Modelling red squirrel population viability under a range of landscape scenarios in a fragmented woodland ecosystem on the Solway Plain, Cumbria, UK.

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Introduction

The red squirrel *Sciurus vulgaris* (Figure 1) was once widely distributed throughout the UK. However, competition with the North American grey squirrel *S. carolinensis*, disease, habitat loss and habitat fragmentation are all thought to have lead to the extinction of red squirrel populations in southern and central England and the decline in many other populations throughout the UK (Skelcher 1997).

The fragmented woodland ecosystem of the Solway Plain, in Northern Cumbria, still hold a small population of red squirrels. We assess the viability of this population and examine a range of landscape management scenarios.

Figure 1. Red squirrel

Methodology

Woodland usage and red squirrel population density was identified using Gurnell et al's (2001) distance sampling and hair tube methods.

A population viability analysis was undertaken using Vortex version 9.75 (Lacy et al. 2007) to assess the effects of dispersal upon the population.

Biological and Environmental Evaluation Tools for Landscape Ecology 'BEETLE' was used to evaluate the functional connectivity of the woodland fragments creating habitat networks.

The viability of each network was assessed using Vortex. The possibility of connecting habitat networks by adding additional woodland to the landscape matrix was modelled using BEETLE.

BEETLE modelling was used to assess potential grey squirrel movements and Outbreak (Pollak et al. 2002) disease modelling was used to assess the effects of the squirrel poxvirus (SQPV) upon viable populations.

Results

- Red squirrel usage was recorded in 5 of the woodland fragments (10, 13,16, 21and 23 in Figure 2).
- The population density was estimated to be 0.65 squirrels ha^{-1}.
- Dispersal between all woodland fragments was predicted to cause 100% probability of extinction using Vortex, based upon a maximum single dispersal distance of 4km (Table 1).

Figure 2 shows functional connectivity of woodland for the red squirrel using BEETLE, modelled at a dispersal distance of 4km. Dark green areas represent red squirrel habitat, light green areas represent potential dispersal areas. Functional networks are considered to be where the light green areas connect the habitat fragments. The dashed lines highlight the largest networks within the survey area.

Figure 2. BEETLE modelling of functional networks for red squirrel

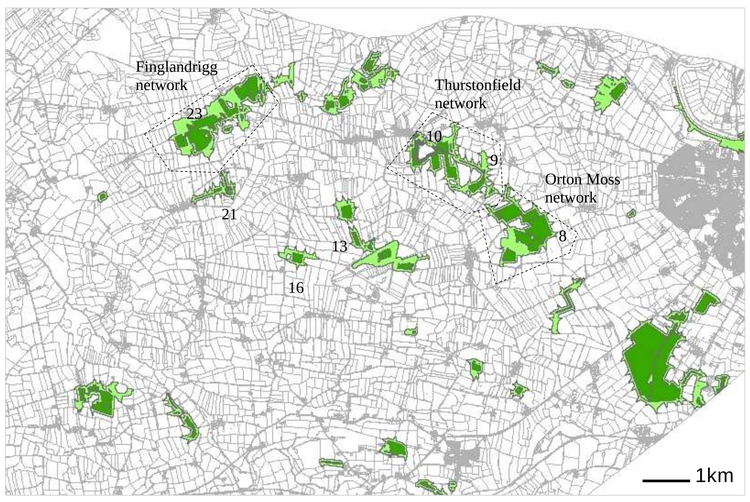

Table 1. Vortex PVA of networks

Scenario	Probability of extinction (under parameters used)
Using only fragments 23 of the Finglandrigg network	80 %
Using all 66ha of Finglandrigg network	13 %
Adding an additional 25ha to the Finglandrigg network (Minimum dynamic area for the Solway Plain is therefore calculated to be 91ha)	1 %
Using all of the Thurstonfield network	100 %
Connecting Thurstonfield to Orton Moss creating a network of 93.98ha	0 %

Figure 3 below shows potential functional connection of networks by including existing woodland which will be mature in 50 years and additional woodland fragments which, if planted now, will potentially aid in future red squirrel dispersal between networks (newly matured and new woodland shown in blue).

Figure 3. Proposed future habitat network for red squirrel.

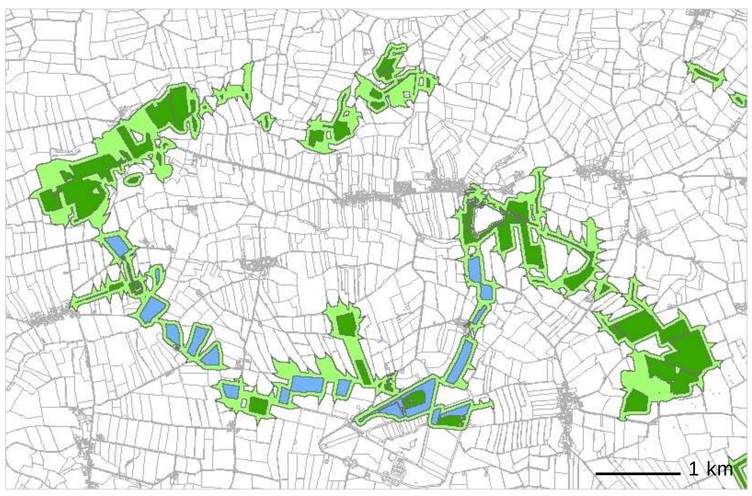

Figure 4 shows grey squirrel habitat networks created using BEETLE at a dispersal distance of 12km. Dark orange areas represent grey squirrel habitat. Functional networks are considered to be where light orange areas connect habitat. The blue arrows represent the possible directions of grey squirrel colonization following the closed linked networks. These areas should be targeted for grey squirrel control.

Figure 4. Grey squirrel habitat network on the Solway Plain

- If the viable populations are exposed to the lethal SQPV the Outbreak modelling has shown both the Finglandrigg network and the connected Thurstonfield and Orton Moss networks would face extinction within one year.

Conclusions

- Modelling the functional connectivity of the woodland fragments on the Solway Plain revealed how highly isolated the woodlands are to the squirrel within this landscape matrix.
- The BEETLE modelling has indicated that squirrels are likely to commute less than 300m between woodland fragments; it is essential, therefore, that each woodland fragment within the networks are connected by land cover that does not hinder potential movement.
- As the MDA was calculated to be 91ha both the Finglandrigg and the joined Thurstonfield and Orton Moss networks will depend upon the red squirrels using the entire available habitat of the networks and small amounts of additional woodland to be viable.
- Planting additional woodland has the potential to functionally connect some networks to create one large network of >200ha however in doing so this would also aid in grey squirrel colonisation of the area increasing the risk of SQPV exposure.
- The two potentially viable networks need to be managed separately to increase red squirrel numbers and movements, whist protecting these population from the incursion of the grey squirrel.

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