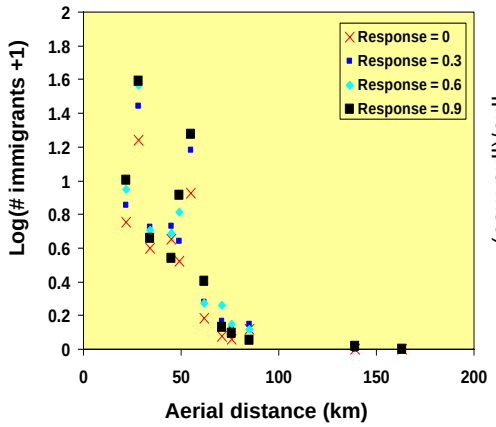
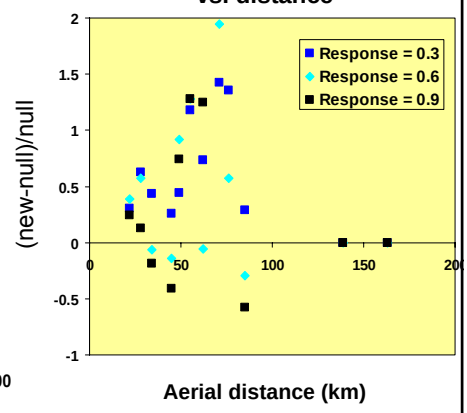
Results

No directionality in terms of impact on distance-dependence

Immigrants vs. distance from origin



Deviation from 'null model' vs. distance



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