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# Habitat and area use by red fox *Vulpes vulpes* vixens in mid-Norway

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During 1990-91, area and habitat use of three red fox Vulpes vulpes vixens were monitored by radiotelemetry in a mixed cultivated and coniferous forest in the county of Sør-Trøndelag, central Norway. When resting, the vixens occurred mostly in dense and mature spruce forest. In contrast, mixed forest and more open habitats also were visited during hunting. On average, the area used was 4.97 km$^2$ (min. 2.03 km$^2$ - max. 10.24 km$^2$). We propose that individual difference in area use reflect differences in food supply, but breeding behaviour and the restricted mobility associated with it may also play a part.

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## INTRODUCTION

Several investigations of habitat and area use in the red fox *Vulpes vulpes* have been carried out in central Europe and North America (Ables 1975, Zimen 1980, Lloyd 1980, Jones & Theberge 1982, Cavallini & Lovari 1991), which give valuable information about aspects of the behaviour of the species in the wild. However, in Fennoscandia, there is no information on habitat choice (Lindström 1989), and in Norway no information has been published on area and habitat use despite the species being one of the most widespread mammals in the country (Christensen 1990). Such basic knowledge of the biology of a species is important in its own right and may, moreover, be valuable in view of the role the red fox is thought to play in managing small game (Marcström et al. 1989), its relationship to competing predators (Overskaug et al. 1994, Lindström et al. 1995) and as a vector of infectious diseases (Blancou 1988, Overskaug 1994). We aim to go some way towards reducing this lack of information by describing the habitat and area use during the active and inactive behaviour of three radio-collared red fox females inhabiting a mixed cultivated and coniferous forest area at Malvik in the county of Sør-Trøndelag, central Norway (63∞20'N 10∞45'E). Two of the foxes lived mainly in undisturbed areas of natural spruce *Picea abies* forest and the third in and near a housing estate.

## MATERIAL AND METHODS

The foxes were healthy individuals (e.g. free from mange (*Sarcoptes scabiei* var. *vulpes*)) and their behaviour could be expected not to deviate from what is normal (see Borg 1987, Overskaug 1994). Box traps were used to capture the animals for tagging. Monitoring took place as follows (number of fixes in brackets): **fox no. 1**-18 months, April 1990-October 1991 (n = 749); **fox no. 2**-6 months, Januar-June 1991 (n = 311); **fox no. 3**-2 months, May-June 1991 (n = 39). **Fox no. 1** was shot, **fox no. 2** was killed in a road accident and **fox**

**no. 3** lost her collar. The foxes were located by triangulation during series of 24-hour monitoring periods to determine behaviour (Kenward 1987) and also once a week at irregular intervals. Area use was calculated using the convex-polygon method of Mohr (1947), and habitat choice by comparing use with availability (Neu et al. 1974). Six distinct types of habitat were defined (**Table 1**), the first three relating to age-classes of spruce forest and the remainder to other features.

## RESULTS

**Fox no. 1** stayed strictly within the same territory for 18 months (n = 749). The area it used was largest (10.24 $km^2$) during the non-breeding period of 1990-91 (August-February n = 221) and more limited (7.5 $km^2$) from the late-winter and during the summer of 1991 (February-August n = 215). The area was further restricted (5.4 $km^2$) for a short period in early and mid-summer (April-June n = 70). Concerning habitat use, comparison between active (n = 521) and inactive (n = 228) behaviour indicated that cultivated ground ($p < .0001$) and mixed forest ($p < .01$) were frequently used, and young forest ($p < .0001$) and bogs ($p < .05$) were avoided during active periods. For diurnal resting, almost the opposite picture was found, with older ($p < .001$) and young ($p < .05$) forest being preferred, and cultivated ground ($p < .01$) and mixed forest ( $p < .05$) being avoided. Bogs were in general avoided and clear-felled areas were preferred (**Table 1a**).

**Fox no. 2** roamed within the same area (totally 2.63 $km^2$) during the six months it was monitored (January-June n = 311), using only slightly less of the area in mid-summer (2.5 $km^2$) (April-June n = 200). When active (n = 178), this vixen preferred old ($p < .0001$) and mixed ($p < .0001$) forest, but when inactive (n = 133) a very strong preference for the older forest ($p < .0001$) was found. Cultivated ground was generally avoided ($p < .0001$) (**Table 1b**).

Data for **fox no. 3** are limited (n = 39), but she used a 2.03 $km^2$ large area during the two summer months in which she was monitored (May-June n = 39), and she mostly remained in a rocky area dominated by mature forest (**Table 1c**).

## DISCUSSION

Previous studies of habitat use in the red fox have indicated that the species generally prefers mature forest (Lloyd 1980, Jones & Theberge 1982), also for denning (Weber 1985, Pacquet & Libois 1986). Overall, this is in accordance with our results in that all three vixens, in two instances strongly significantly, mostly occurred in relatively old forest, particularly when resting. **Fox no. 1** also used young forest for resting. A principal reason that the red fox rests in relatively old and young spruce forest may be that both these types of habitat are very dense throughout the year, thereby providing good cover during day-time resting. Hardwood forest, in contrast, lacks foliage for much of the year, resulting in a more open habitat with less cover. Favourable thermic conditions and/or adaptation to, for instance, hunting pressure, may therefore explain this tendency to live in dense spruce forest. Another possible explanation for selecting old, undisturbed forest is the location of dens in this type of habitat. This was the case for **fox no. *2***, since we were able to identify a denning site and prove reproduction (three cubs) in one of her preferred old forest localities. **Fox no. 1** probably also reproduced in an old forest locality, at least the second summer she was monitored, but her assumed den was situated such that we were unable to make reliable observations without disturbing the possible occupants.

***Table 1.*** *Habitat use during active (nocturnal hunting activity) and inactive periods (daytime resting) in three radio-collared red fox vixens in a cultivated and coniferous forest area in central Norway. The habitats are defined as: 1) clearings, 2) young spruce forest (3-10 m), 3) older forest (ready for harvesting), 4) bogs, 5) cultivated fields, and 6) mixed forest, mainly consisting of aspen (*Populus tremula*) and birch (*Betula pubescens*). A) Red fox no. 1 (monitored Apr. 1990-Oct. 1991, fixes n = 749), B) Red fox no. 2 (monitored Jan.-June 1991, fixes n = 311), C) Red fox no. 3 (monitored May-June 1990, fixes n = 39).*

**A) Red fox no. 1.**

| Habitat | Area | Active fixes | | | Inactive fixes | | |
|---|---|---|---|---|---|---|---|
| | da | n: | t | p: | n: | t | p: |
| 1 Clear cuttings | 525 | 42 | 3.039 | 0.05 | 28 | 4.899 | 0.0001 |
| 2 Young forest | 4176 | 139 | -6.544 | 0.0001 | 98 | 0.680 | 0.05 |
| 3 Older forest | 2379 | 125 | 0.414 | n.s. | 79 | 4.048 | 0.001 |
| 4 Bogs | 1146 | 35 | -3.237 | 0.05 | 1 | -5.149 | 0.0001 |
| 5 Cultivated fields | 695 | 86 | 8.823 | 0.0001 | 1 | -3.811 | 0.01 |
| 6 Mixed forest | 1322 | 94 | 3.497 | 0.01 | 21 | -1.665 | 0.05 |
| Total | 10243 | 521 | | | 228 | | |

**B) Red fox no. 2.**

| Habitat | Area | Active fixes | | | Inactive fixes | | |
|---|---|---|---|---|---|---|---|
| | da | n: | t | p: | n: | t | p: |
| 1 Clear cuttings | 0.1 | 0 | - | - | 0 | - | - |
| 2 Young forest | 25 | 0 | - | - | 0 | - | - |
| 3 Older forest | 165 | 46 | 10.767 | 0.0001 | 97 | 31.703 | 0.0001 |
| 4 Bogs | 0.1 | 0 | - | - | 0 | - | - |
| 5 Cultivated fields | 1717 | 30 | -13.577 | 0.0001 | 1 | -15.631 | 0.0001 |
| 6 Mixed forest | 723 | 102 | 8.910 | 0.0001 | 35 | -0.3020 | n.s. |
| Total | 2630 | 178 | | | 133 | | |

**C) Red fox no. 3**

| Habitat | Area | Total fixes | | |
|---|---|---|---|---|
| | da | n: | t | p: |
| 1 Clear cuttings | 332 | 1 | -2.328 | n.s. |
| 2 Young forest | 318 | 2 | -1.810 | n.s. |
| 3 Older forest | 987 | 22 | 0.973 | n.s. |
| 4 Bogs | 70 | 13 | - | - |
| 5 Cultivated fields | 140 | 1 | - | - |
| 6 Cultivated fields | 183 | 0 | - | - |
| Total | 2030 | 39 | | |

In contrast to their conservative behaviour when resting, the foxes showed more flexible strategies when choosing the habitat they used when hunting. **Foxes no. 1** and **2** showed a strong preference for mixed forest and **fox no. 1** also for cultivated fields and clear-felled areas. Mixed forest may act as a corridor when foxes are hunting. It probably also offers a high abundance of prey, as indicated by catch indices for rodents in the study area (Overskaug unpublished). In summer we were able to directly observe the great success of the foxes when hunting young fieldfares (*Turdus pilaris*) in the mixed forest (Overskaug unpublished). Fieldfares often nest in colonies in mixed forest and non-fledged young sitting on the ground represent an obvious, easy and valuable resource for the predator. On several occasions, we also observed **fox no. 1** hunting rodents in cultivated fields and clear-felled areas.

Several authors have reported that fox territories are larger in rural than in urban or suburban areas (Lindström 1982, Voigt & Macdonald 1984). Our impression of area use in **fox no. 1**, which mainly lived in continuous spruce forest and altogether roamed over more than 10 $km^2$ compared to **fox no. 2** which lived in an urban/suburban area using less than 3 $km^2$, may offer general support for this relationship. A key underlying factor determining territory size is access to food (Macdonald 1983, Carr & Macdonald 1986) - the less food available, the larger the territory required. One explanation for the smaller territory in **fox no. 2** may therefore be more stable access to food in her area compared to forest habitats with fewer houses. We believed that garbage might represent an important food resource for **fox no. 2** and we ocasionally observed her feeding upon garbage or visiting localities where household food remains were accessible. Moreover, garbage as an important food resource for suburban foxes is reported from France and Britain (Brosset 1973, Harris 1981).

However, in the summer, at least in 1991, the area used by **fox no. 1** was nearly half that used on a year-round basis, probably due to denning and the restricted mobility associated with it. Therefore, in addition to the effect of the resource distribution factor, we suggest that seasonal variation in area use and behavioural adaptations related to it should be taken into account when comparing the size of territory used by different individuals.

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## SAMMENDRAG

### Habitat- og arealbruk hos rødrevtisper i Midt-Norge

I Malvik kommune i Sør-Trøndelag fylke, ble i 1990-91 tre rødrevtisper *Vulpes vulpes* L. studert ved telemetri. Hvile-habitatet var generelt knyttet til barskog med gode skjulmuligheter, men ved jakt ble også blandingsskog og åpne områder visitert. Arealbruken var i gjennomsnitt 4.97 $km^2$ (2.03 $km^2$-10.24 $km^2$). Vi foreslår at næringstilgang, samt spesielle omstendigheter som forplantning, kan være av betydning for individuell størrelsesforskjell på leveområder.

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