

**The Ecology of the Red Fox (*Vulpes vulpes*)
in the Central Tablelands
of New South Wales**

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A thesis submitted in fulfilment of the requirements of the degree of Doctor of
Philosophy in Applied Science at the University of Canberra

November 2000

For Moya Lenore Farrell
1940-2000

This thesis is my original work and has not been submitted, in whole or in part, for a degree at this or any other university. Nor does it contain, to the best of my knowledge and belief, any material published or written by another person, except as acknowledged in the text.

Mani Berghout
November 2000

ACKNOWLEDGEMENTS

First and foremost I would like to thank my supervisors Jim Hone and Glen Saunders for their guidance, feedback and enduring patience at all stages of the project.

This research was funded by the Vertebrate Biocontrol Cooperative Research Centre, with logistical support from NSW Agriculture.

I thank the landholders and their staff in the Murringo district for access to their properties and for keeping an eye out for my wellbeing, in particular Dugald and Jeannie Walker and Richard and Judith Taubman. Col Walker provided me with a place to lay my weary head and a well-stoked fire.

A big thankyou to the staff of the Vertebrate Pest Research Unit in Orange for hours of trapping, radio-tracking and spotlighting, in particular Barry Kay, Geoff Quinn, Daryl Heffernan, Sylvana Maas and Lynette McLeod. I also thank Peter Fleming for practical advice on field techniques. Roy Winstanley supplied fox stomachs and Jan Martin helped pick through them. Chris (I'm sorry, I don't know your surname) was a wonder at shooting foxes at the completion of the project. Thankyou also to the wider community for returning tagged foxes. Bob Berghout provided mathematical genius in unravelling the mysteries of fox activity rhythms and David Judge and Kerry Beggs provided statistical advice.

I am eternally grateful to Dannielle Denning, Jan Martin, Sylvana Maas and Lynette McLeod for being such great company on long stretches in the field and wonderful help on numerous tasks from spotlight counts and radio-tracking to locating dens and monitoring rotting lambs. Thankyou to the many volunteers who did such a sterling effort on the 24-hour radio-tracking sessions. Pete West valiantly proofread great slabs of thesis at short notice.

The mutual support of postgraduate students at the Applied Ecology Research Group at the University of Canberra, the Vertebrate Biocontrol CRC and the Vertebrate Pest Research Unit kept me sane, and I thank you all for being such excellent company for bouncing ideas and providing frivolous distractions.

I thank my parents for their unconditional support and encouragement throughout the entire project, and for their belief in my abilities. I am also indebted to Anne Cawsey and Bronwyn Goody for their incredible confidence-boosting abilities.

And of course Dave Hunter, for love, support and complete confidence in me.

ABSTRACT

The red fox occurs across a very broad range of habitats, and displays great behavioural flexibility under different environmental conditions. In Australia, mounting concern over the impacts of foxes on livestock and native fauna has highlighted a need for more information on fox ecology under Australian conditions as a fundamental step towards developing more strategic means of managing foxes. This study explores ranging behaviour, dispersal, use of dens, activity rhythms, population dynamics and diet in the absence of management in productive agricultural land in the central tablelands of New South Wales.

The study was conducted from June 1994 to June 1997 on private property near Murringo, NSW Australia (34°15' S, 148°30' E). The site was primarily sheep and cattle grazing land and had a history of no fox management. Rainfall was considerably below average for much of the study.

A total of 83 foxes were trapped over 3931 trapnights, of which 50 were fitted with radio-collars (23 adult and 6 juvenile females, 12 adult and 9 juvenile males) and 26 released with eartags only (all juveniles: 10 females, 16 males). Thirty-three foxes were radio-tracked using fixed towers between March 1995 and December 1996, with between 11 and 28 foxes tracked at any time. Mean home range size was 446.1 ha \pm 69.8 se using 95% Minimum Convex Polygons (MCP), and 276.4 ha \pm 36.3 se using 95% kernel utilisation distributions. Male home ranges defined by MCP were significantly larger than female ranges, but no significant difference was found using 95% kernels. Core ranges were estimated to be 133.4 ha \pm 23.7 se using 50% MCP and 59.8 ha \pm 6.1 se using 95% kernels, with no significant difference between sexes. No significant differences were found between range sizes of adults and juveniles or between years or seasons. While most home ranges were steady for the duration of the study, some foxes were observed to shift range location and 4 foxes displayed nomadic behaviour for at least some of the study. There was a high incidence of overlapping home ranges, most commonly between females or males and females but occasionally between males, but core areas were usually separate. Fully overlapping core areas were observed in 1995 but not in 1996.

Juvenile foxes were significantly more likely to disperse than adults, and usually travelled further (juveniles 61.1 km $31.6 \pm se$; adults 5.9 km $1.1 \pm se$). Males and females were equally likely to disperse, and there was no significant difference in the distance travelled. The furthest distances were 285 km and 140 km, but mean distance of dispersal excluding these animals was 12.3 km $\pm 4.3 se$ ($n = 13$).

Thorough surveys across a 16.4 km² area located 200 dens, with 68 of these active in 1995 and 96 active in 1996. Density of breeding foxes was estimated to be 0.55 and 0.52 adult foxes/km² in 1995 and 1996 respectively based on natal den counts. Density estimates based on active den counts, which include non-breeding foxes, were 0.91 and 1.30 foxes/km² in 1995 and 1996 respectively. These estimates appear lower than other studies in similar habitats but this is likely due to using a half home range boundary strip around the surveyed area in the present study. Application of mark-recapture analysis found very high 'recapture' rates of dens and gave a similar estimate of the total number of dens to that observed directly. Natal dens were regularly distributed across the study area, whereas active dens tended to be in clusters. There was a high turnover of which dens were used each year, but the total number of natal dens was similar across years (16 in 1995 and 17 in 1996). Natal dens were more likely to be used on repeat occasions than other dens, but not necessarily by the same vixen. Litter size based on sightings of emergent cubs was 2.8.

Foxes were predominantly nocturnal, with a major peak in activity about an hour after sunset. A new method of analysing activity rhythm data using Fourier series to mathematically describe animal movements was developed, that allowed systematic identification of the cyclical components underlying overall movement patterns. General fox behaviour could be clearly described by a 24-hour and a 12-hour cyclical component when corrected for variation in daylength. The rising and setting of the sun appeared to be a major trigger underlying movement patterns. Seasonal and sex differences were observed in patterns of activity.

The annual rate of increase of the fox population was found to vary around a mean of zero between June 1994 and June 1997. A major drop in fox numbers as estimated by spotlight counts occurred in the second half of 1995, but numbers recovered by the

end of 1996. Kaplan-Meier analysis of radio-tagged foxes found annual adult survival was generally very high (0.56-0.96) with lowest survival between July and October. Causes of mortality were human-related outside the site and apparently of natural causes within the site. However foxes dying of natural causes outside the site were unlikely to be found. There was no overall movement of foxes into or out of the site. Immigration was detected following the drop in fox numbers in late 1995, but there was no evidence of immigration prior to this period although emigration occurred.

A sensitivity analysis was conducted on the effects of a small change in life history parameters on finite rate of increase using published data as well as adult mortality data from the present study. The two most influential life-history parameters were adult and juvenile survival, while changes in fecundity and age at first reproduction had much less impact on finite rate of increase. In terms of management, in which fertility control is being considered as an alternative to lethal control, this implies that a small change in fecundity may cause less change in the rate of increase of foxes than lethal control.

Foxes were culled in June 1997 on completion of the study. Estimated density using a Petersen estimate was 2.4-5.3 foxes/km² and index-manipulation-index was 1.4-3.2 foxes/km². The different methods used to cull foxes appeared to target different age groups within the population, and were generally biased in favour of younger foxes. Success at killing animals was low, leading to large standard errors in the population estimates.

Stomachs of foxes shot in the Orange district were found to contain predominantly rabbit and carrion, with invertebrates present when abundant. These findings were not strictly representative of the diet of foxes in the study area, where rabbits were scarce. Foxes scavenged heavily on lamb carcasses within the study site. The quantity of fresh lamb carrion removed from a lambing paddock in winter 1996 was estimated to support 13-24 foxes, with available fresh lamb theoretically able to support 240-440 foxes. Density based on removal of fresh carcasses was estimated to be 0.83-1.5 foxes/km².

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