Modelling the urban environment through ecological eyes

Challenges of modelling nature

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Ecological Modelling and Systems Ecology

Using **mathematical** and **conceptual** modelling, **systems analysis**, **thermodynamics**, **computer simulations**, and **ecological theory** to understand **ecosystem functions,** describe **ecological processes** and inform the **sustainable management** of **resources**.
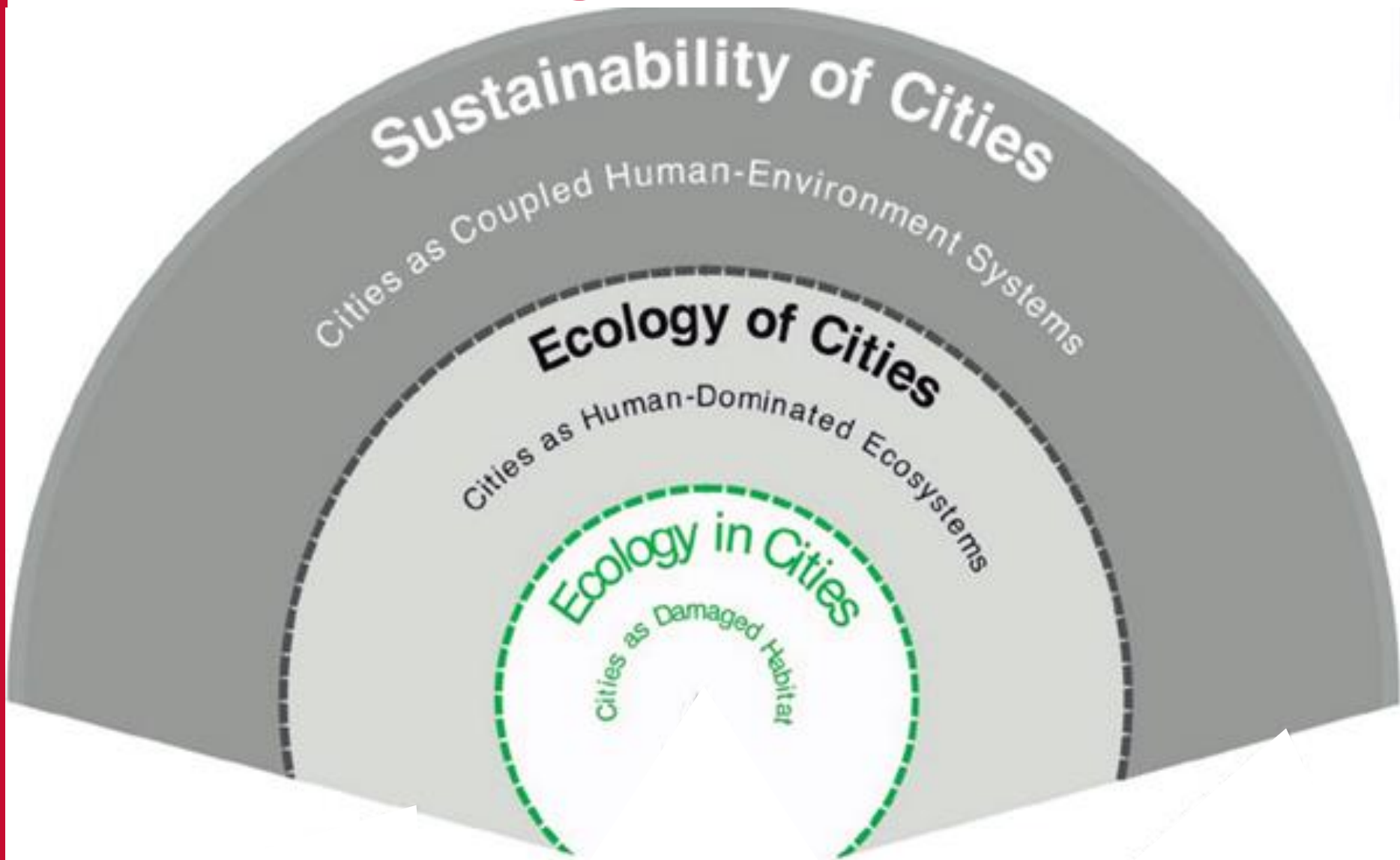
Process-based models embedded in theory with explicit causative agents as opposed to strictly statistical or correlative descriptions.

Modelling can be applied to a wide spectrum of issues ranging from basic ecology to human ecology to socio-ecological systems.
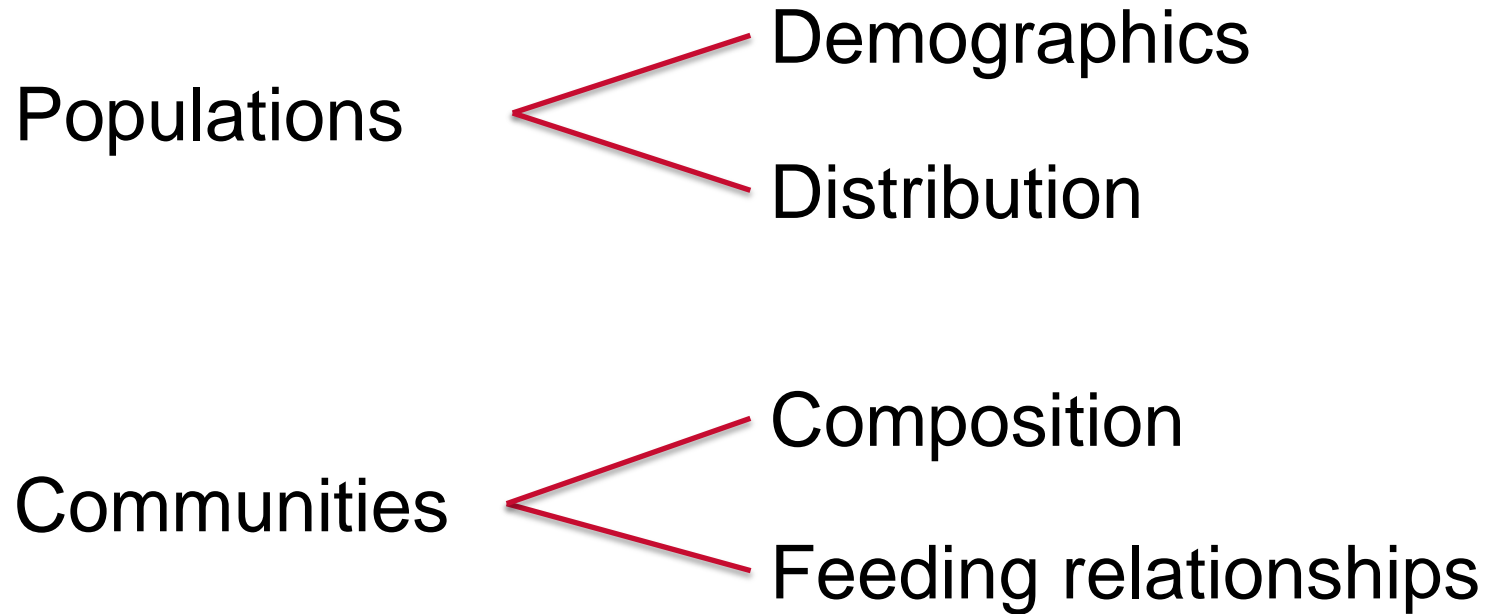
Two Paradigms

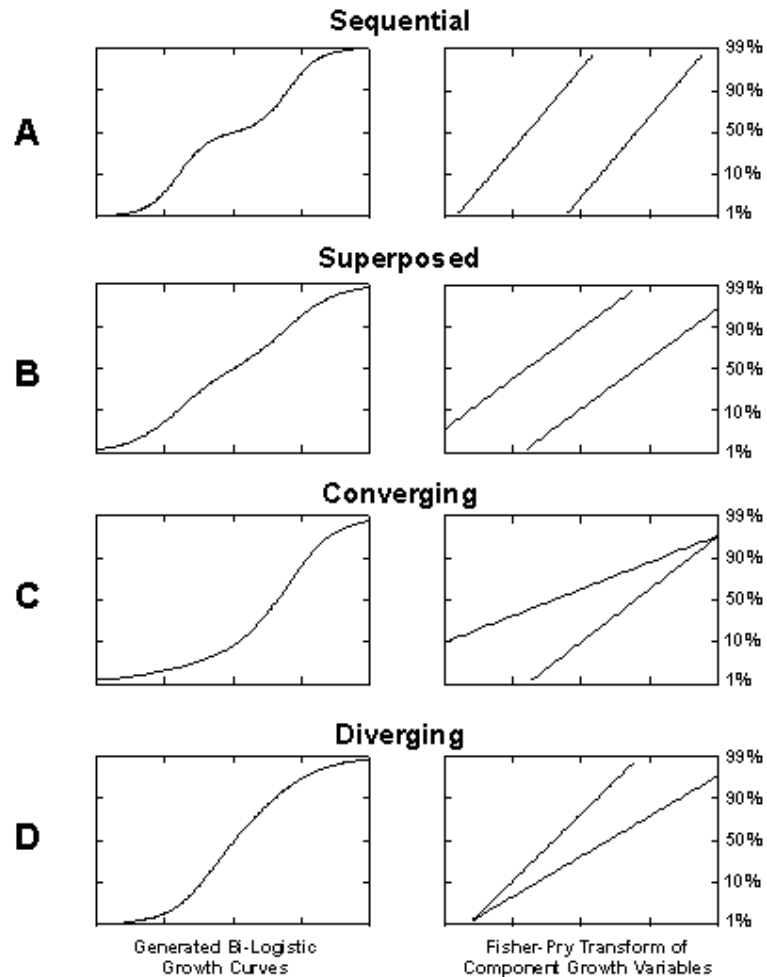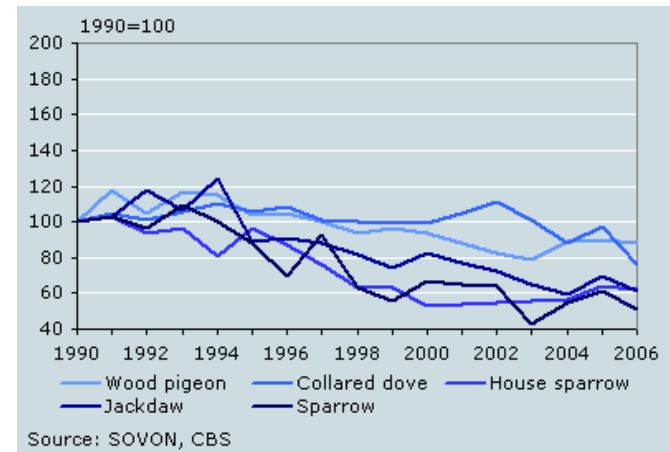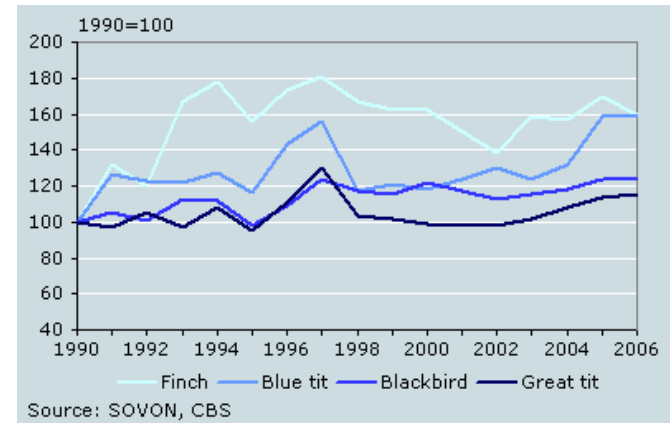Ecology < IN / OF > The City

Three Paradigms

Sustainability of Cities

Cities as Coupled Human-Environment Systems

Ecology of Cities

Cities as Human-Dominated Ecosystems

Ecology in Cities

Cities as Damaged Habitat

IN

Populations
- Demographics
- Distribution

Communities
- Composition
- Feeding relationships

Population change

Bi-logistical growth curve

Species vary

https://phe.rockefeller.edu/Bi-Logistic/
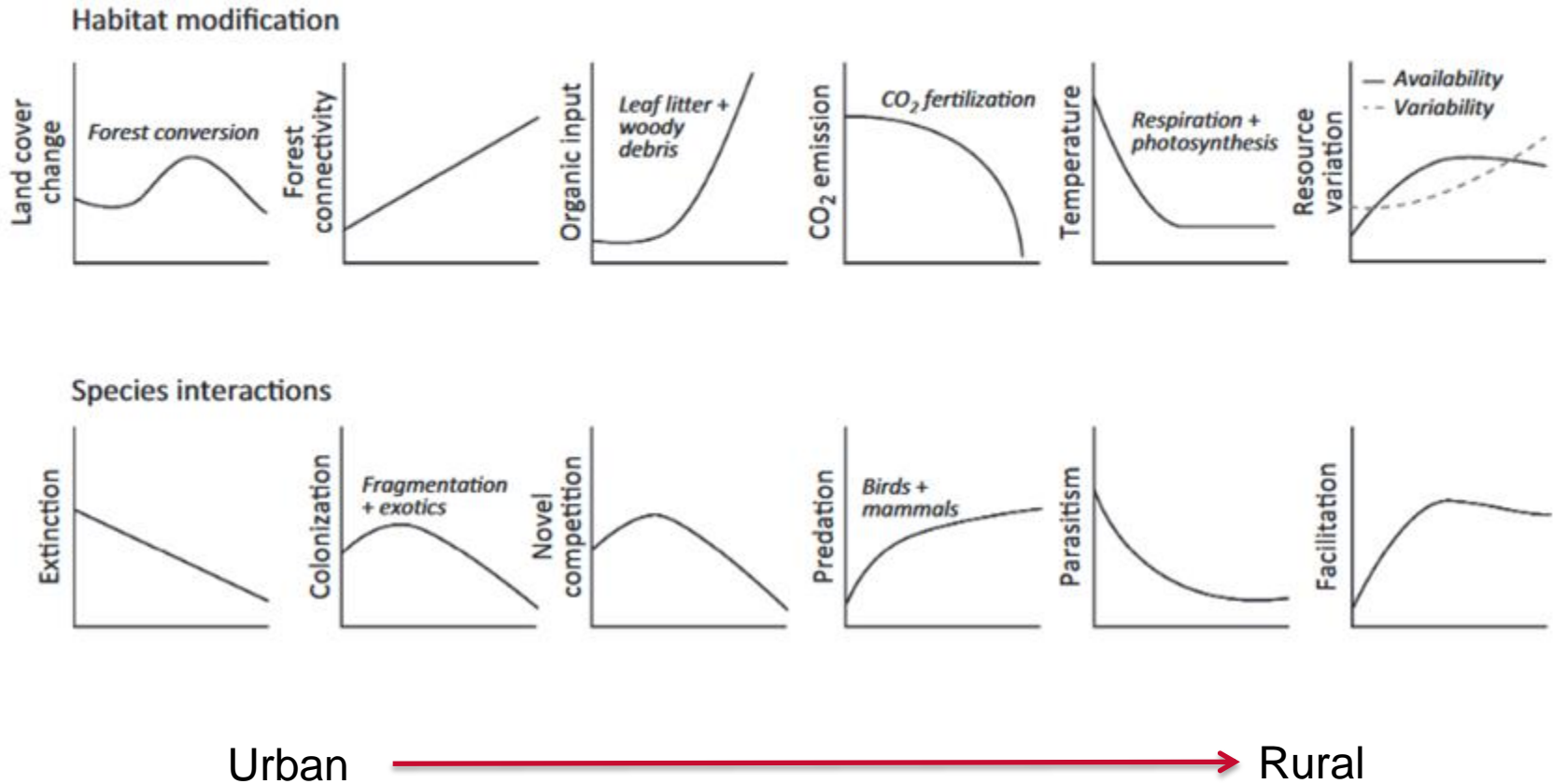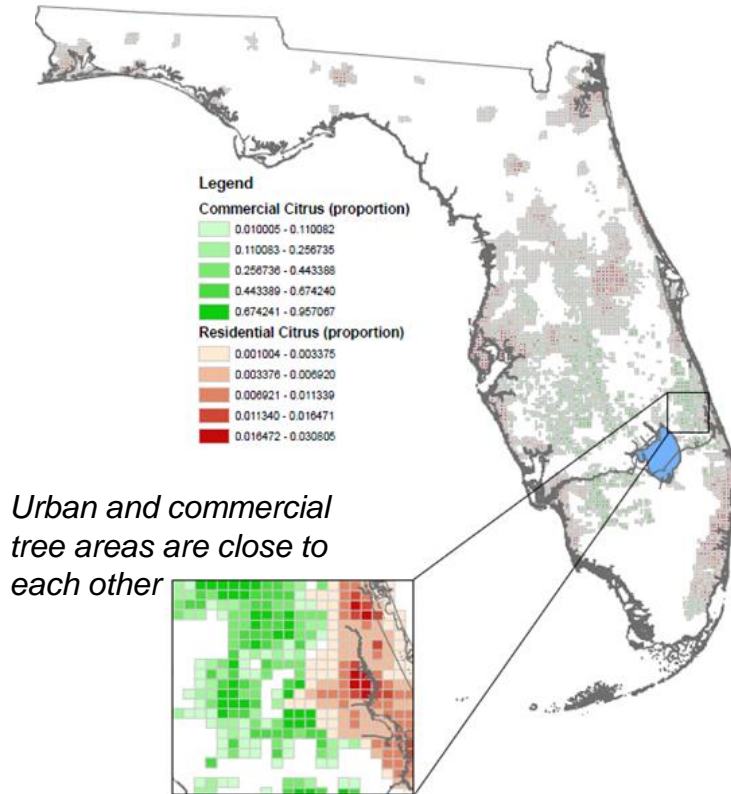https://www.cbs.nl/en-gb/news/2008/05/bird-population-declines-in-urban-areas

Hypothesised landscape signatures

Urban tree diseases

Urban trees are an important source of inoculum into the wider environment and agriculture, but epidemics in urban areas are poorly understood.

The example of citrus diseases in Florida

Legend

Commercial Citrus (proportion)
- 0.010005 - 0.110082
- 0.110083 - 0.256735
- 0.256736 - 0.443388
- 0.443389 - 0.674240
- 0.674241 - 0.957067

Residential Citrus (proportion)
- 0.001004 - 0.003375
- 0.003376 - 0.006920
- 0.006921 - 0.011339
- 0.011340 - 0.016471
- 0.016472 - 0.030805

Urban and commercial tree areas are close to each other

Urban trees

Commercial trees

Citrus canker disease was subject to **$1 billion eradication attempt** in Florida 1995-2005

Modelling urban tree epidemics

Spatially-explicit stochastic epidemic models (syn. agent based models) are used to understand disease risk in urban tree populations.

The models can be used to design optimised surveillance programs to maximise the probability to detect invading epidemics before they get out of control

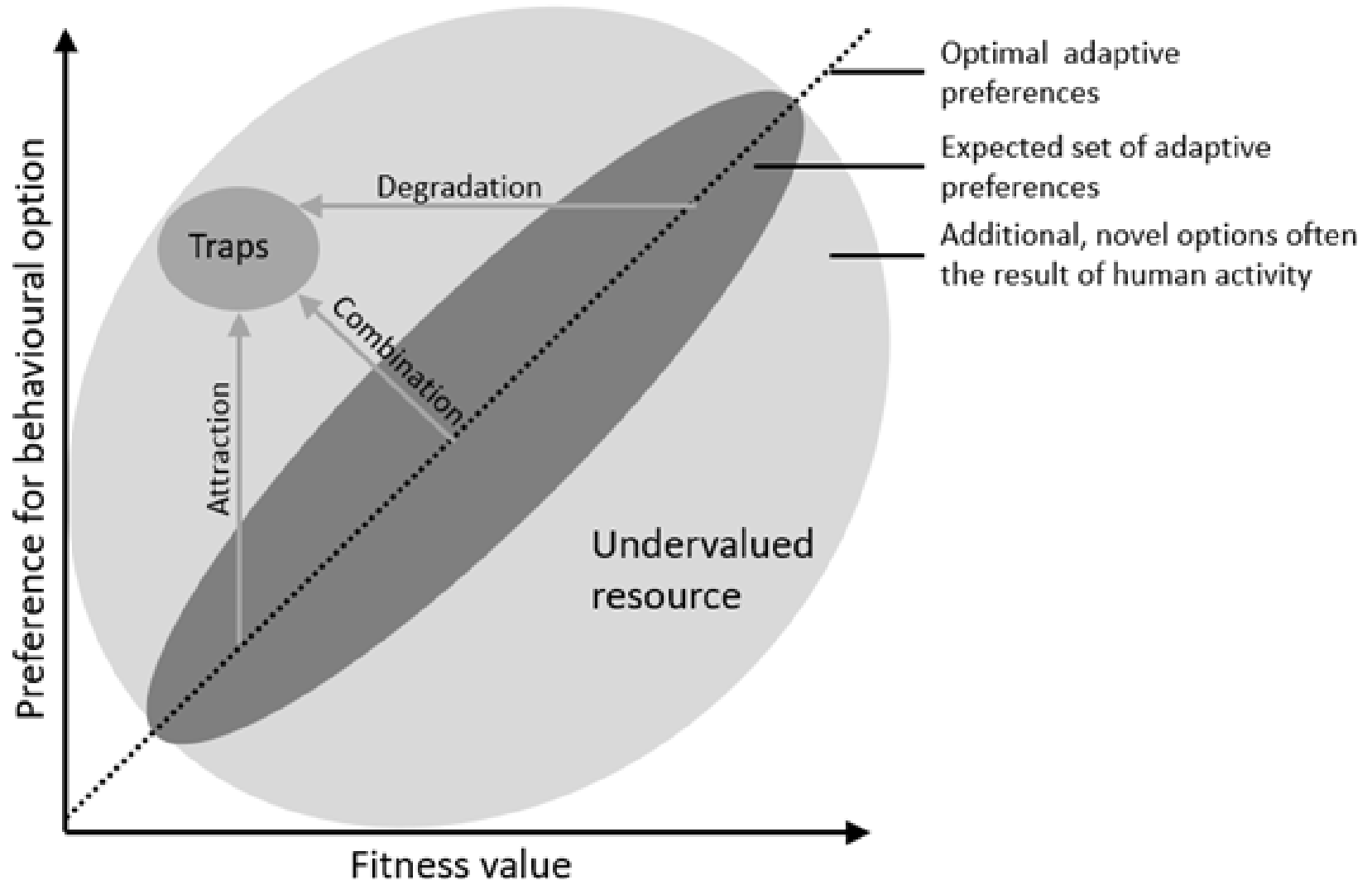**Which trees should we survey to maximise our chance of early detection?**

Map of disease risk (blue-red) and sampling locations (green) in a landscape
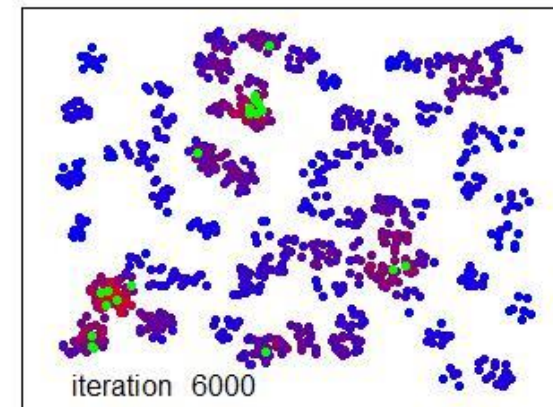
Progress of the simulated-annealing optimisation algorithm relating to the sampling pattern above
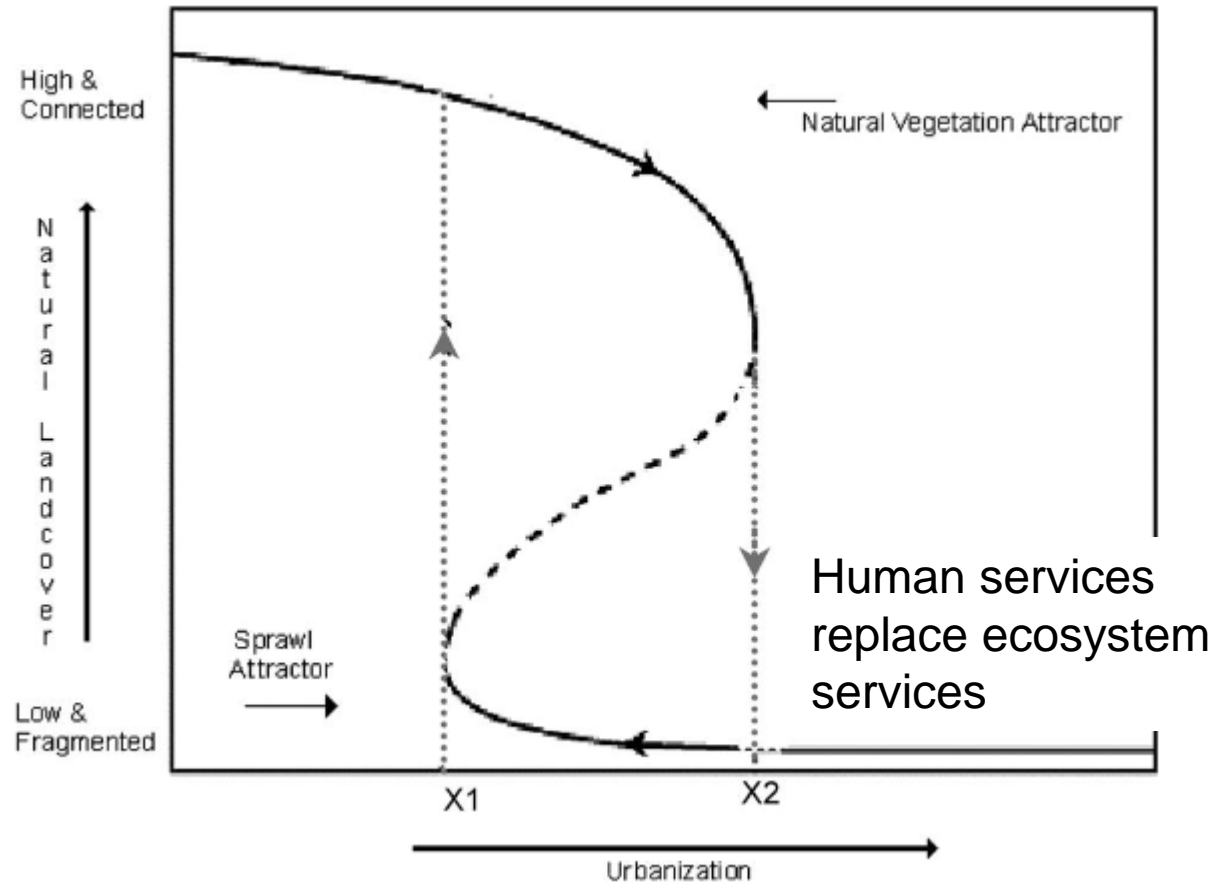
IN - **Distribution**
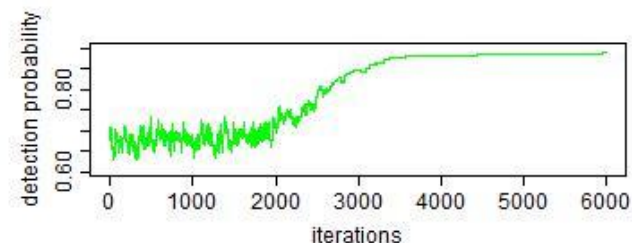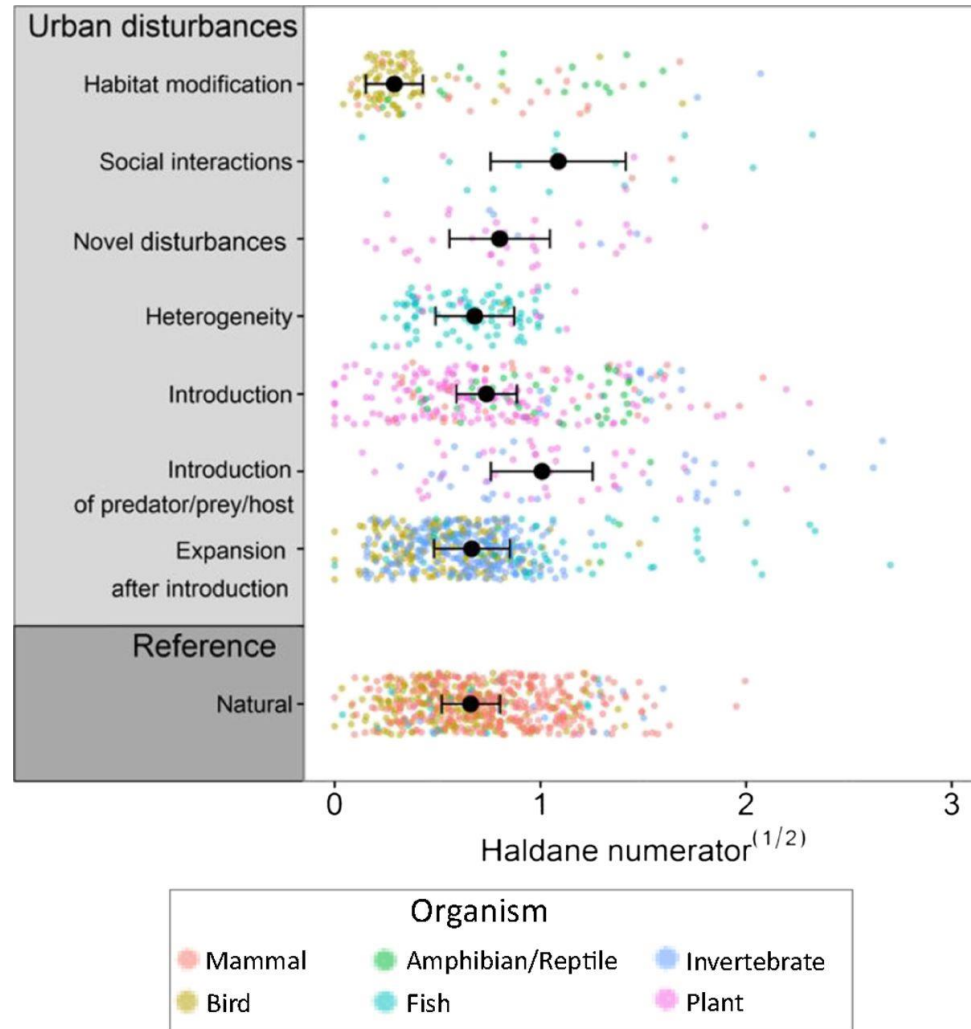
Evolutionary trap

Urbanization increases natural vegetation decreases

Points are reached where the vegetation is too fragments and degraded

Human services replace ecosystem services

Alberti & Marzluff (2004). *Urban Ecosystems,* 7, 241-65.

Multimodel predictions for Urban Disturbance categories

Haldane numerator$^{(1/2)}$

Organism: Mammal, Amphibian/Reptile, Invertebrate, Bird, Fish, Plant

IN - **Distribution**

OF – Biodiversity, ecosystem functions & ecosystem services

Ecosystems

- Flows of energy
- Flows of material
- Landscape ecology
- Social sciences
- Urban planning
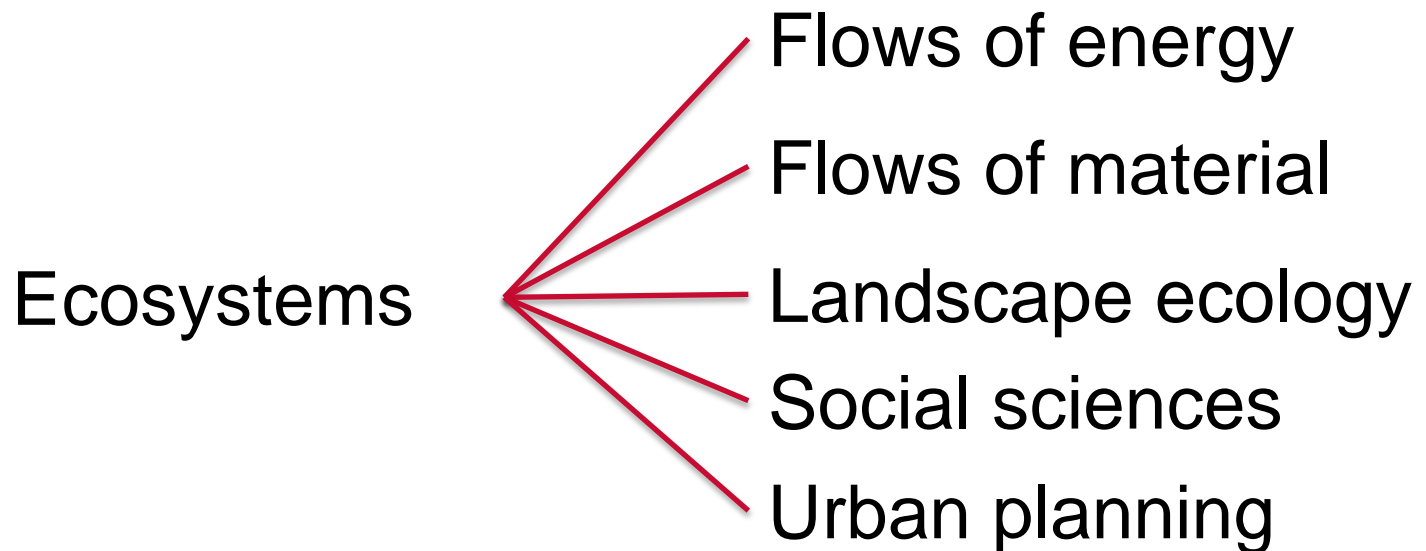
An Urban Ecosystem

Water: ML/year
Energy: GWh/year
GHG Emissions: tonnes/cap-year

OF − **Flow of energy, Flow of material**

Scenarios - Ecosystems

Changes of the estuary anticipated by the participants of the Delphi workshop per site compartment. Intervals of change were given as i) changes within the next 5 years; ii) changes within the next 15 years; ii) changes within the next 26 years; iv) no changes until 2044.
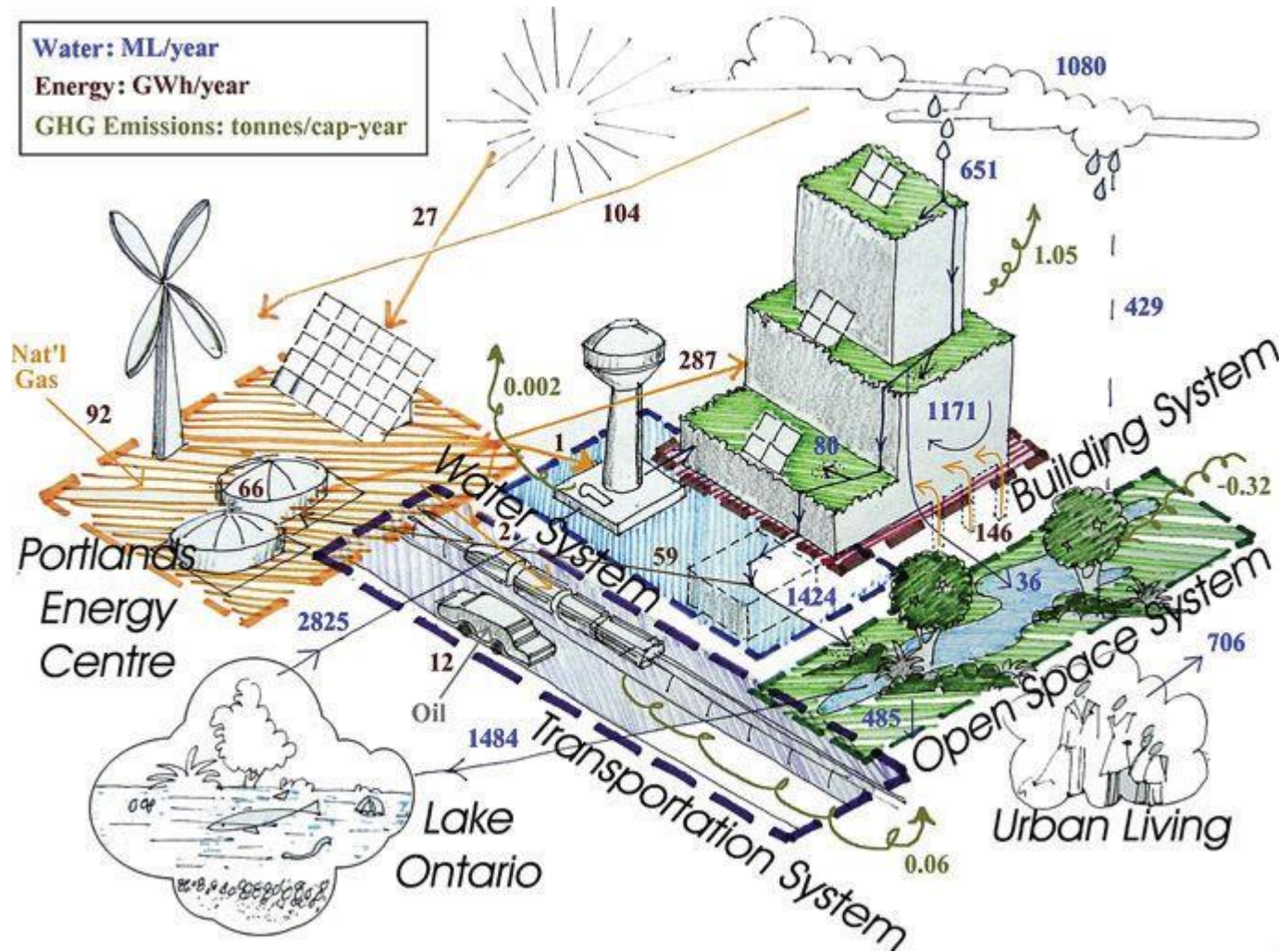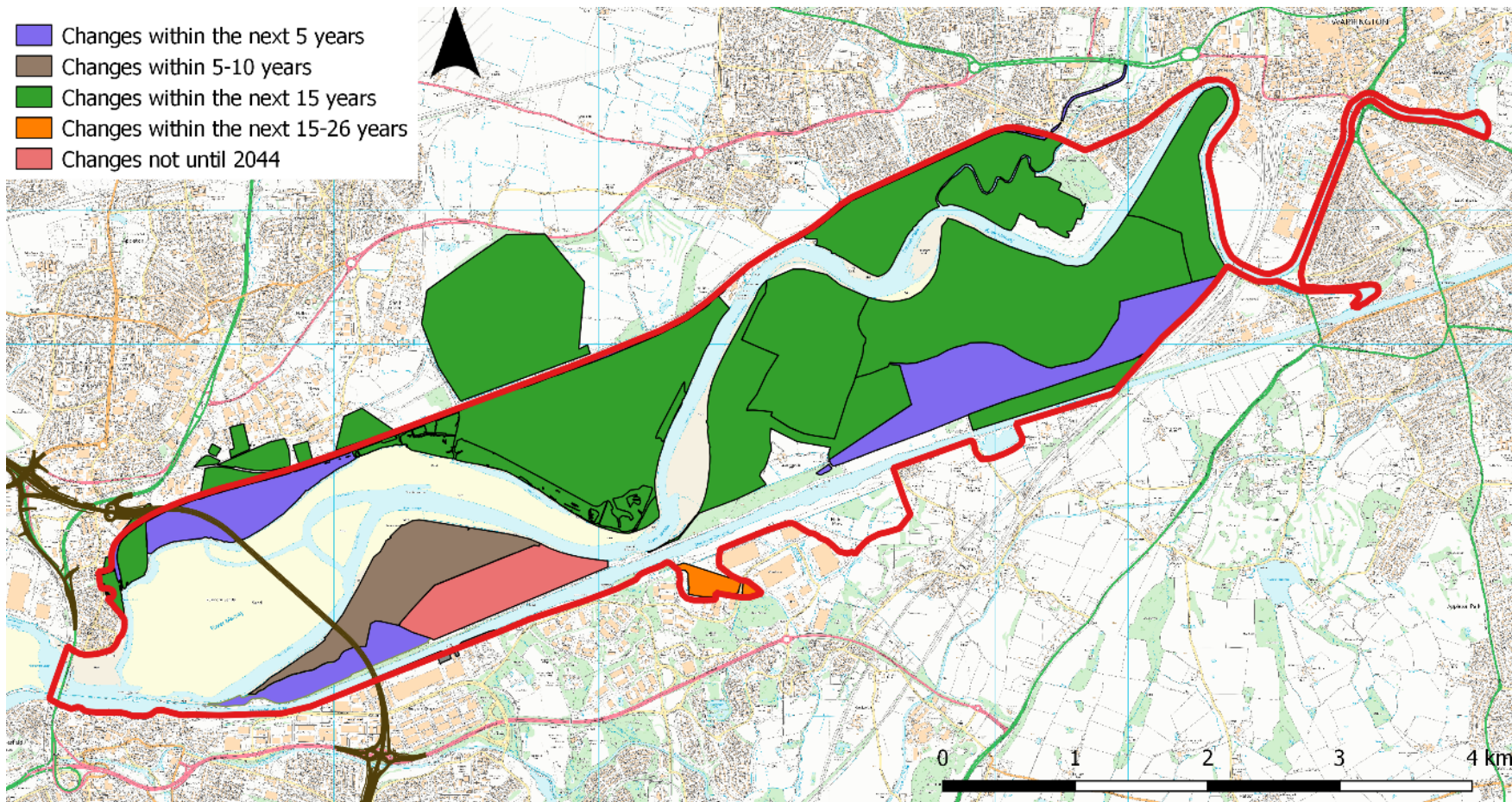
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OF — **Landscape ecology**

MERSEY GATEWAY
ENVIRONMENTAL TRUST

Land-cover assessment

Sentinel 2A 10m satellite remote sensed imagery

Supervised classification using training samples

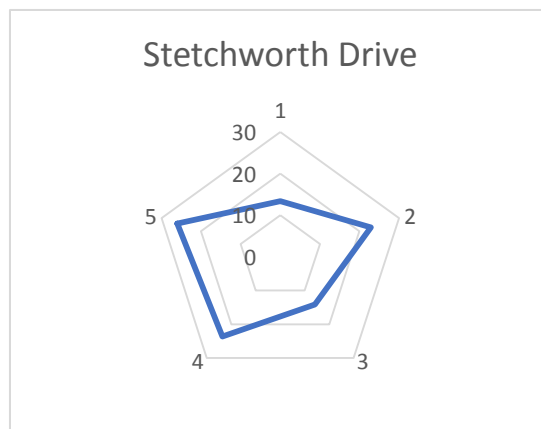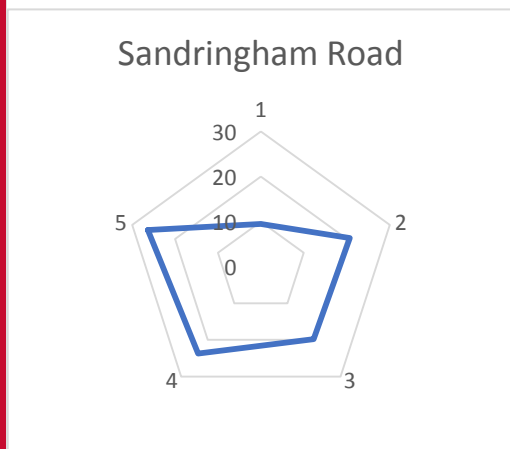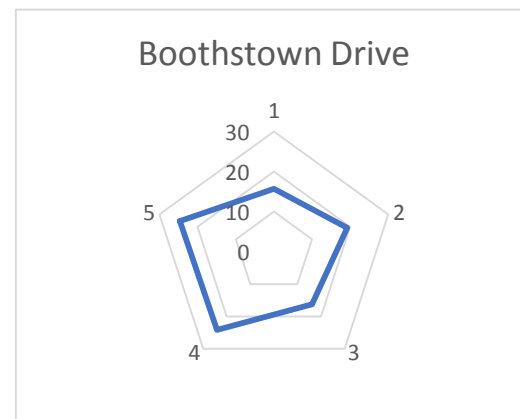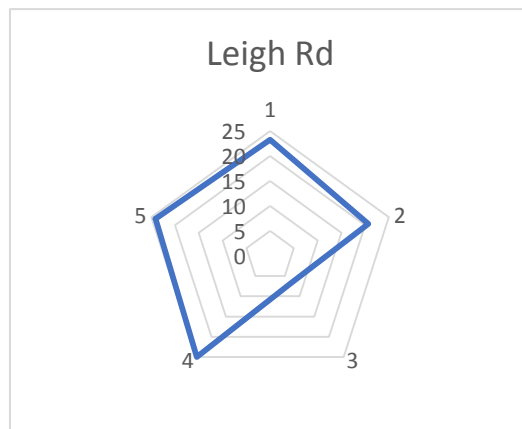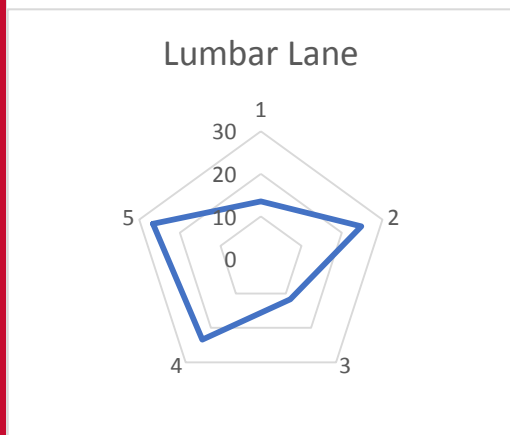Integrate with City of Trees GM Tree Audit dataset and Ordnance Survey water (canal, river, open water) layer (OS VectorMap Local, 1:10,000)
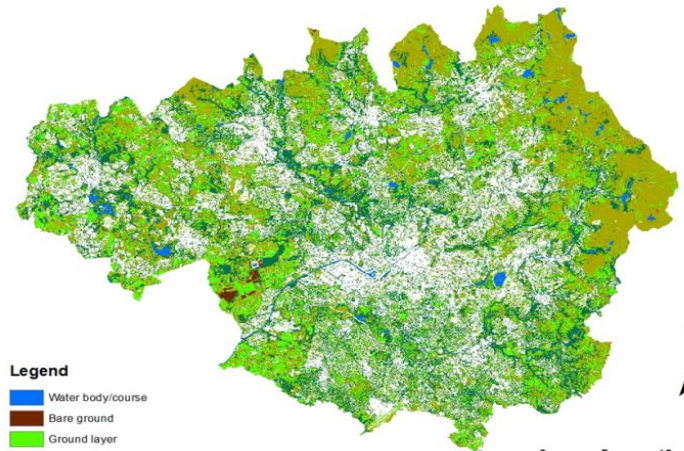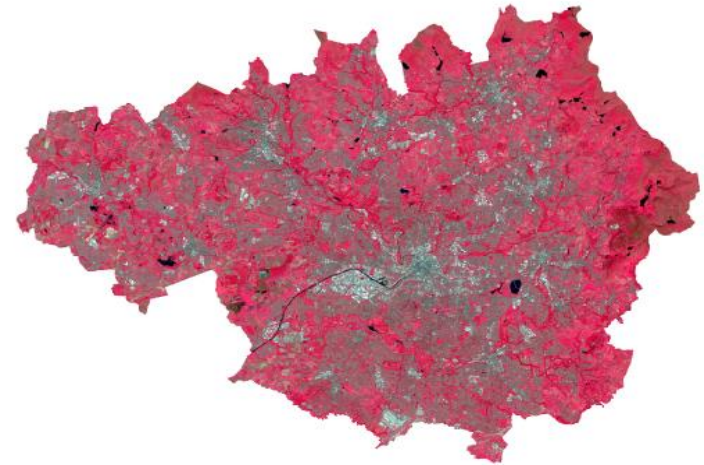
Legend
- Water body/course
- Bare ground
- Ground layer
- Field layer
- Canopy
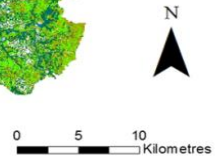
Creating Diversity Profiles For LSOA to be modelled against social factors (e.g. depravation)
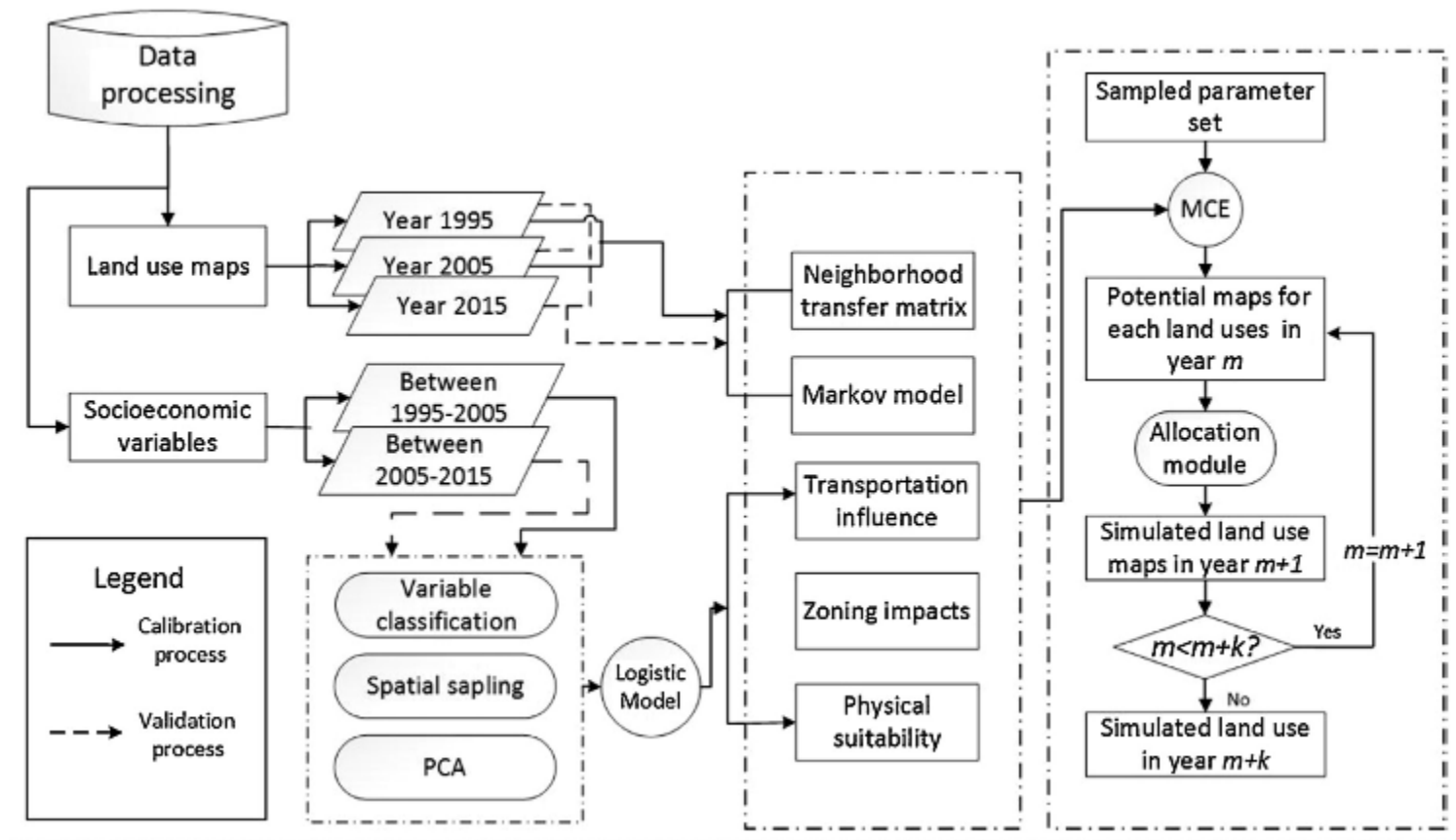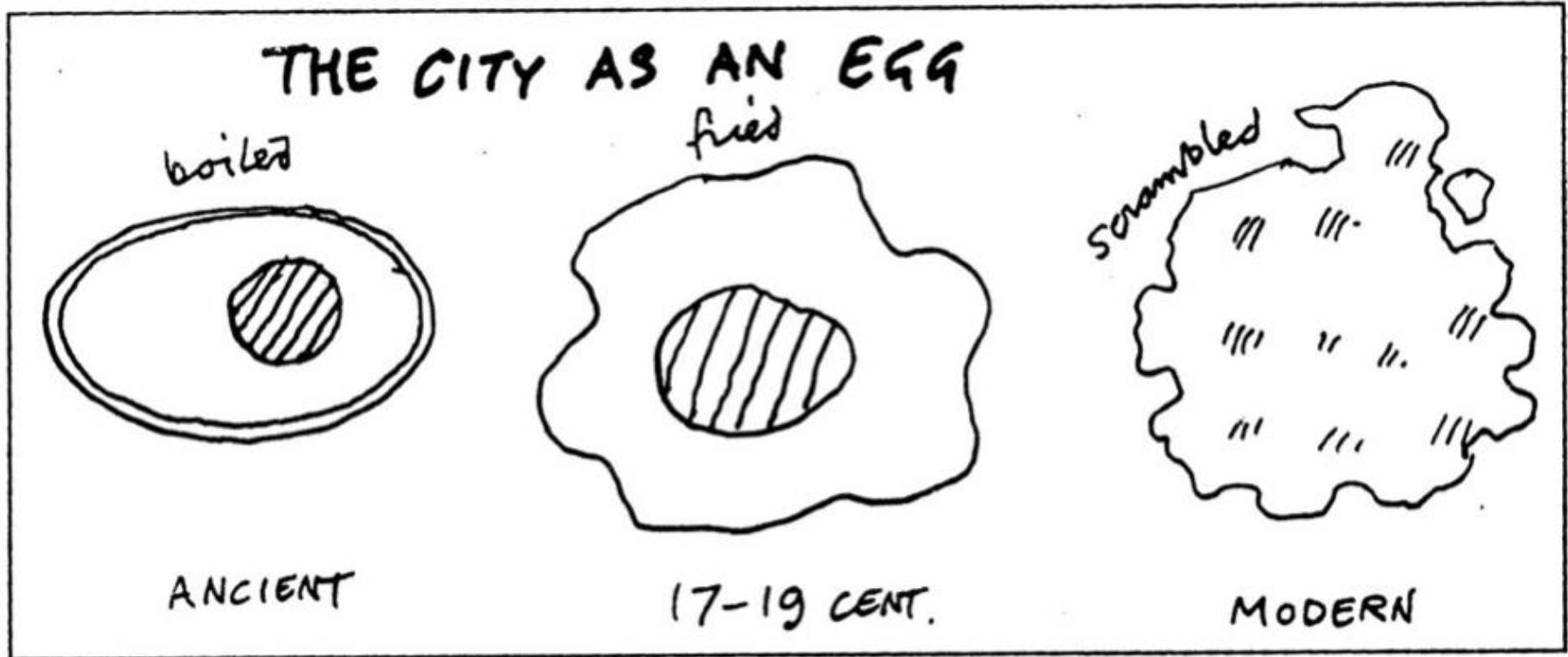

1 = Trees
2 = Shrubs
3 = Plants
4 = Lawn
5 = Pave

OF – **Social science**

Royal Horticultural Society

Sharing the best in Gardening

Workflow of the dynamic process of the Markov-logistic-CA model

A concept

Jorg Sieweke https://transductionuva.wordpress.com/reports/taxis-urban-metabolism/

OF – Urban planning
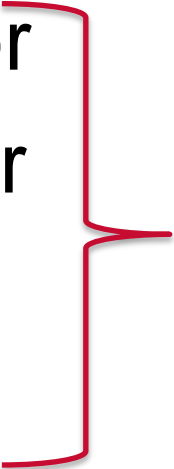
Challenges

- Multi-actor
- Non-linear
- Chaotic
- Open

  } Systems

- Understanding – public and professional