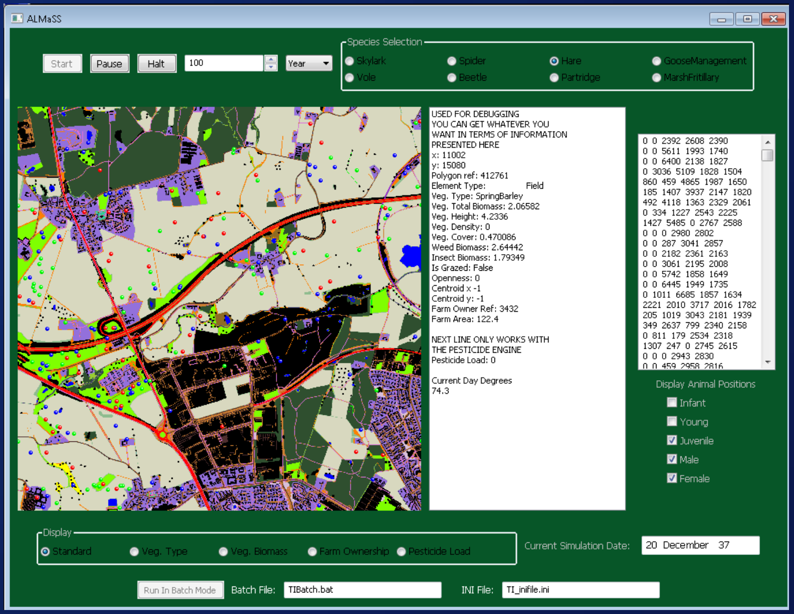
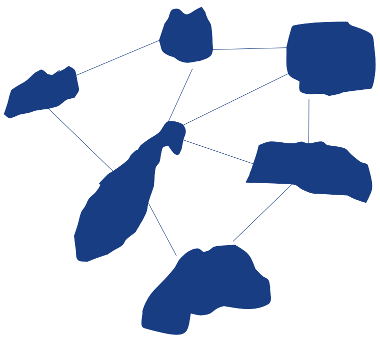
Landscape-scale simulation for terrestrial population modelling and ERA



AARHUS UNIVERSITY Bioscience

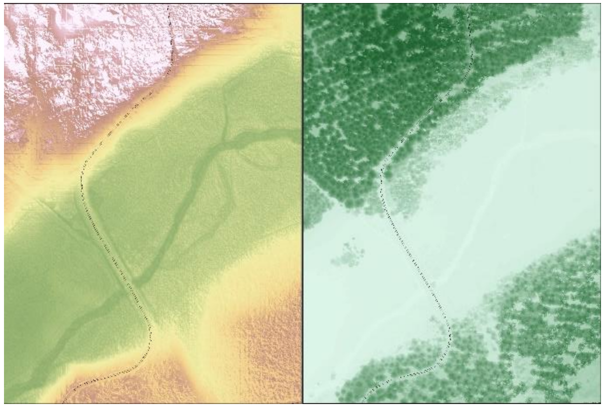
Chris Topping

Landscape scale mapping and modelling



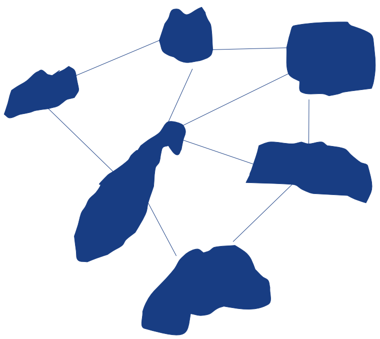
Meta-population models
early 1990s

More detailed, then
GIS maps



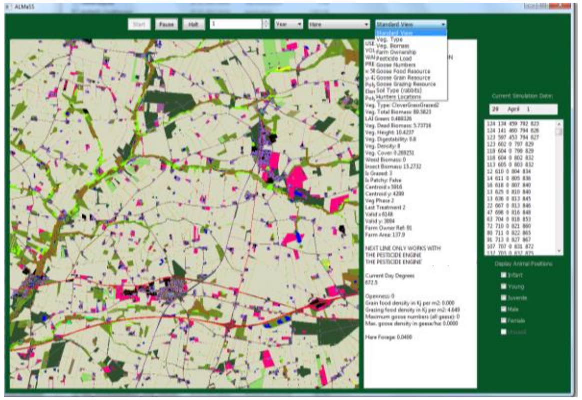
Lidar terrain mapping

Landscape scale mapping and modelling



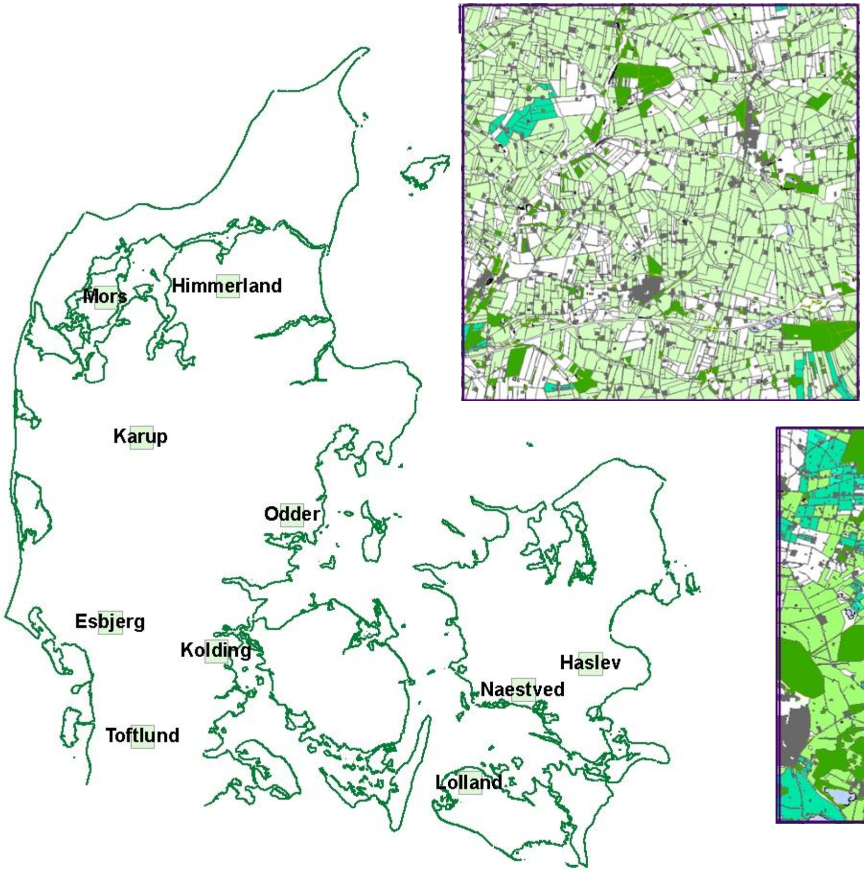
Meta-population models 1980s

Agent-based models



Agent-based simulation

Landscape capture



FarmID	Farm Type	Total Crop Area	SpringBarley	SpringWheat	Oats
10000	1	2973.990	0.053	0.016	0.002
10001	7	3067.520	0.058	0.001	0.016
10002	2	3449.770	0.087	0.000	0.007
10003	5	3332.790	0.057	0.004	0.006
10004	1	3772.150	0.103	0.003	0.015
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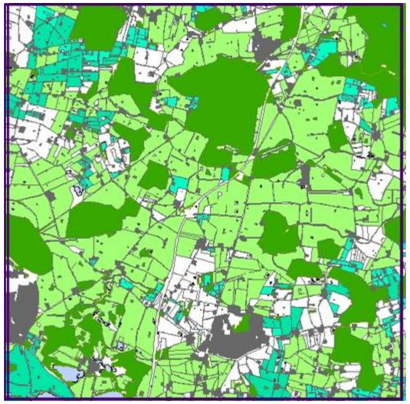
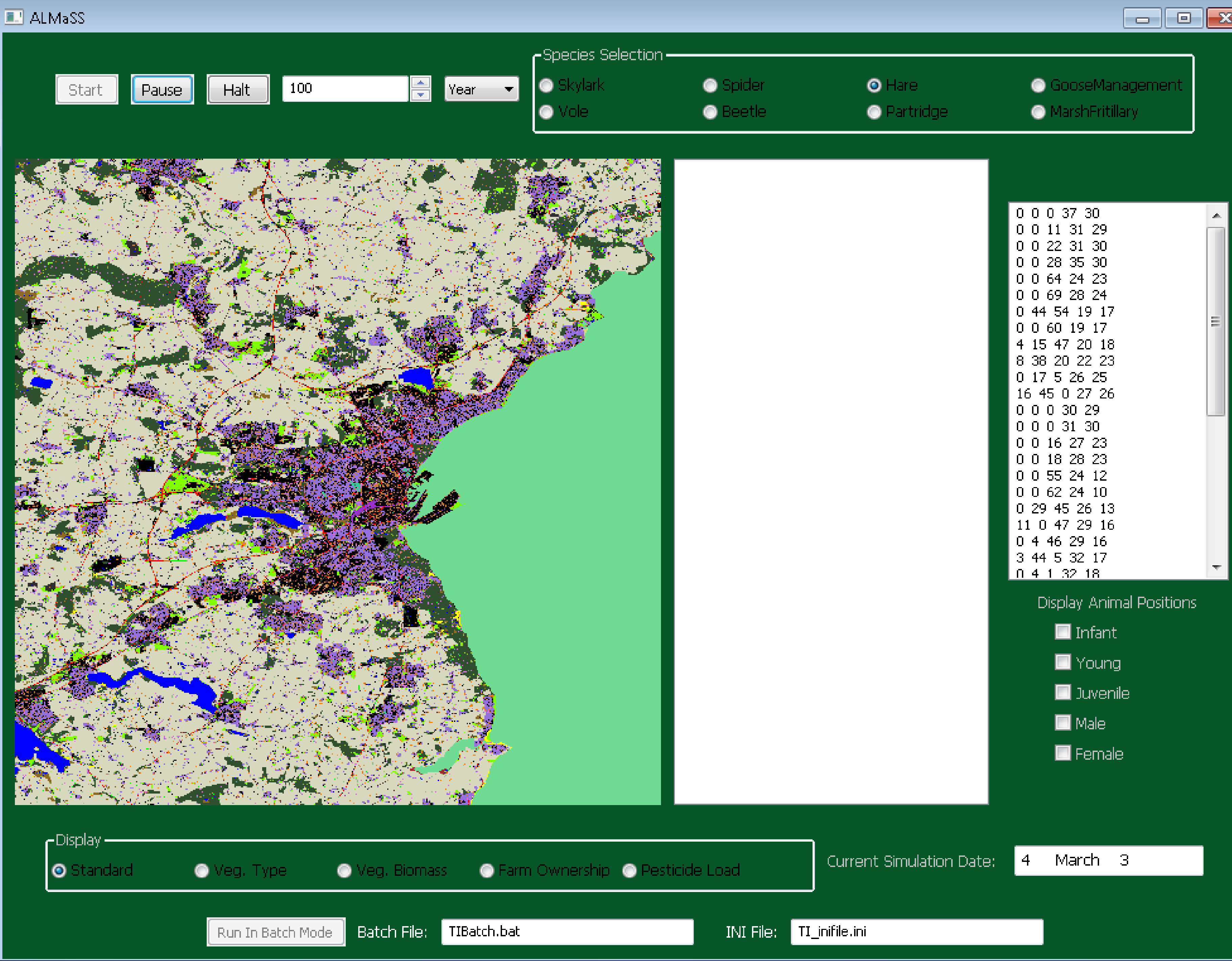
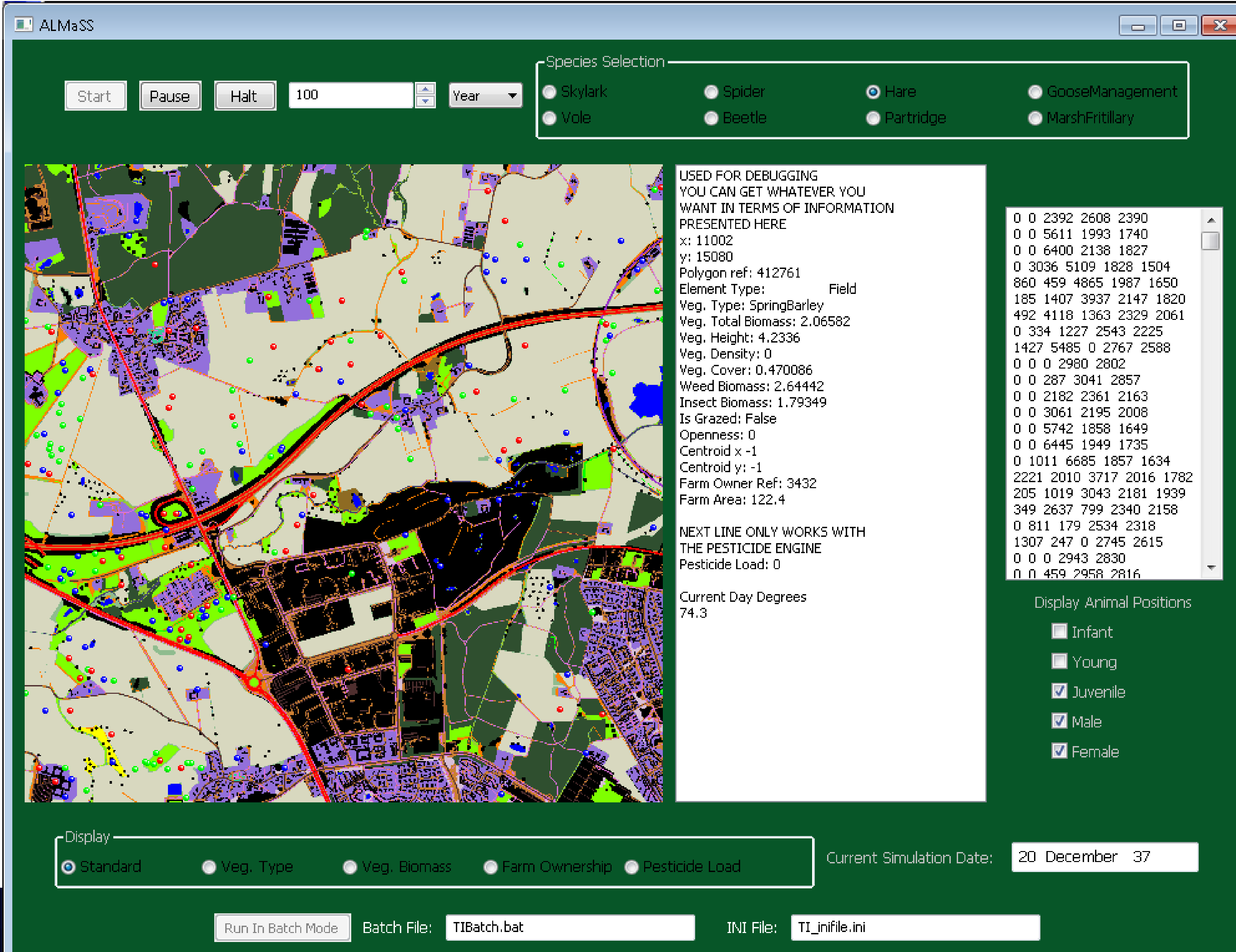
10010	2	83.060	0.234	0.000	0.000



Uses planning GIS information e.g. road maps, municipality information, together with farmer subsidy registration information to generate very accurate and very detailed landscapes for simulations.


ALMaSS
Start
Pause
Halt
100
Year
Species Selection
Skylark
Spider
Hare
GooseManagement
Vole
Beetle
Partridge
MarshFritillary
0 0 0 37 30
0 0 11 31 29
0 0 22 31 30
0 0 28 35 30
0 0 64 24 23
0 0 69 28 24
0 44 54 19 17
0 0 60 19 17
4 15 47 20 18
8 38 20 22 23
0 17 5 26 25
16 45 0 27 26
0 0 0 30 29
0 0 0 31 30
0 0 16 27 23
0 0 18 28 23
0 0 55 24 12
0 0 62 24 10
0 29 45 26 13
11 0 47 29 16
0 4 46 29 16
3 44 5 32 17
Display Animal Positions
Infant
Young
Juvenile
Male
Female
Display
Standard
Veg. Type
Veg. Biomass
Farm Ownership
Pesticide Load
Current Simulation Date:
4 March 3
Run In Batch Mode
Batch File:
TIBatch.bat
INI File:
TI_inifile.ini

ment


ALMaSS
Start
Pause
Halt
100
Year
Species Selection
Skylark
Spider
Hare
GooseManagement
Vole
Beetle
Partridge
MarshFritillary
USED FOR DEBUGGING
YOU CAN GET WHATEVER YOU
WANT IN TERMS OF INFORMATION
PRESENTED HERE
x: 11002
y: 15080
Polygon ref: 412761
Element Type: Field
Veg. Type: SpringBarley
Veg. Total Biomass: 2.06582
Veg. Height: 4.2336
Veg. Density: 0
Veg. Cover: 0.470086
Weed Biomass: 2.64442
Insect Biomass: 1.79349
Is Grazed: False
Openness: 0
Centroid x -1
Centroid y: -1
Farm Owner Ref: 3432
Farm Area: 122.4
NEXT LINE ONLY WORKS WITH
THE PESTICIDE ENGINE
Pesticide Load: 0
Current Day Degrees
74.3
0 0 2392 2608 2390
0 0 5611 1993 1740
0 0 6400 2138 1827
0 3036 5109 1828 1504
860 459 4865 1987 1650
185 1407 3937 2147 1820
492 4118 1363 2329 2061
0 334 1227 2543 2225
1427 5485 0 2767 2588
0 0 0 2980 2802
0 0 287 3041 2857
0 0 2182 2361 2163
0 0 3061 2195 2008
0 0 5742 1858 1649
0 0 6445 1949 1735
0 1011 6685 1857 1634
2221 2010 3717 2016 1782
205 1019 3043 2181 1939
349 2637 799 2340 2158
0 811 179 2534 2318
1307 247 0 2745 2615
0 0 0 2943 2830
Display Animal Positions
Infant
Young
Juvenile
Male
Female
Display
Standard
Veg. Type
Veg. Biomass
Farm Ownership
Pesticide Load
Current Simulation Date:
20 December 37
Run In Batch Mode
Batch File:
TIBatch.bat
INI File:
TI_inifile.ini

Using landscape simulation in ERA – model testing

- The testing is our assurance that our model system is behaving like the real world.
- This is done be detailed testing at different hierarchical levels.
- This when combined with a relevant scenario = baseline
- For example skylarks:
  - landscape scale population,
  - nest and chick development and survival,
  - within and between field dynamics.

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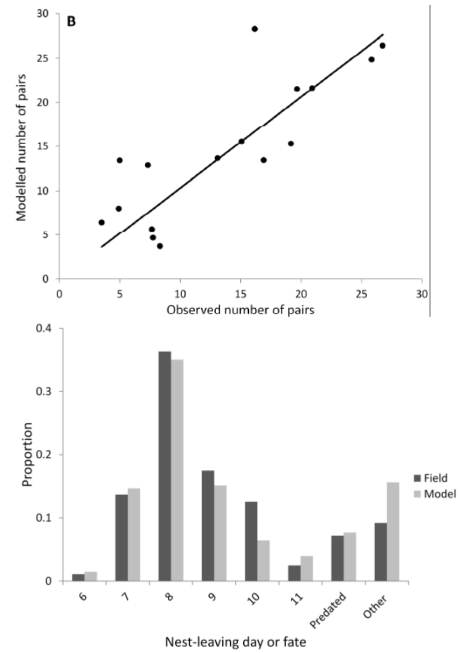
Modelling Skylarks (*Alauda arvensis*) to Predict Impacts of Changes in Land Management and Policy: Development and Testing of an Agent-Based Model

Christopher J. Topping*, Peter Odderskær¤, Johnny Kahlert

Department of Bioscience, University of Aarhus, Rønde, Denmark

Model testing against 4 independent data sets looking at pair density, location, nest and egg fate, and seasonal changes in density:



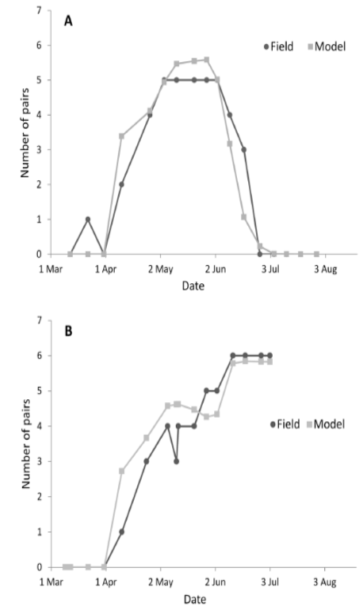
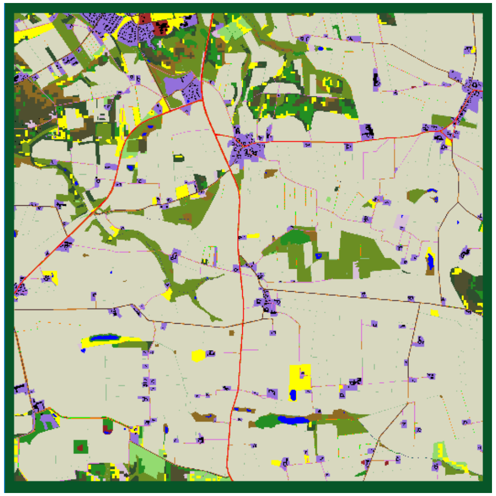


Figure 5. Comparison of the seasonal distribution of the number of territorial pairs observed in the Kalø study area on fields without (A) and with (B) scrapes, and those predicted by the ALMaSS skylark model.

Simulation of pesticide application & fate

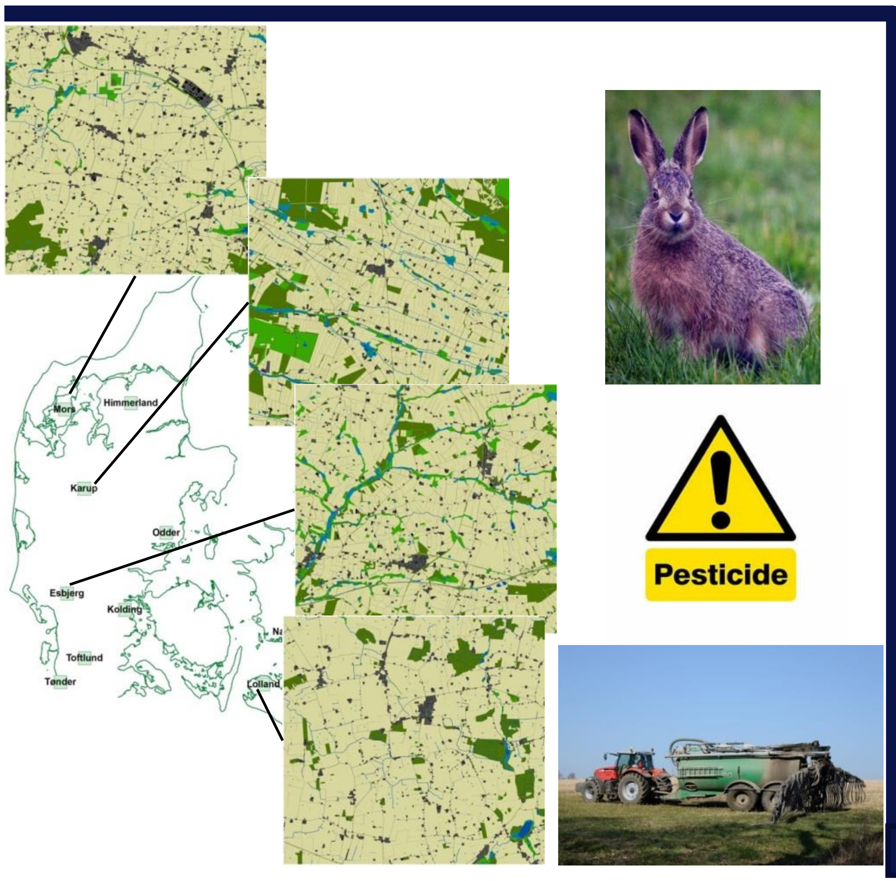
- Based on farming practices
- Simulated per field and farm
- Currently background pesticide use is based on general data but in future actual use can be simulated.

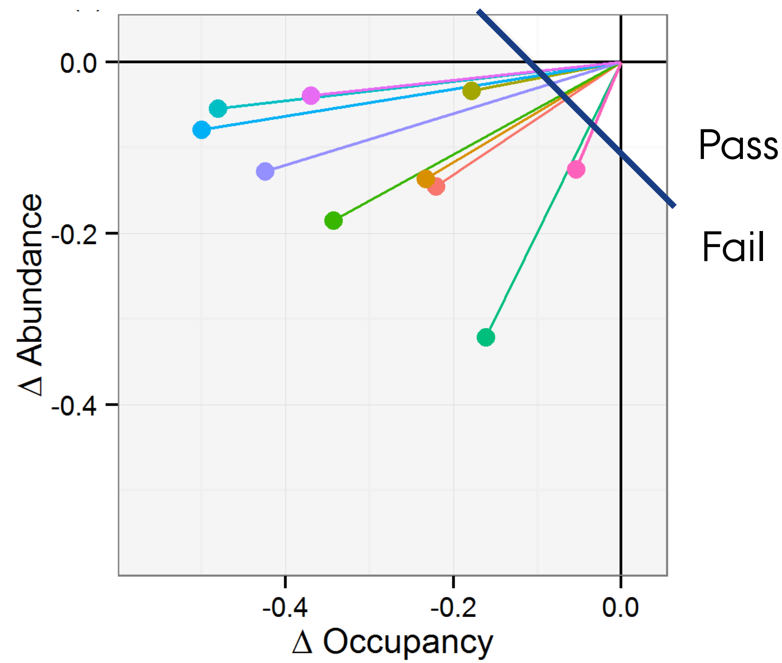


- Projected use of the pesticide to be tested is applied against this background:
- Fate includes drift, partitioning between soil and vegetation compartments, environmental decay etc..

An example application

Hares and pesticides – how ERA could be done in ALMaSS

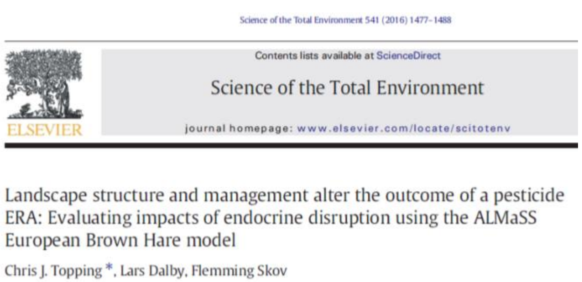




Evaluating the importance of different ERA assumptions

This example evauates the effect of landscape structure and farming by recombining farming and landscape using the same ERA protocol.

The same assumptions and pesticide have different effects depending on the farming and landscape ***context***


Science of the Total Environment 541 (2016) 1477–1488

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journal homepage: www.elsevier.com/locate/scitotenv

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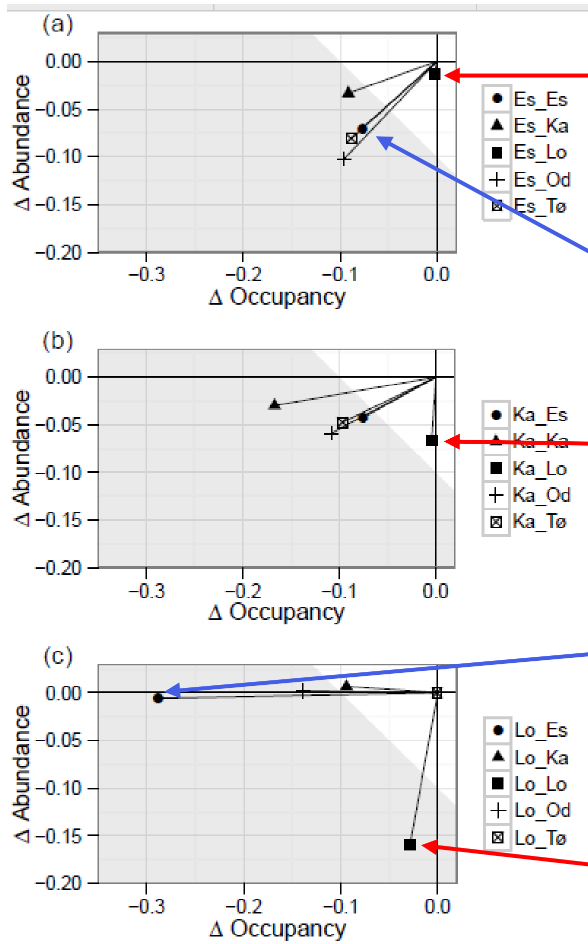
Landscape structure and management alter the outcome of a pesticide ERA: Evaluating impacts of endocrine disruption using the ALMaSS European Brown Hare model

Chris J. Topping *, Lars Dalby, Flemming Skov



Lo farming on Es landscape -> Very low impact

Es farming on Es landscape -> -0.08 occupancy

Lo farming on Ka landscape -> Low impact

Es farming on Lo landscape -> -0.28 occuancy

Lo farming on Lo landscape -> High impact (mostly abundance)

Context is king – why?

Assuming we have a toxic impact on an individual it is affected.

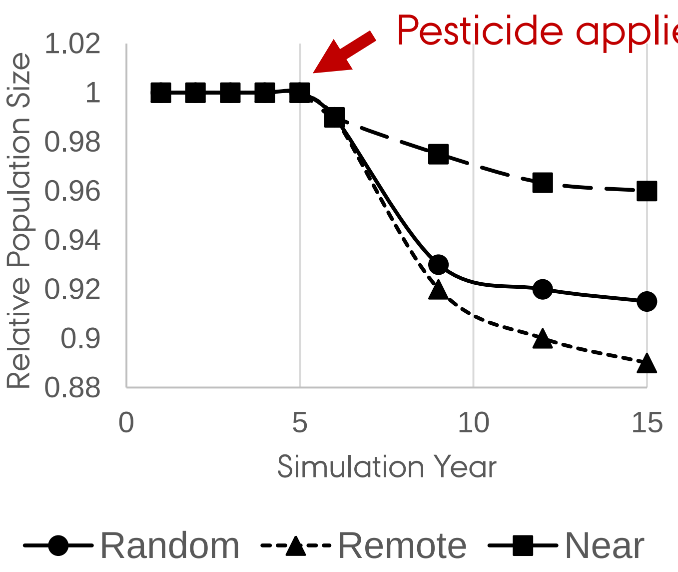
Context affects both exposure and susceptibility (individual and population).

Context is king – why?

Assuming we have a toxic impact on an individual it is affected if exposed.

The context determines both exposure and susceptibility (individual and population levels)

An example:



Vole simulation on 10 x 10 km landscape, orchard application of an endocrine disruptor.

Optimal vole habitats randomly distributed, moved near to orchards or moved away from orchards.

...but the ***actual net*** population impact is largest in 'Near'!

From: Dalkvist, et al. 2013. Landscape structure mediates the effects of a stressor on field vole populations. Landscape Ecology 28: 1961-1974

Some emerging issues

- Toxicity matters - but not more than ecology
- Habitat spatial-arrangement and quality are important, but very hard to predict the effect of these in advance
- Temporal scales matter – year on year use and fragile dynamics
- Protection goals cannot be directly re-used in a landscape population context:
  i) net and relative effects (previous example)
  ii) 'action at a distance' (no effect for off-crop is very difficult to achieve in some systems)
  iii) we need new spatial definitions (changes in distributions vs in-crop/off-crop)

To handle this we need a systems approach.

Systems approach to ERA – what it means

- Populations considered in space and time at scales commensurate with spatial dynamics
- Realistic agricultural management and landscape structure
- Multiple stressors, regulated and un-regulated (even if only one product is being assessed).

The result is that the impact of the pesticide is compared against a realistic population state.

Looking forward

Context dependency creates problems, but solutions are not far off

FarmID	Farm Type	Total Crop Area	SpringBarley	SpringWheat	Oats
10000	1	2973.990	0.053	0.016	0.002
10001	7	3067.520	0.058	0.001	0.016
10002	2	3449.770	0.087	0.000	0.007
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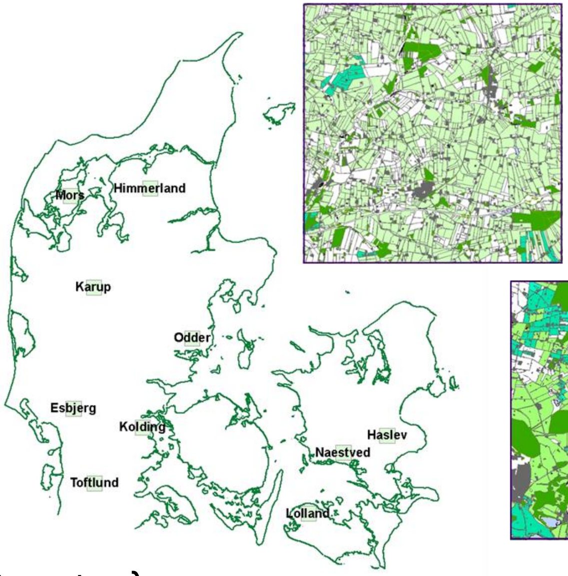
10010	2	83.060	0.234	0.000	0.000

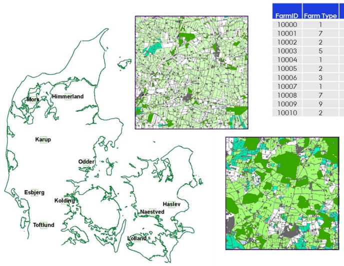
Danish data available:

Detailed GIS mapping
Lidar mapping
Farm subsidy information
Fertlizer usage per farm
Register of animals per farm



(pesticide use from Sustainability Directive)

Unfortunately this is not *yet* the case for the rest of the EU



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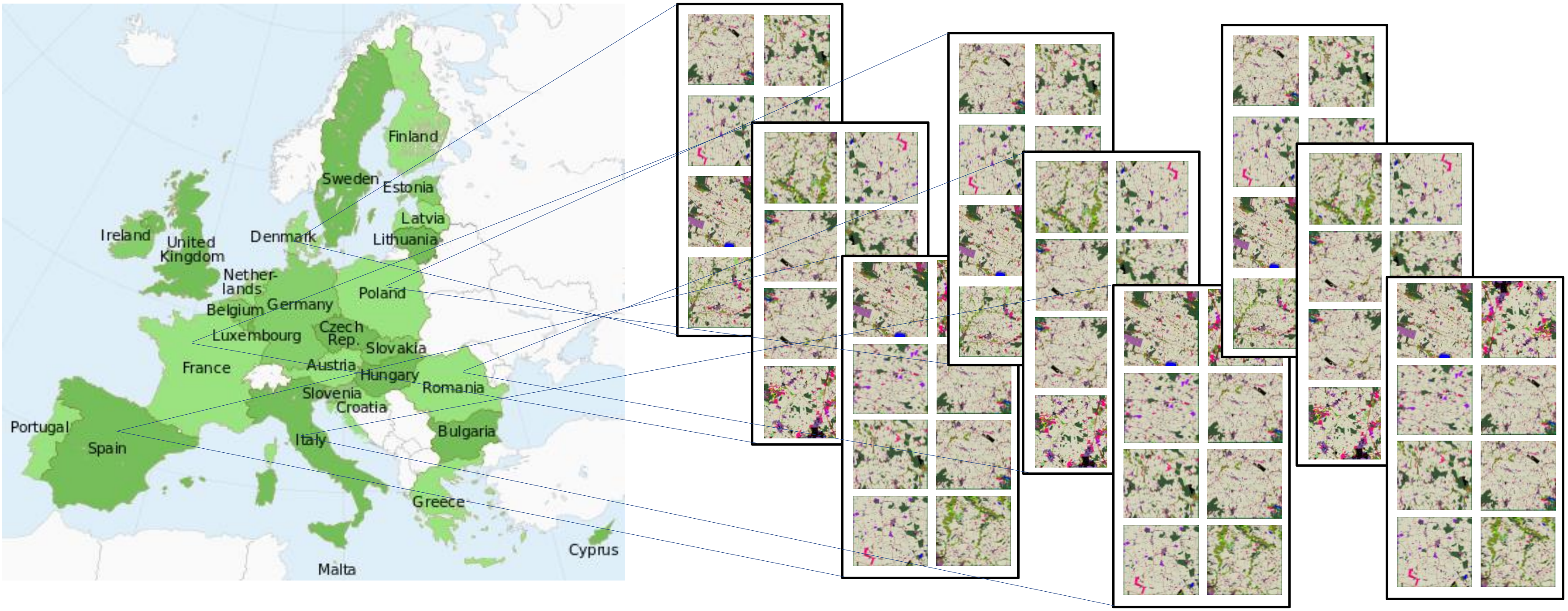
10009	9	2894.950	0.065	0.000	0.009
10010	2	83.060	0.234	0.000	0.000

Looking forward

… but when data of this sort becomes more widely available:



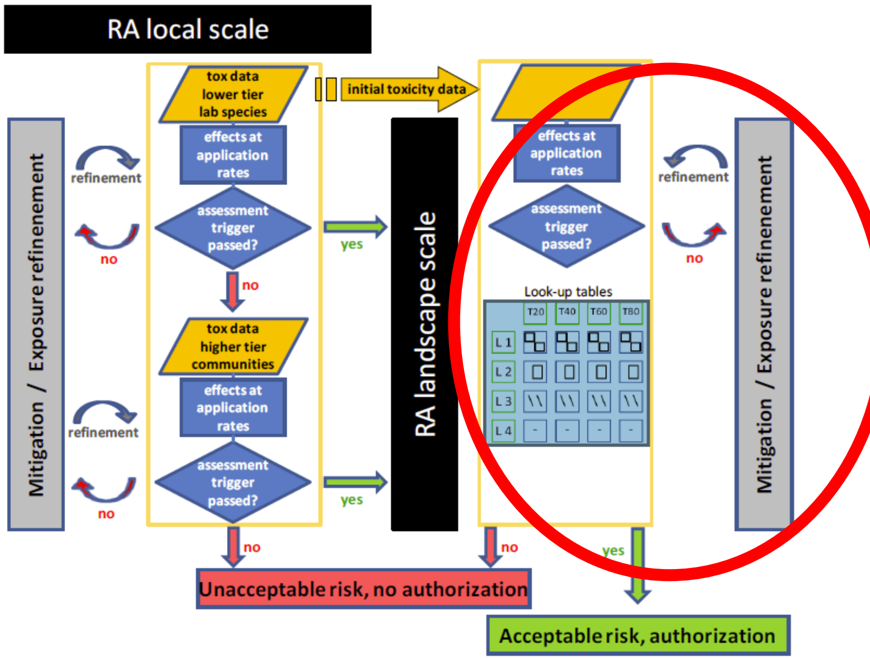
Looking forward

Representative landscapes from each zone and eventually each country.

Allows the identification of ‘hot-spot’ conditions.

This leads to potential for landscape specific mitigation, or restricted approval.

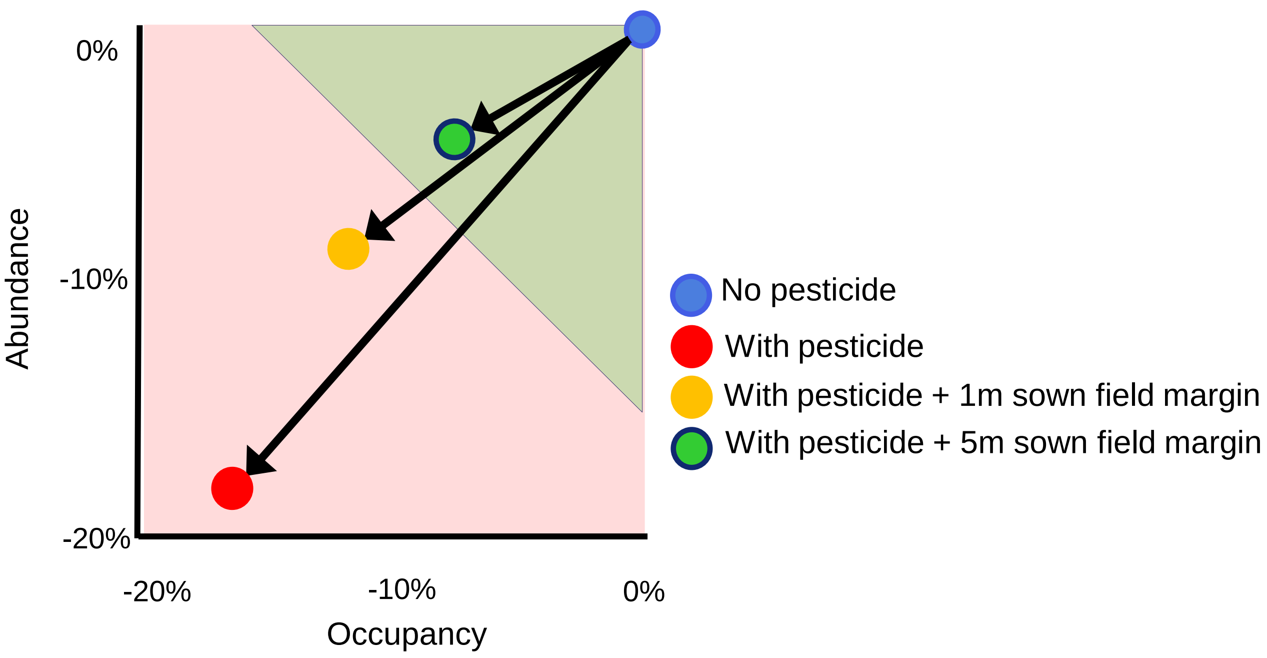
Aim here is a ***simple process*** – based on a complex model.



RA: risk assessment. T20…T80: toxicity descriptor of the active substance or PPP to be assessed. L1…L4: landscape scenarios with diverging field and off-field structures.

Looking forward

Landscape context provides potential for tailored ***mitigation*** options



These options might be specific to a zone, country, or landscape type

Conclusions

- We have come a long way since 1991(3) - landscape-scale population-based ERA is a reality.
- The new approach yields new possibilities and creates new challenges.
- With new data availability these approaches can be implemented across the EU.
- Solutions already exist to most of the technical problems.
- However, new thinking is needed in the implementation of landscape-scale ERA and systems approaches.

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