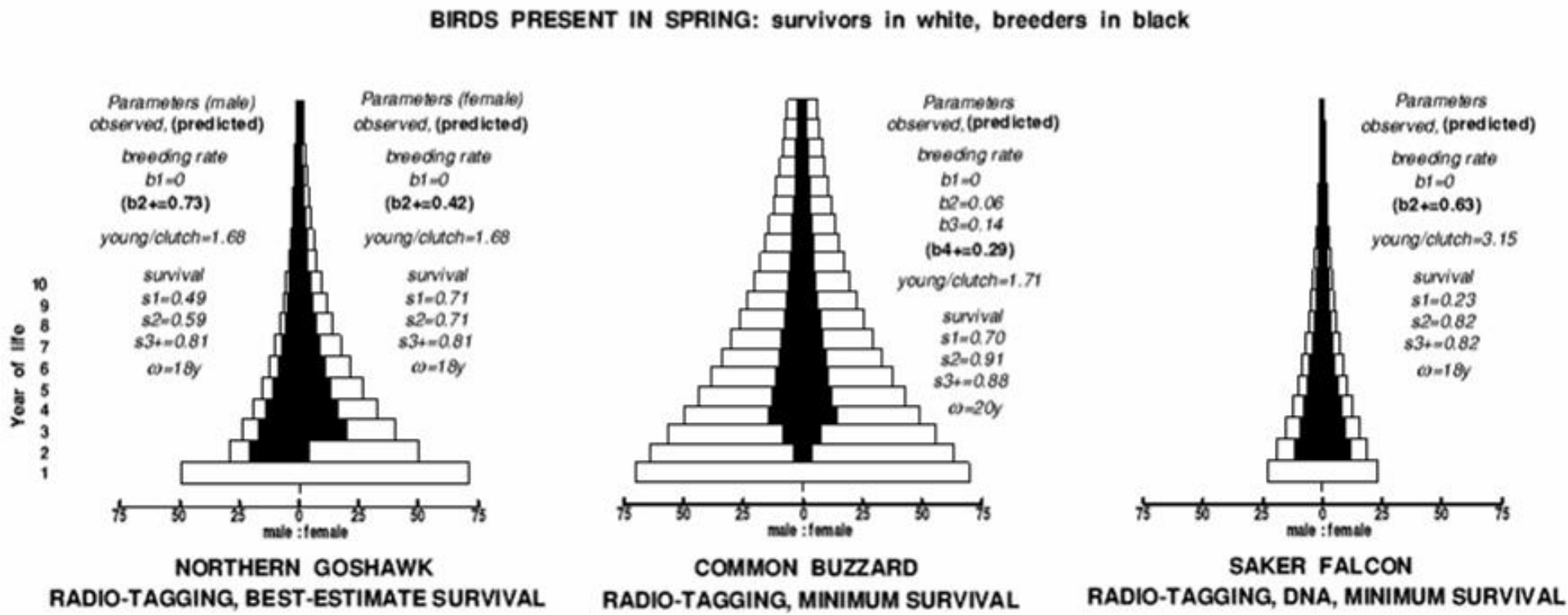
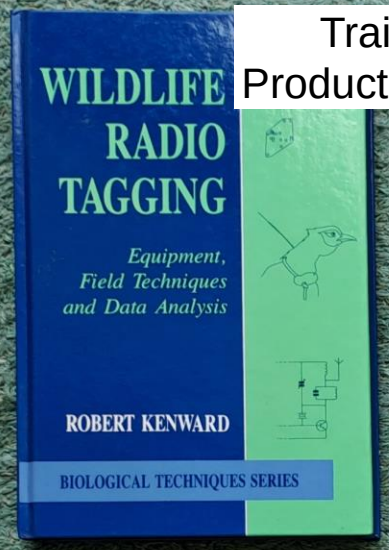
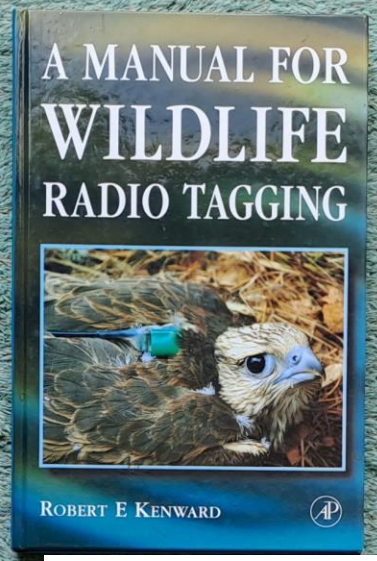

Beware the Allee Effect
when restoring species.
Professor Robert Kenward

My field-research area was primarily radio-tagging of raptors and other relatively elusive species to gain data for modelling, in this case to estimate population structure for goshawks, buzzards and falcons.





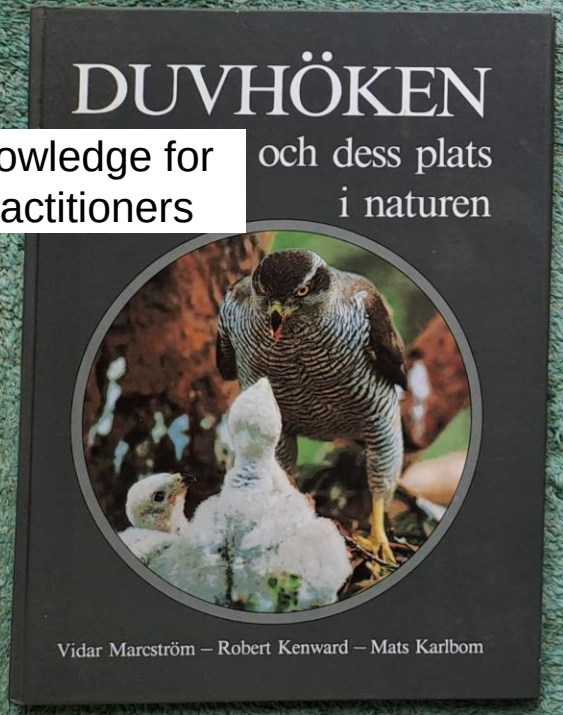
Training,
Product signpost

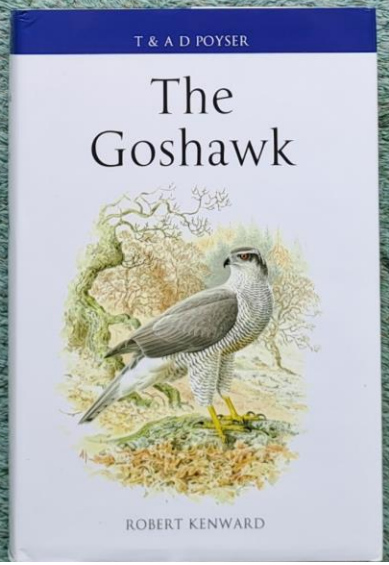


Training,
Product signpost

Glocal knowledge
transfer system

Knowledge for
practitioners





Knowledge,
Socio-economic Model

Knowledge
Agent-Based Model

Dispersal modelling from radio-tagged buzzards too, then new approach: Agent-Based Models

Land Cover Map of Great Britain then enabled Agent-Based Modelling of how buzzards settle in lanscape by using habitat to predict home ranges

- **Species:** 10-day radio-tracking, 72 Common Buzzards during 1990-1995 in southern UK.

Kenward et al. 2001. *Ecology 82:1905-1920*

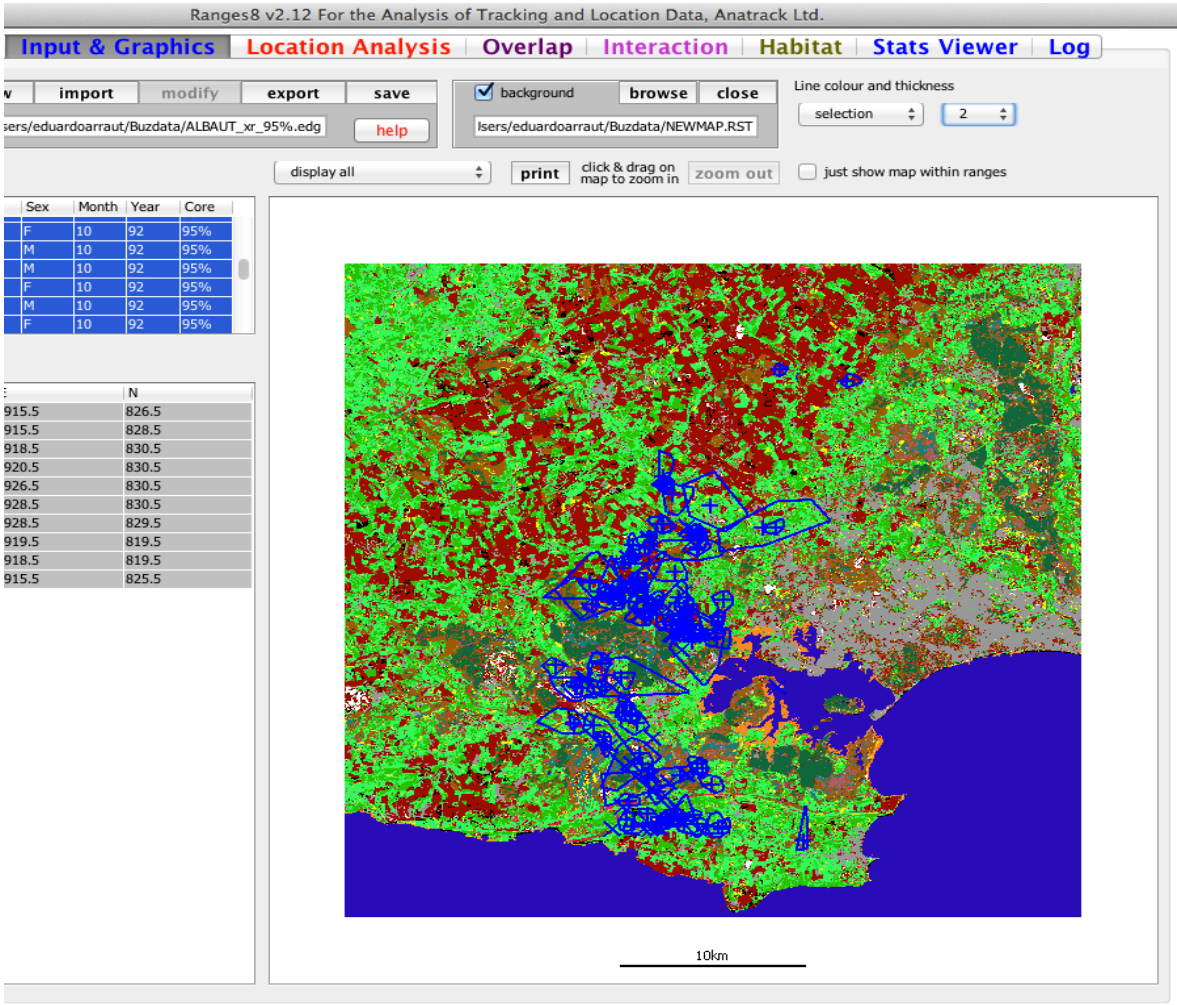
- **MAP:** Landsat, 1990. Resolution: 25x25m. Overall classification accuracy: 71% (unevenly distributed among land cover classes)

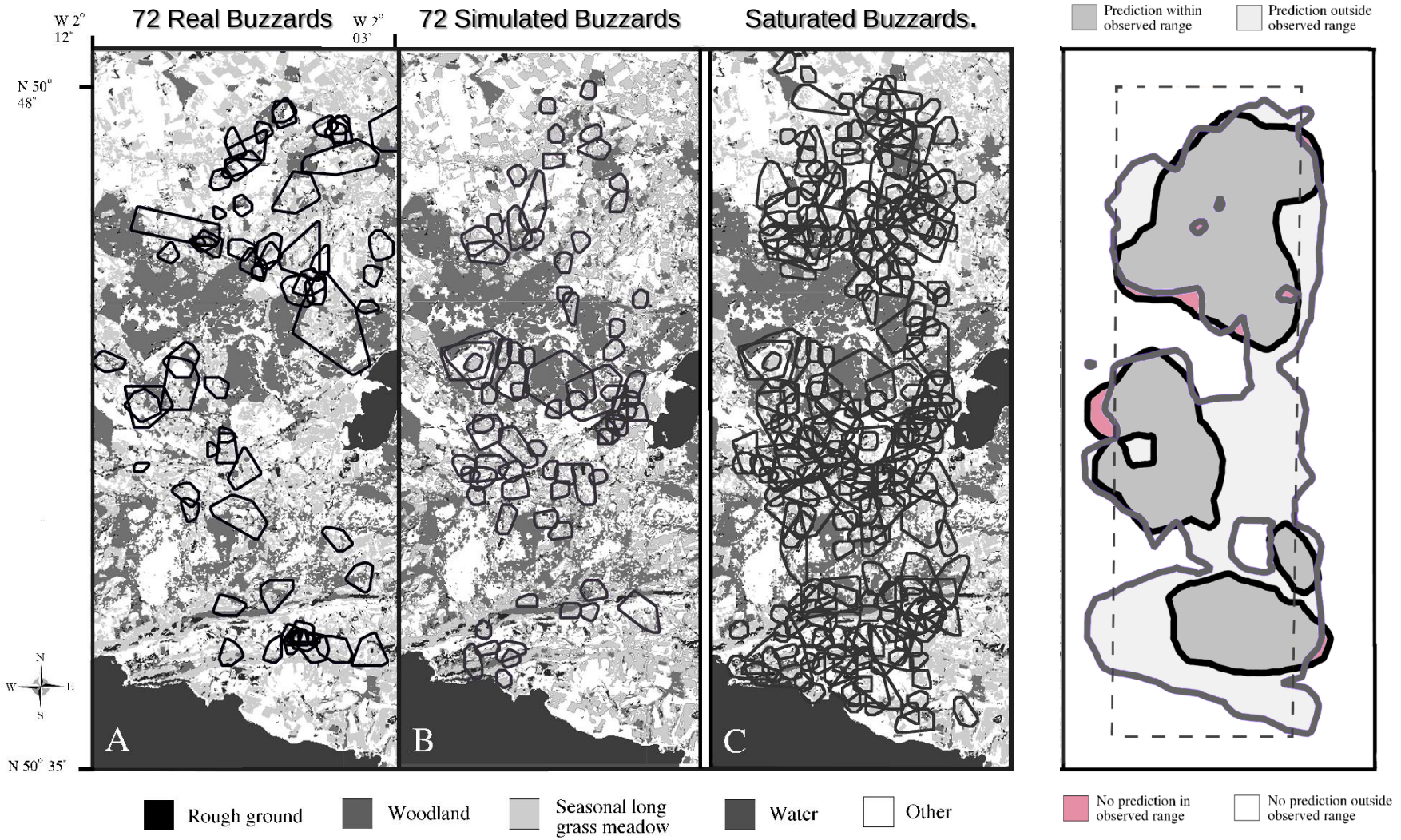
Fuller et al. 1994, *Photogrammetric Engineering & Remote Sensing*

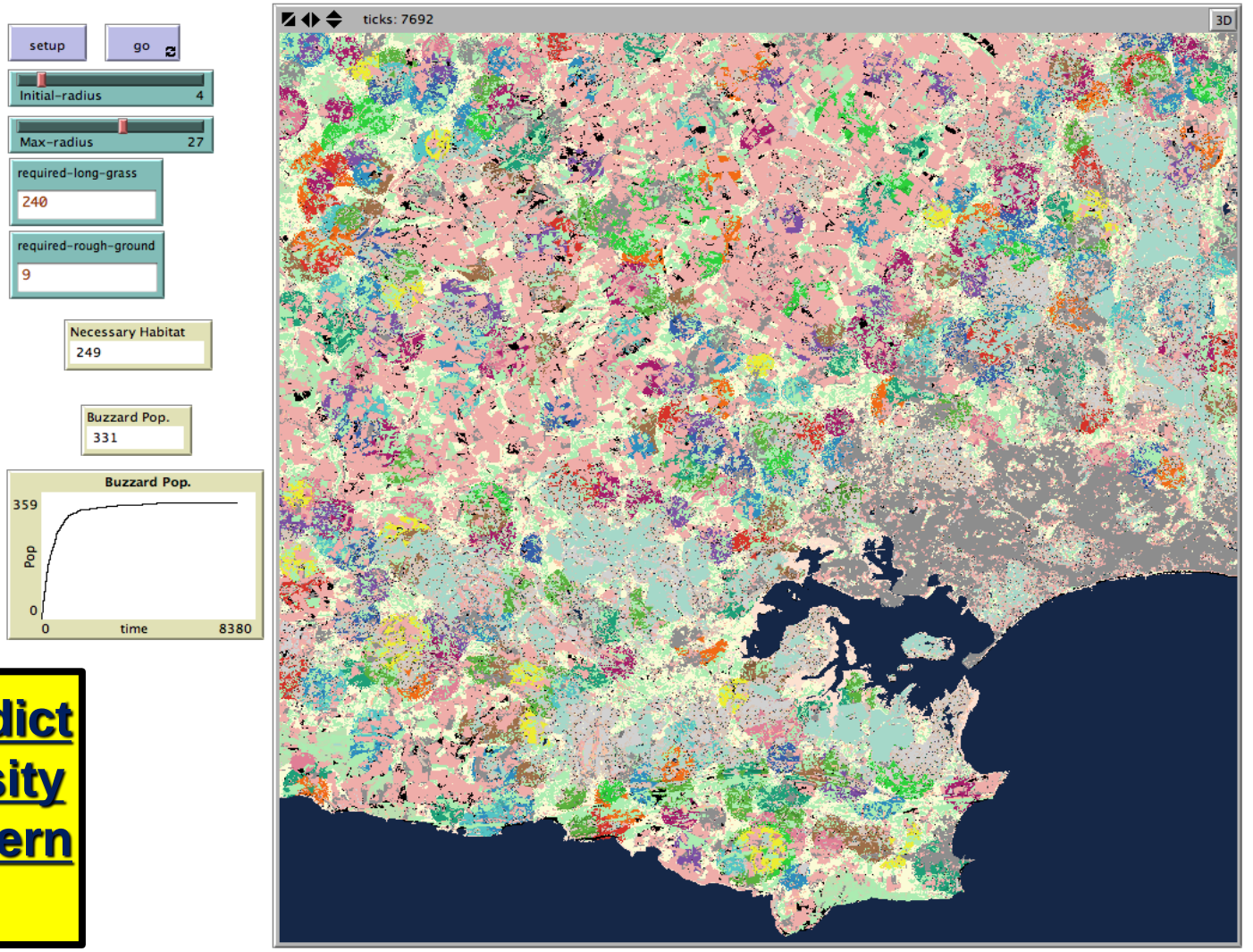
- **RADA:** Range Area Dependence Analysis estimates resource/habitat requirements from relationship of home range structure and placement within the landscape.

Kenward et al. 2018, *PLoS ONE 13: e0206354.*

Arraut et al. 2021, *Proceedings of the Royal Society B*



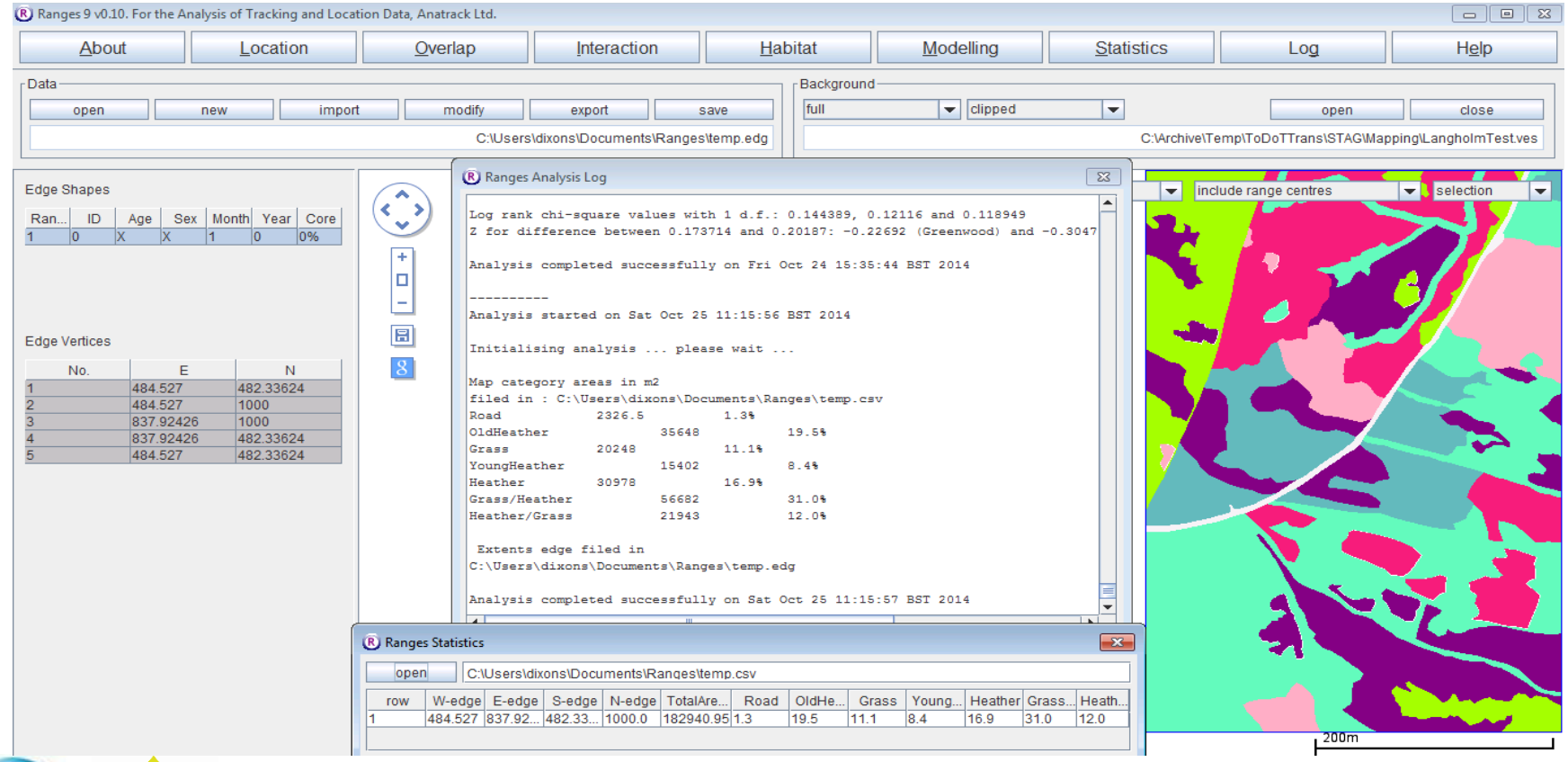

W 2° 12'
72 Real Buzzards
W 2° 03'
72 Simulated Buzzards
Saturated Buzzards.
N 50° 48'
N 50° 35'
N
W
E
S
A
B
C
Rough ground
Woodland
Seasonal long grass meadow
Water
Other
Prediction within observed range
Prediction outside observed range
No prediction in observed range
No prediction outside observed range



Scope to predict buzzard density across Southern Britain

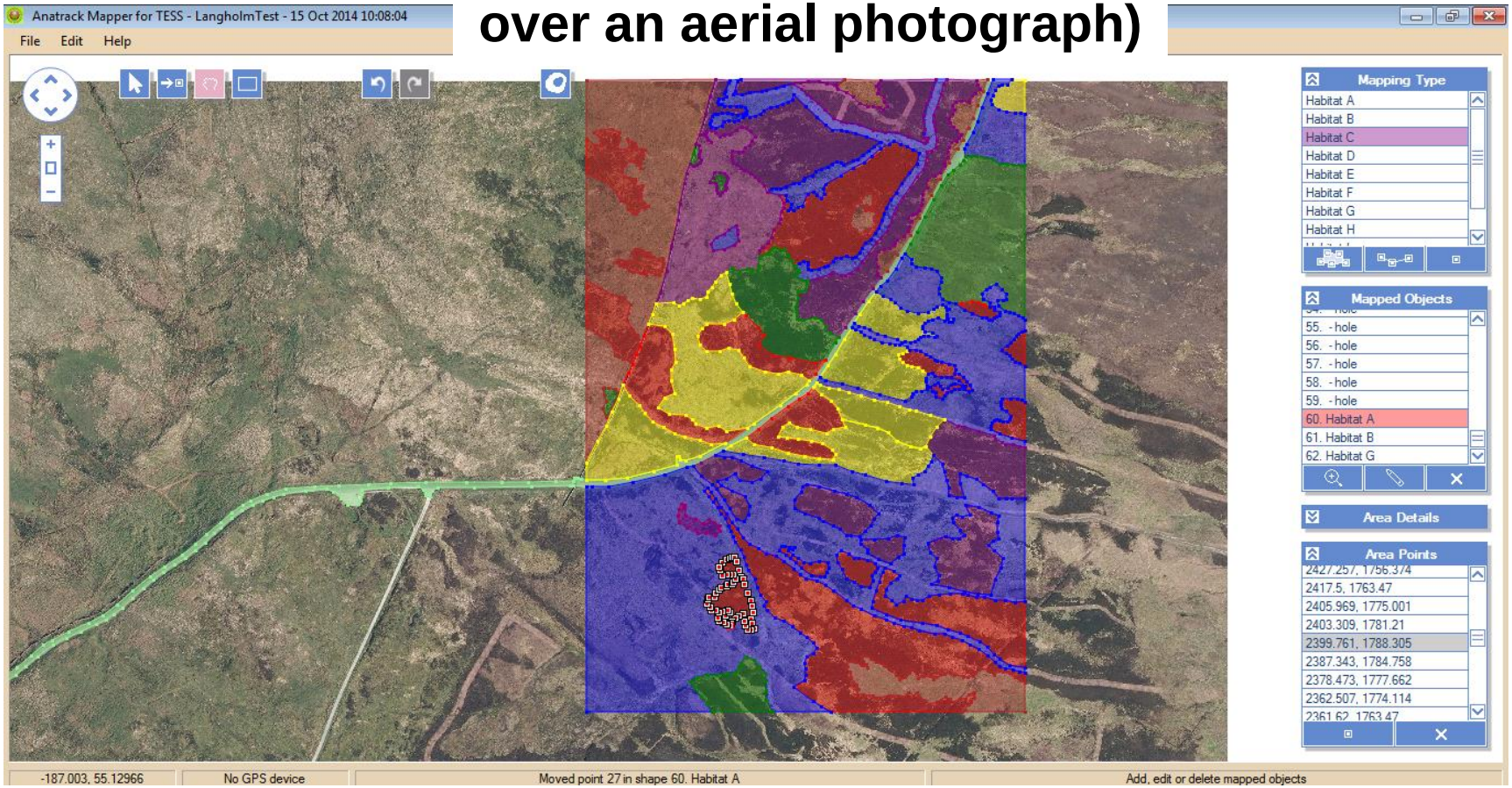
With automated radio-tracking arranged locally, this can lead to predictive modelling to support decisions by local people …

e.g. predictive modelling software to restore game habitats with improved carbon uptake or other Nature-based Solutions

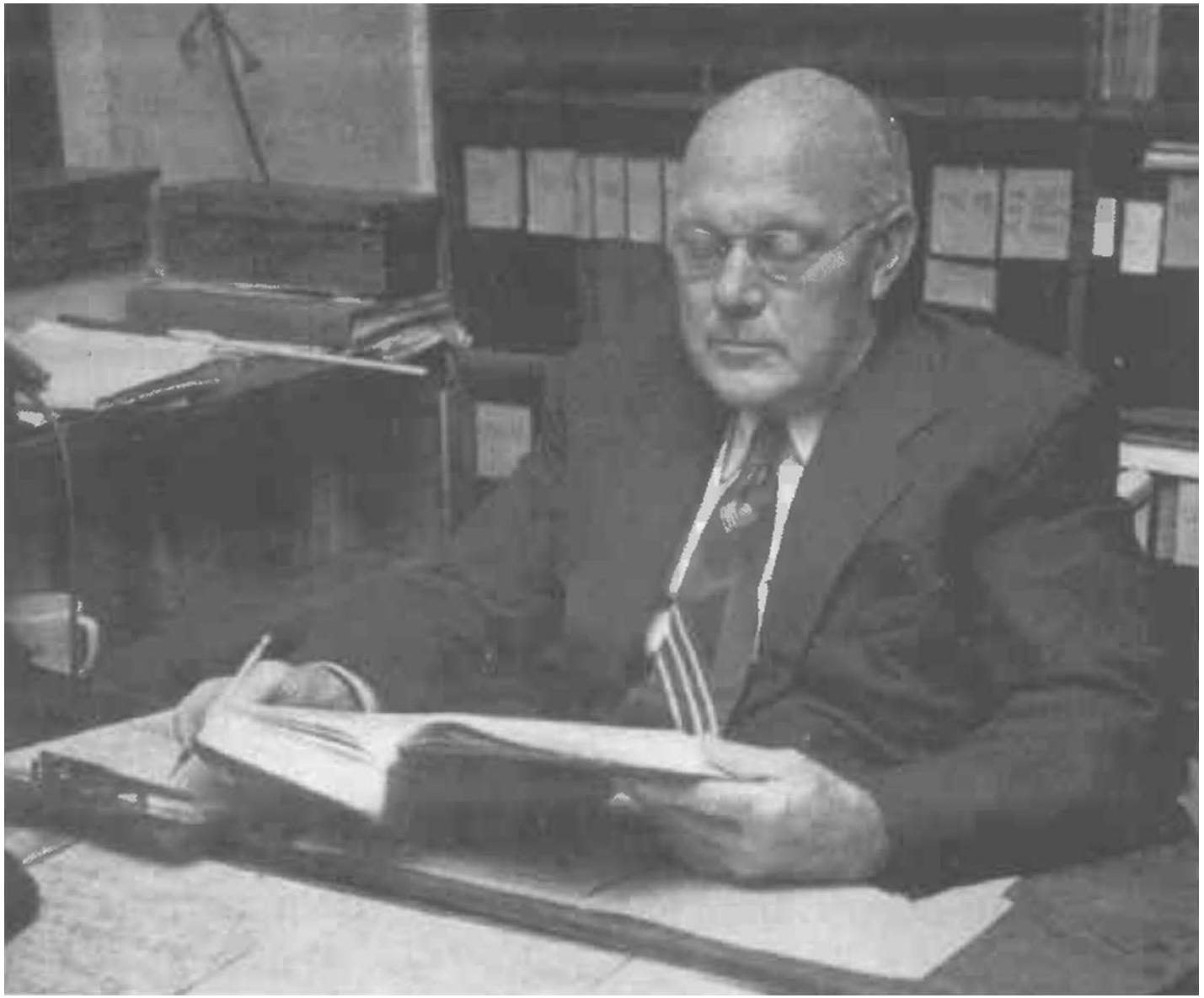


… because case studies have shown that local communities enjoy mapping.

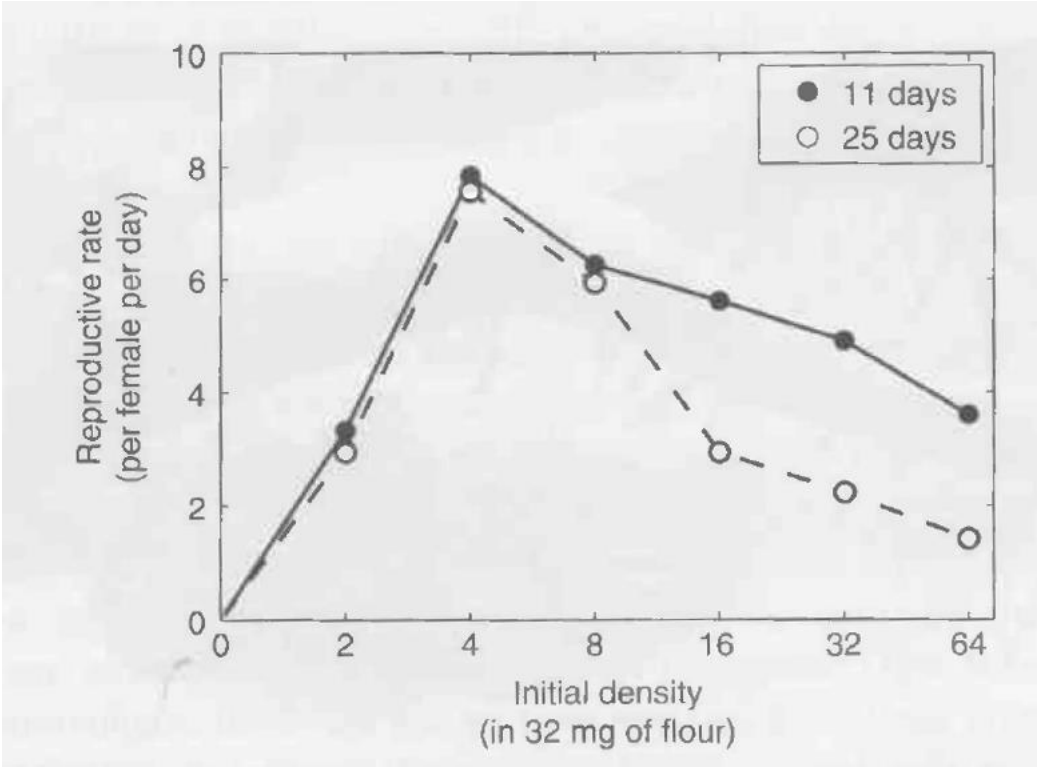
With a multilingual mapping tool (here for grouse habitat mapped over an aerial photograph)



Warder Clyde Allee 1885-1955

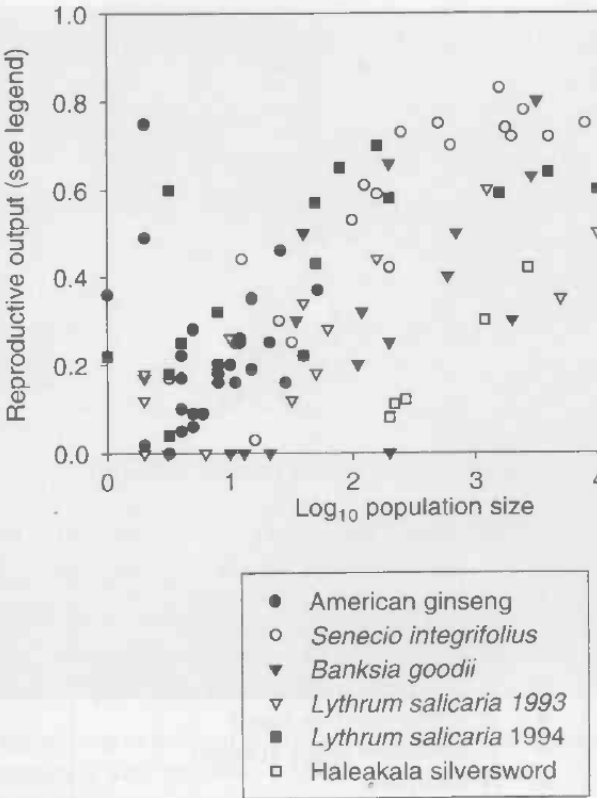


Early experimental work by Allee was on flour beetles (*Tribolium confusum*) and fish



The 'Allee effect' is a decline in fitness of individuals as their density declines, a contrast to classical density dependence in which low density individuals fare best (most resource-share).

Allee effects (clockwise) in plants, moths, caribou



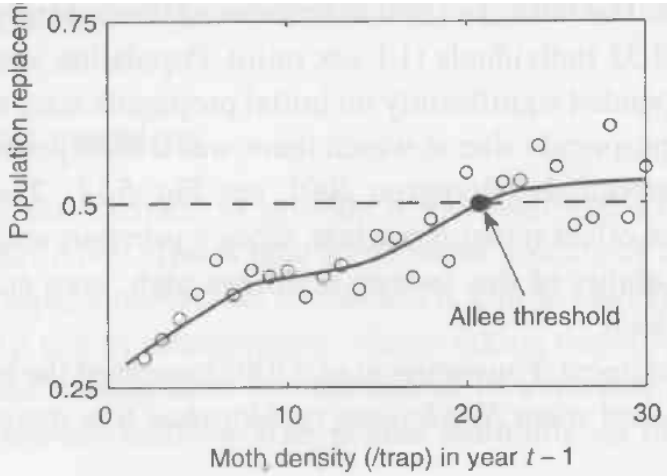


Figure 5.13. The proportional size (P) of the population in year t (y-axis) relative to the population size in year t–1 (x-axis). The Allee threshold at P = 0.5 works out at ~20.7 moths per trap, the carrying capacity at ~673 moths per trap. The bottom panel is a close-up of the low-density populations of the top one. Redrawn from Tobin *et al.* 2007

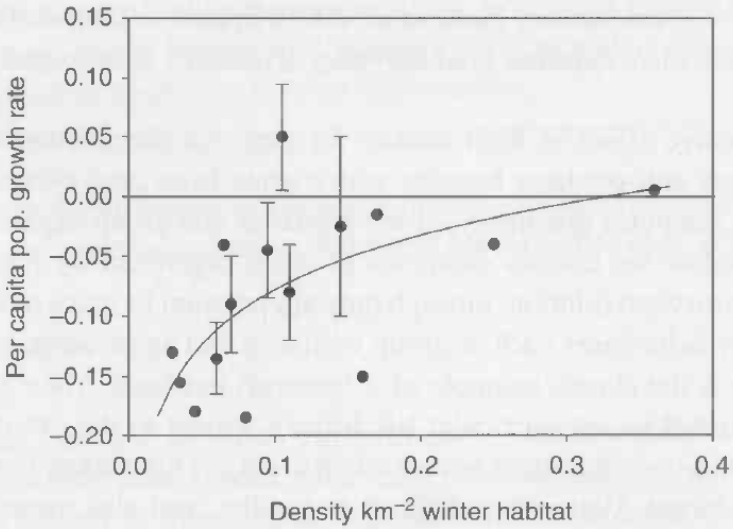


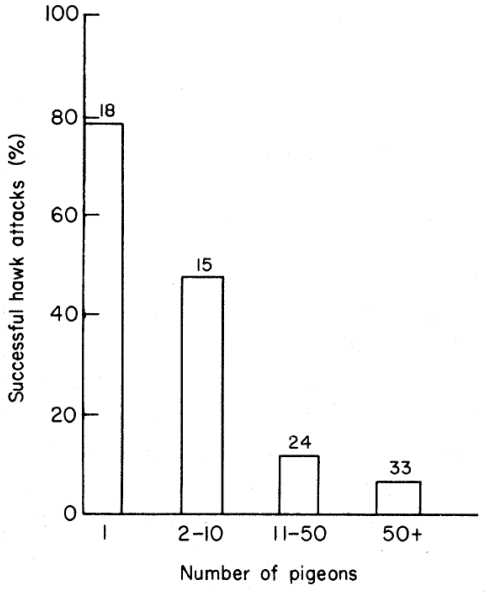
Figure 2.7. Per capita population growth rate of 15 subpopulations of caribou as a function of density in their winter habitat. Predation was the main source of mortality in 11 subpopulations. From Wittmer *et al.* (2005).

Forsyth, S. 2003. Density dependent seed set in the Haleakala silversword – evidence for an Allee Effect. Oecologia 136:551-7.

Tobin, P.C., Whitmire, S.L., Johnson, D.M, Bjornstad, O.N. & A.M. Lienhold. 2007. Invasion speed is affected by geographic variation in the strength of Allee effects. Ecology Letters 10:36-43

Wittmer, H., Sinclair, A. & B. McLellan. 2005. The role of predation in the decline and extinction of the woodland caribou. Oecologia 144:257-67.

Allee effects: predatory mechanisms and results (top); significance in predator & prey reintroductions (below)



The percentage of hawk attacks which were successful at single pigeons and at flocks. Number of attacks is given above histograms.

Kenward, R.E. 1978. Hawks and doves: factors affecting success and selection in goshawk attacks on woodpigeons. J. Animal Ecology 47:449-460.

Angulo, E., Roemer, G.W., Berec, L., Gascoigne, J. & F. 2007. Courchamp. Double Allee effects and extinction in the island fox. Conservation Biology 21:1082-91

Fischer, J. & D. Lindenmayer. 2000. An assessment of the published results of animal reintroductions. Biological Conservation 96:1-11.

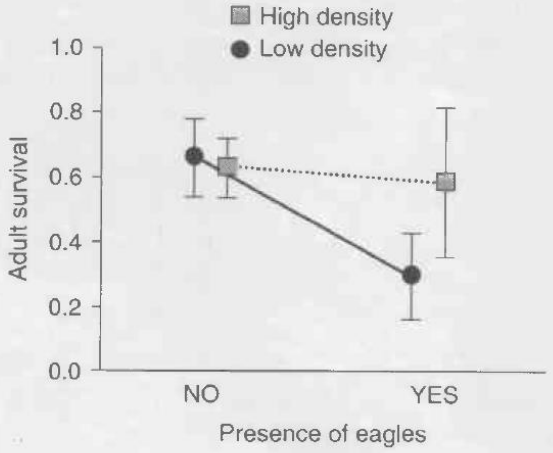


Figure 2.10. Fox populations were classified as high density (squares) and low density (circles). There is a component Allee effect in adult survival (significantly lower survival at low density) but only in the presence of the predator. From Angulo *et al.* (2007).

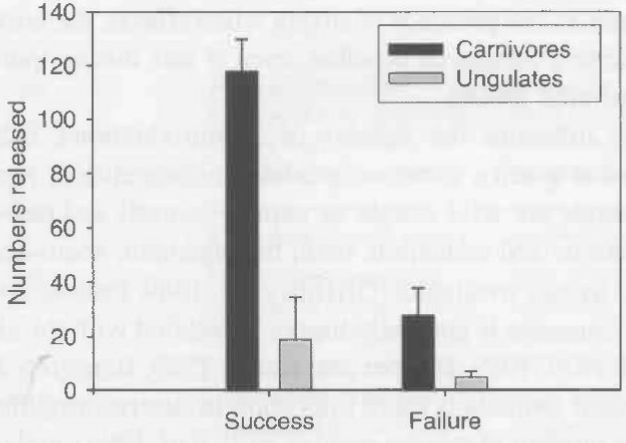


Figure 5.1. Success or failure of reintroductions according to the number of individuals released. For carnivores conclusions on success or failure are taken from the literature, for ungulates from calculating population growth rate (positive = success, negative = failure). From Deredec and Courchamp (2007).

Raptors with Allee effect data

Common Buzzard	Quite strong natal dispersal (10-100 range-widths), philopatric, short pre-breeding dispersal (1-5 r-w), results in rolling-front dispersal not leap-frogging. Small (<8 bird) releases worked only due to priming
Red Kite	Very strong natal dispersal (10-1000 range-widths), very philopatric, pre-breeding dispersal uncertain, results in slow rolling-front dispersal, not leap-frogs. Medium (10-15 bird) releases worked well.
Peregrine Falcon	Natal and pre-breeding dispersal from rings only, recolonisation of south coast from southwest fast. Small (2-4 bird) releases relatively inefficient.
Hen Harrier	Very strong natal dispersal, philopatry, pre-breeding dispersal poorly documented, communal roosts, slow recolonisation, maybe strong Allee effects.
Black H	??? However, if you want to swim where there may be sharks, it's unwise not to think of them!

SUMMARY

1. Background in modelling, from radio-tagging data, of raptor population structure, dispersal and settling.

2. Automated tracking techniques of locally tagged species can enable local modelling on local maps.

3. Warder Clyde Allee developed concept of animal fitness depending positively on animal density.

4. Allee effects can help manage pests, but can also increase extinction risk and hinder reintroductions.

5. There is evidence that Allee effects result from dispersal behaviour of some raptors.

6. This is only evidence, not proof. However, if you want to swim where there are sharks, it’s unwise not to think of them.

www.naturalliance.eu www.sakernet.org
www.perdixnet.org www.naturalliance.org

Allee Effect papers

Courchamp, F., Berec, L. & Gascoigne, J. 2008. Allee effects in ecology and conservation. Oxford University Press.

Forsyth, S. 2003. Density dependent seed set in the Haleakala silversword – evidence for an Allee Effect. Oecologia 136:551-7.

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Courchamp, F., Angulo, E., Rivalan, P. et al. 2006. Rarity value and species extinction: the anthropogenic Allee effect. PLoS Biology 4:2405-10.

Tobin, P.C., Whitmire, S.L., Johnson, D.M, Bjornstad, O.N. & A.M. Lienhold. 2007. Invasion speed is affected by geographic variation in the strength of Allee effects. Ecology Letters 10:36-43.

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