ANIMAL SPACE USE

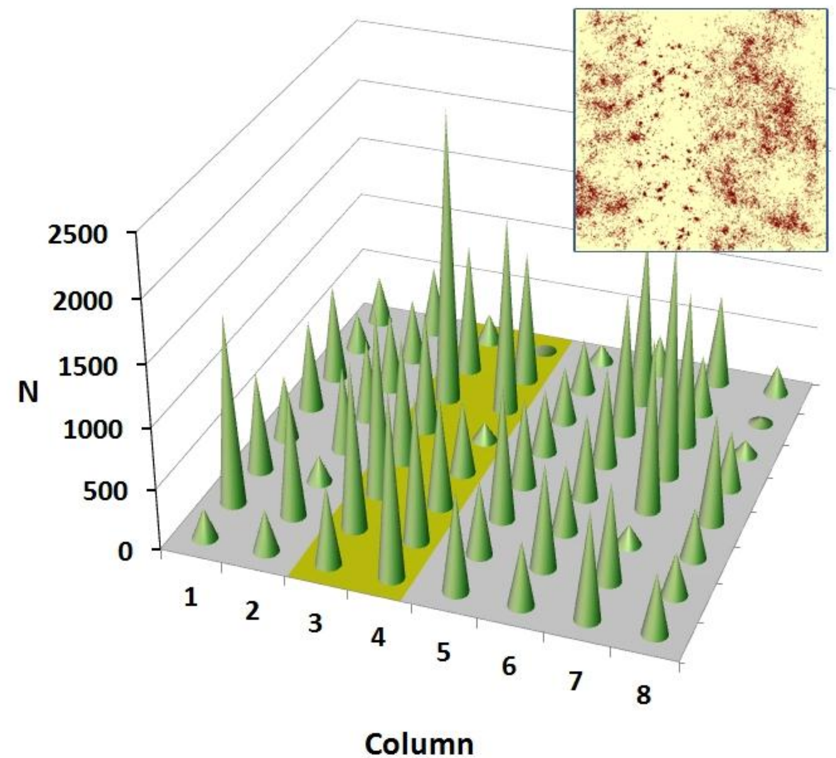
Memory Effects, Scaling complexity, and Biophysical Model Coherence

By Arild O. Gautestad

Drilling to the core of animal ecology

Predicting individual space use and population dispersion

- Spatial memory effects and multi-scaled habitat use complicates dynamical modelling and statistical analysis
- Some preference for familiar sites may invoke self-reinforcing patch use
- Standard approaches to estimate local strength of habitat selection may produce confusing results.

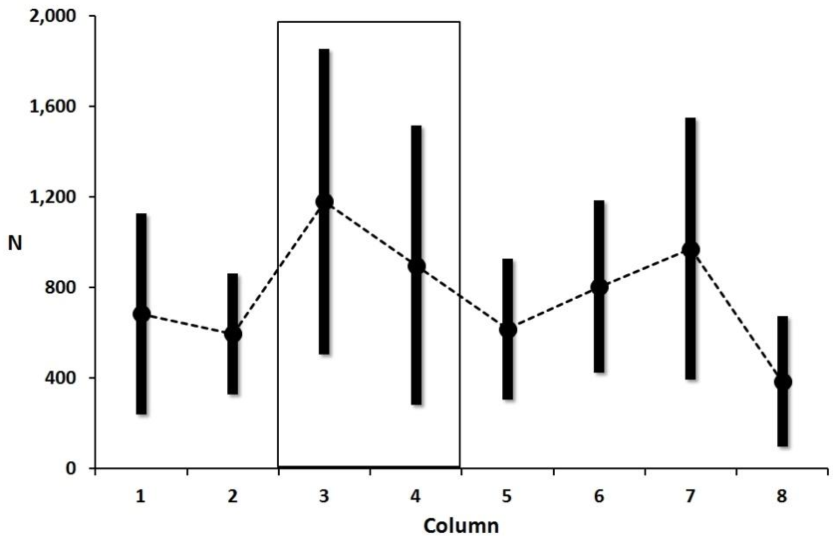


Simulation: spatial dispersion of 100 individuals, repeatedly relocated over a period of time.

Simulation of complex space use

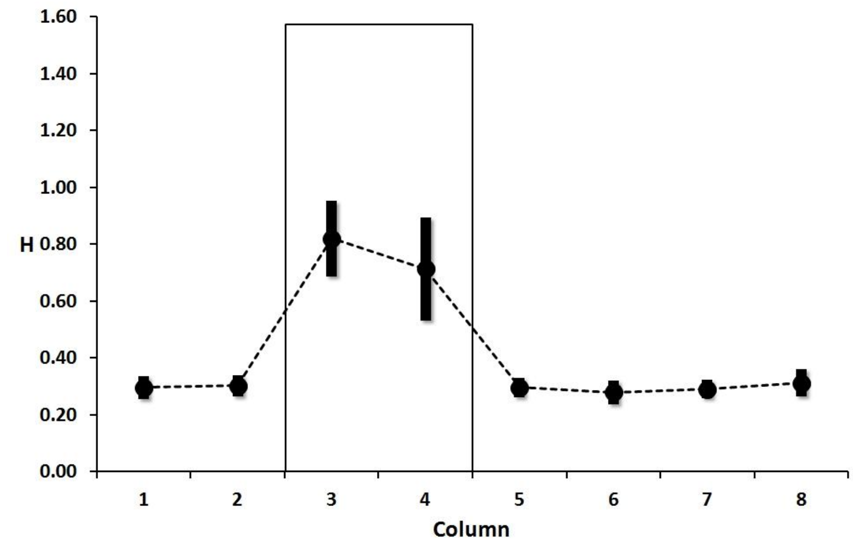
Classical analysis

Habitat selection strength based on density of spatial relocations:



Alternative analysis

Habitat selection stength based on the alternative H-index:



With reference to the 3D image, see *previous page*: local density (N) of fixes varies spatially owing to a mixture of influence from environmental conditions, multi-scaled movement and site fidelity. **A statistical model** that is derived from a process framework which implements this complexity provides parameters with high predictive power.
In this example the best habitat was correctly verified in column 3 and 4 (*right*). The traditional index for selection strength performed poorly (*left*). Vertical bars: +/- 1 standard deviation.

Looking for an alternative direction

- *”Out-of-the-box thinking may be required to capture realistically the kind of system complexity that emerges from the combined effect from memory map utilization, multi-scaled cognition and environmental conditions.”*

Multi-scaled space use

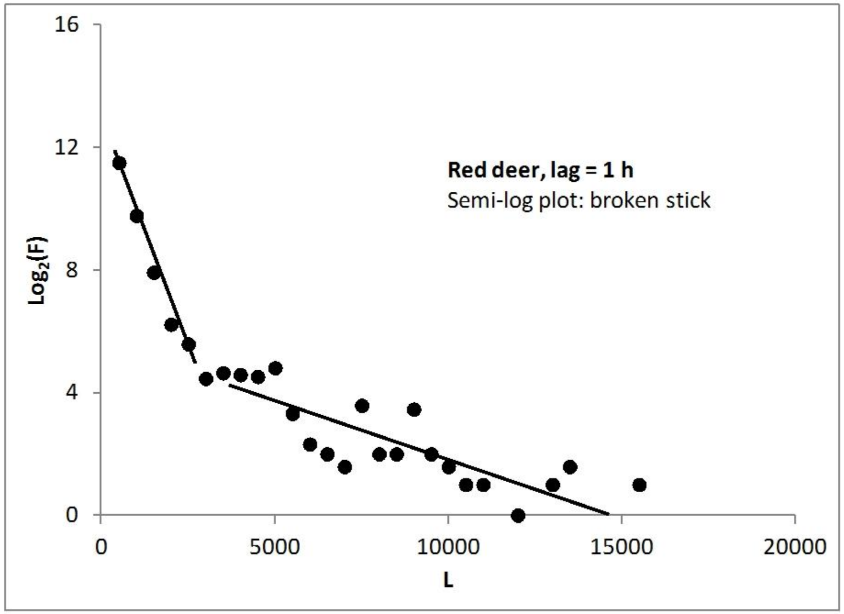
from concept to dynamic models

Standard interpretation:

composite Brownian motion

• Step length distribution from GPS relocations shows double-Poisson ”broken stick” in a semi-log presentation (upper pane)

• Model assumption: Mechanistic mixture of separate periods with ”intensive” (intra-patch) and ”extensive” (inter-patch) movement

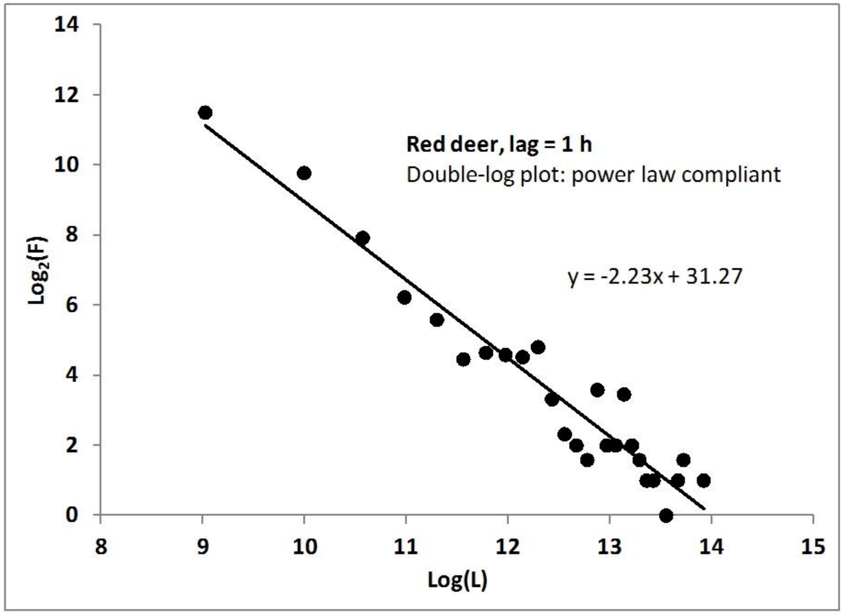


Alternative interpretation:

scale-free movement

• Step length distribution is power law compliant with linear slope in a log-log presentation (lower pane, *same data*)

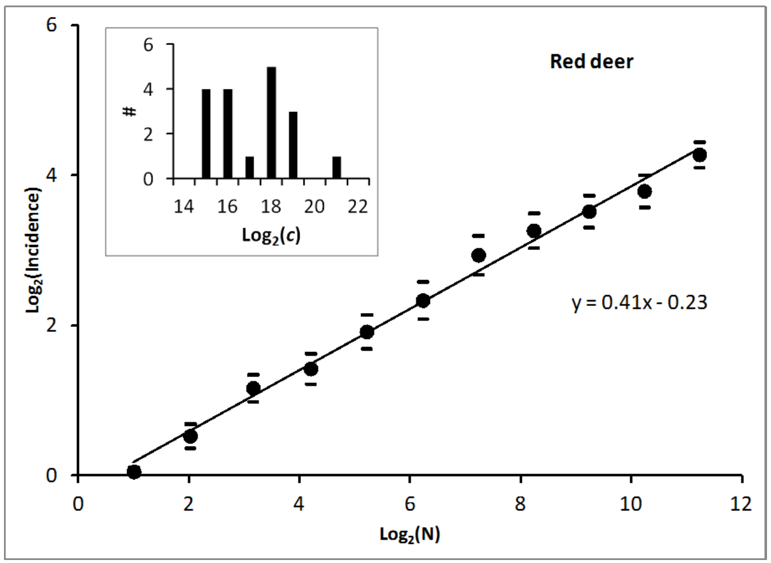
• Model assumption: The Parallel processing postulate – simultaneous execution of movement-influencing goals over a range of temporal scales.



METHODS ARE NOW AVAILABLE TO TEST THE ALTERNATIVE MODEL (non-mechanistic dynamics) AGAINST THE MECHANISTIC COUNTERPARTS.

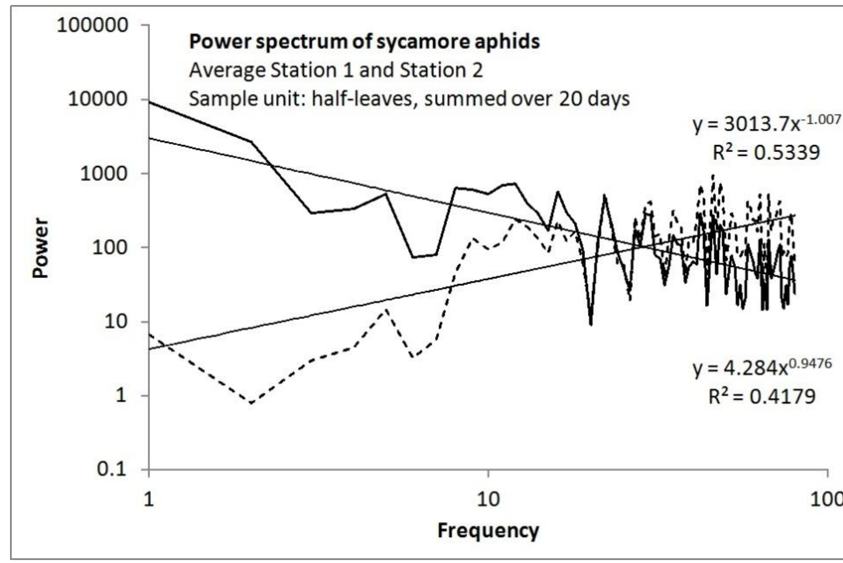
Implications: resolving paradoxes

Individual level: resolving the home range ghost paradox



Non-asymptotic, power law expansion of home range size as a function of sample size of GPS relocations

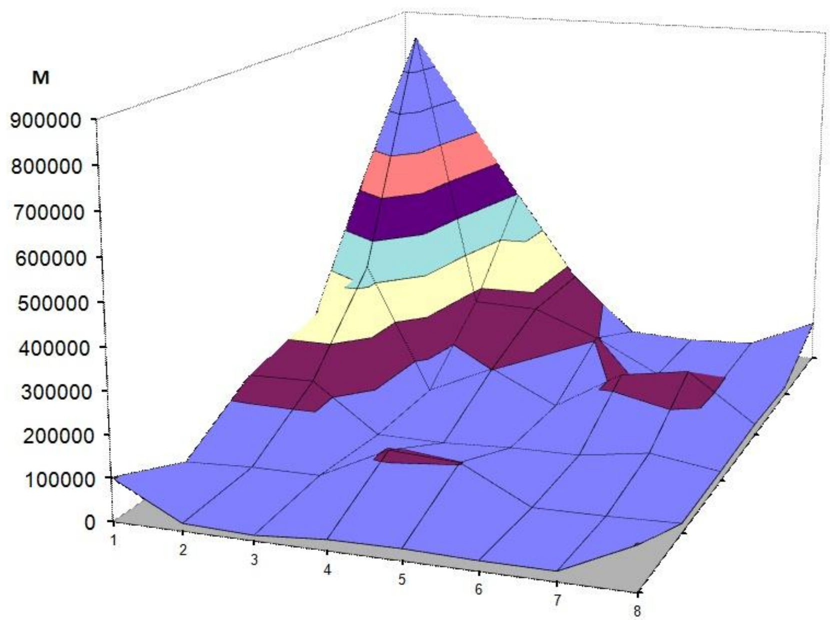
Population level: resolving the Z-paradox

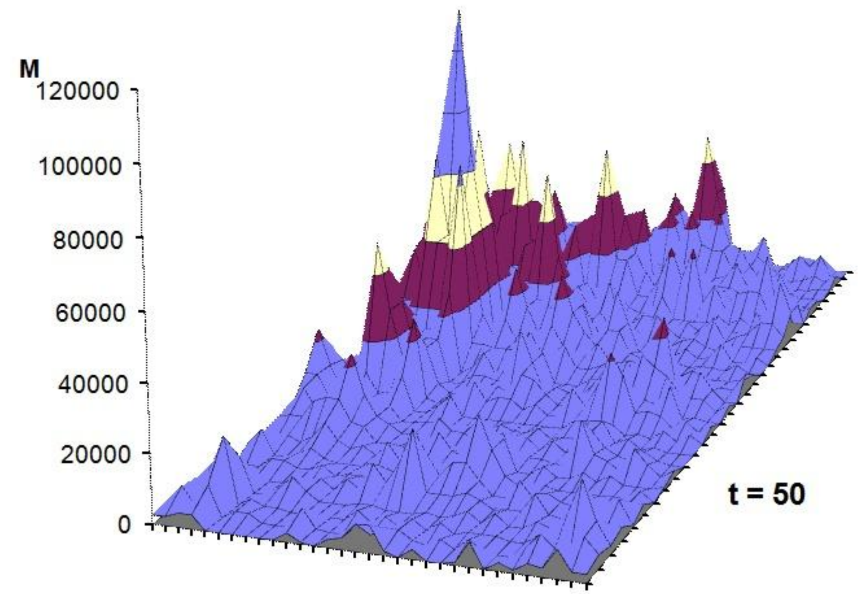


√ of Variance of population abundance changing proportionally with scale: V=aM^2 ; power spectrogram showing 1/f noise

Population-level simulation

The Zoomer model: parallel processing-compliant space use





Intraspecific cohesion (conspecific attraction)

Intraspecific cohesion with local crowding avoidance

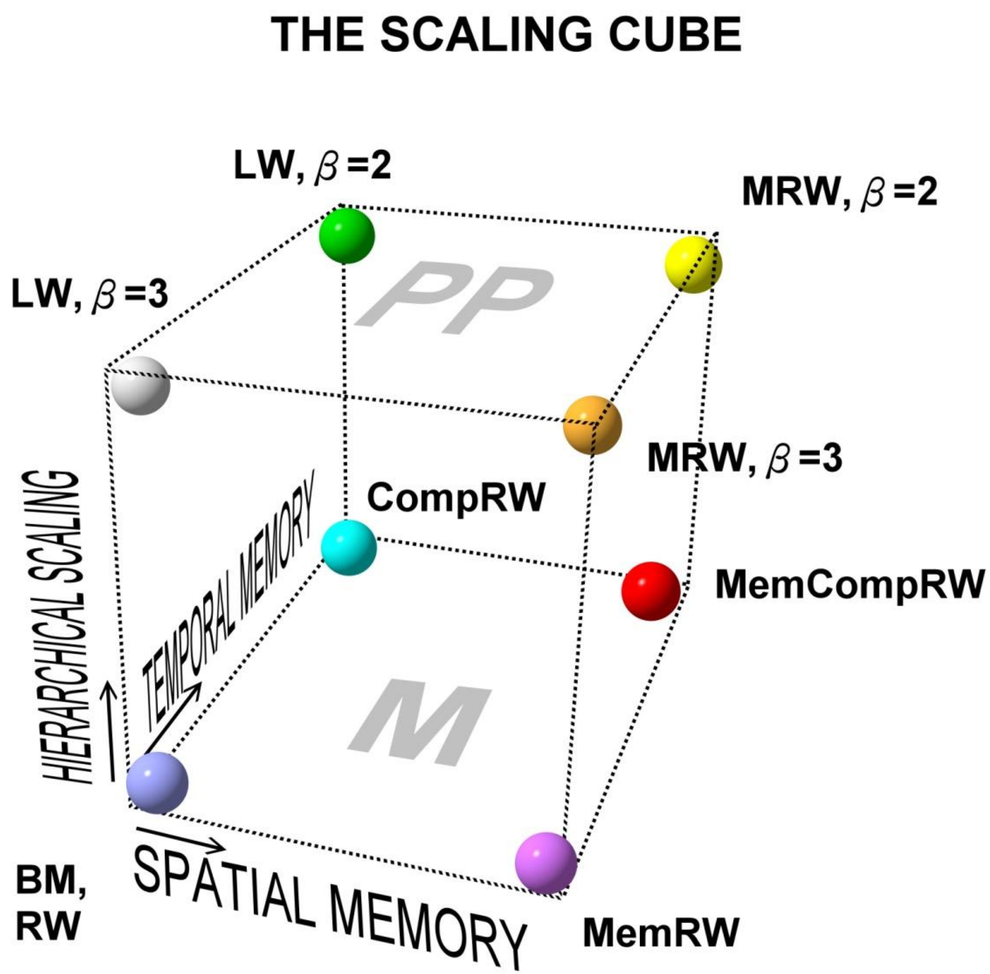
Statistical-mechanical representation of animal movement and population kinetics

• System decomposition into three dimensions: spatial memory, temporal memory and hierarchical scaling (parallel processing)

• Classical random walk (Brownian motion, correlated random walk) is found in the lower left corner

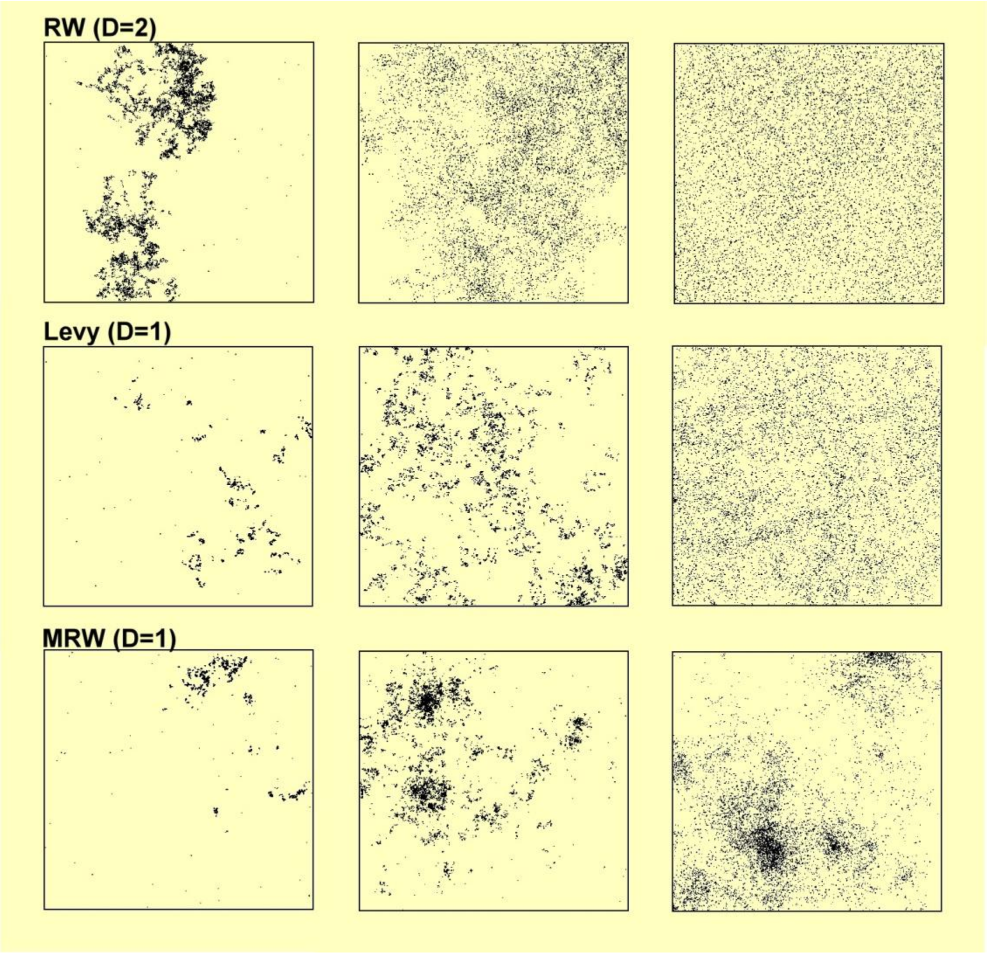
• Scale-free Lévy walk is found in two variants: the mechanistic ”look-alike” (composite random walk; CompRW) and the parallel processing variant (LW).

• Statistical-mechanical models with spatial memory (site fidelity) are found in four variants on the right-hand ”wall”.



The biophysics of movement

Scrutinizing standard assumptions and explaining an alternative framework



Targeting a broad range of readers

- More than three times as many figures as equations (108 figures; 31 equations)
- Target audience: biologists and physicists with interest in studies on animal space use and population dynamics
- Particular field of relevance: modelling and statistical interpretation of individual space use, based on sets of GPS relocations.

ANIMAL SPACE USE has been selected for the Dog Ear Publishing Award of Literary Excellence.

This is a highly scientific/technical book for a very select audience of scientists in the field of animal behavior. It's intelligent, well organized, and well written.

Reba Hilbert

Dog Ear Publishing Editor

Author and book presentation:

www.gautestad.com
www.thescalingcube.com
www.animalspaceuse.com

Email:
arild@gautestad.com