Effects of habitat fragmentation on the red squirrel, *Sciurus vulgaris* L.

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**Abstract**

The effects of woodlot size and isolation, in relation to habitat fragmentation, on the distribution of the red squirrel were studied. In The Netherlands, 50 woodlots (0.55–13.78 ha) were surveyed in an agricultural landscape for the presence of red squirrel. In 26 woodlots squirrel dreys (nests) were found. Logit regression analysis showed that woodlot size and the area per woodlot covered with coniferous trees were the best predictors of squirrel presence. Addition of isolation variables by means of a stepwise forward regression method showed significant effects of the distance to a large, permanently inhabited wood and the amount of surrounding wood. No effect was found for the distance to the nearest woodlot (>0.5 ha). The model could be further improved by adding a measure of the amount of hedgerows surrounding a woodlot.

**Introduction**

Animal species use landscapes on different scales. The medium-sized European badger (*Meles meles*) and most birds of prey, for example, roam the whole landscape in search for food. For them, a landscape is a mosaic of more or less suitable habitat elements. On the other hand, small mammals, such as voles and forest-interior birds, are confined to a restricted number of habitat types. For these species a landscape consists of suitable habitat patches separated by unsuitable habitat. Each species will have its own specific response to changes in its landscape.

According to the metapopulation concept (Levins 1970), the probability for a subpopulation to become extinct decreases as patch size is reduced and increases with isolation of patches. On the other hand, probability depends on dispersal capabilities of the species and on distances between patches. Moreover, landscape elements like roads, hedgerows and ditch verges may (positively or negatively) influence dispersal movements between occupied and empty patches. In a metapopulation both local extinction and recolonization events occur continuously. When the recolonization rate of patches cannot keep up with the rate of local extinction, the metapopulation itself becomes extinct and the species disappears from the landscape (Opdam 1988). Species with spatially separated habitat patches are assumed to be most affected by landscape changes resulting in habitat fragmentation, especially when they have a low dispersal rate.

Several studies during the last 20 years have focused on the impact of fragmentation on forest species in agricultural landscapes. Van Dorp and Opdam (1987) found significant effects of woodlot size and isolation on size and diversity of forest bird communities. Similar effects were found for invertebrates (*e.g.* Brönmark 1985; Soesbergen and...
Mabelis 1989). For small mammals, Smith (1974) and Gottfried (1979) found a relationship between the proportion of occupied patches, the isolation of patches and the density of subpopulations for pikas (*Ochotona princeps*) and white-footed mice (*Peromyscus leucopus*). Getz *et al.* (1978) found *Microtus pennsylvanicus* mainly in habitat patches which were connected with roadsides of interstate highways. These roadsides formed important landscape elements for the range expansion of the species. For chipmunks (*Tamias striatus*), fence rows formed crucial corridors for recolonizing empty woodlots (Henderson *et al.* 1985).

Here we investigate effects of habitat fragmentation on the red squirrel (*Sciurus vulgaris* L.). The red squirrel is smaller than the grey squirrel (*Sciurus carolinensis*), which does not occur in The Netherlands. Body and tail measure 21–25 and 15–20 cm respectively. The color varies from red dark brown or almost black, with white underparts. The red squirrel is active during the day and spends most of its time in trees, especially conifer trees, searching for seeds. Dreys or nests are usually built high in the crowns of conifers or, less frequently, in deciduous trees. In The Netherlands the species is common in the forested part of the country. Mature coniferous and mixed forests are preferred as habitat. Pure deciduous wood is inhabited less frequently. Red squirrel habitat in The Netherlands has become more and more dissected into small fragments, especially outside the larger forest tracts. During the last 25 years, the number of small woodlots (0.5–10 ha) has more than doubled, while the total amount of wood has remained approximately the same.

We will relate the distribution of the red squirrel to woodlot size, to several variables pertaining to isolation of the woodlots, and to differences in habitat quality.

**Methods**

The area of investigation (Fig. 1) is situated in Twente (province of Overijssel, The Netherlands). The approximately 150 km² area consists of 7 large woods from 30–200 ha in size, many small woodlots less than 14 ha in size and maize fields and pastures. In part of the area there is a dense network of hedgerows.

There were 60 woodlots of more than 0.5 ha, and all of these were checked for the presence or absence of red squirrels. Only 50 contained suitable squirrel habitat and these were used for the analysis. These woodlots ranged from 0.55–13.78 ha in size. The remaining woodlots consisted of unsuitable habitat (that is, they were alder carrs). The size limit of 0.5 ha is well below the home range size of red squirrel. In Belgium, for example, Wauters and Dhondt (1986) found home range size ranged between 1.52–3.59 ha in large forests with a species composition comparable to our woodlots.

The large woods (>30 ha) were not studied, because they are inhabited permanently, according to data of the National Forest Service. They are assumed to act as sources of squirrels for the area. The area (per woodlot) covered by coniferous trees has been used to represent differences in habitat quality (Table 1). Coniferous trees are the most suitable trees for building dreys, and they provide high energy food nearly all year (Corbet and Southern 1977; Wauters and Dhondt 1987). In our woodlots the Scots pine (*Pinus sylvestris*) is the dominant conifer.

In order to analyze the effects of patch size and