CHAPTER 5

LANDHOLDER BAITING COORDINATION CASE STUDY- MOLONG RURAL LANDS PROTECTION BOARD

5.1 Introduction

Fox control is undertaken on agricultural and conservation lands for the control of fox impacts, commonly for reducing unwanted predation on domestic stock and native species. A variety of techniques is utilised for fox control in Australia (see Chapter 1), but the most common method is poisoning with 1080-impregnated baits. Baiting for foxes is encouraged by various State government agencies (including NSW Department of Primary Industries (NSW DPI), NSW Department of Environment and Conservation (DEC), and Rural Lands Protection Boards) and is often presented as an effective means of reducing fox-associated damage on lands where baiting is undertaken. However, for reasons including bait caching (Chapter 3) and bait degradation (Chapter 2), current baiting methods may suffer from some inefficiencies. Additionally, insufficient spatial or temporal coverage of baits at a landscape scale is likely to reduce the effectiveness of baiting campaigns.

Fox populations are not static; births, deaths and seasonal patterns of dispersal result in constant changes in dynamics (Harris and Trewhella 1988). Most dispersal occurs in juvenile males from late summer until early winter (Saunders *et al.* 1995), although adults are also known to undertake long range movements to establish or extend territories (Zimen 1984). Such movements result in the rapid recolonisation of areas where foxes have been removed (e.g. Bogel *et al.* 1974; Kinnear *et al.* 1988; Saunders *et al.* 1995) through the creation of a 'dispersal sink'. Undertaking more frequent control and/or targeting a greater control area are possible strategies that could increase the effectiveness of baiting, and reduce the potential for immigration into critical areas. Undertaking further control in an additional area or buffer surrounding the area to be protected has also been shown to be effective in reducing wild dog and fox immigration into central core areas (Thomson *et al.* 1992; Thomson *et al.* 2000). Coordinating baiting campaigns with a number of landholders is also recommended to increase the effective baited area through greater participation and peer pressure. This in turn increases the effectiveness of baiting through reductions in fox density over a greater area, reducing 'edge-effects' and immigration into core areas.

Undertaking baiting outside a landholders cadastral (property) boundary requires unconditional cooperation with neighbours, which may not always be possible. Many landholders will not use 1080 due to a perceived lack of need to bait (e.g. cattle producers), or concern over possible impacts on not-target species such as wildlife or working dogs. To confront these perceptions, and attempt to encourage greater coordination of and participation in fox baiting programs, the 'Outfox the Fox' program (Outfox) was initiated by NSW DPI in 1999 (Balogh *et al.* 2001).

'Outfox' is the largest strategic group baiting program in New South Wales with landholders from six Rural Lands Protection Boards (RLPBs) (Young, Condobolin, Forbes, Central Tablelands, Molong and Dubbo) participating (Balogh *et al.* 2001). The program promotes the use of best practice management including replacement baiting, baiting at least twice per year and synchronising baiting with adjoining landholders (Balogh *et al.* 2001). As part of 'Outfox', landholders are encouraged to undertake fox baiting during two critical periods – autumn and spring. These periods target juveniles during dispersal (March) and vixens when searching for additional food whilst young are in the den (September) (Balogh *et al.* 2001). These periods also generally coincide with the autumn and spring lambing peaks to provide protection for flocks when they are most susceptible (Bailey 1996; Armstrong 1997).

The 'Outfox' program was initiated and then actively promoted through media releases, radio and television interviews and personal meetings between RLPB staff and landholders during 1999 and 2000. Since 2000, promotion by RLPB staff has been the only vehicle to encourage participation in the program. Early landholder surveys in 2001 suggest that the program was effectively increasing the number of landholders who were undertaking cooperative baiting (Balogh *et al.* 2001); however no subsequent assessments have been undertaken.

There are 48 RLPB districts in New South Wales as established under the *Rural Lands Protection* Act (1998). The core functions of the RLPB system are to protect the community from exotic and endemic animal disease, support and regulate the control of pest animals and insects, and manage and maintain travelling stock reserves (Lane 1998). Each board is funded by rural rate-payers through an annual fee to support these activities. Regulation of the pest animal control activities undertaken by rate-payers is an important RLPB function. Each RLPB is responsible for regulating the supply and use of 1080 baits for pest animal control undertaken on lands within their jurisdiction. This ensures that each RLPB can offer sound assistance and advice based on local knowledge, and facilitates monitoring and regulation of which control activities are undertaken. Therefore, the RLPB system provides a source of records for the tracing of 1080 use for fox control within each RLPB area. NSW DPI, as the 1080 permit holding authority for New South Wales, is responsible for auditing the use of 1080 to ensure that it is used responsibly.

This chapter assesses the spatial and temporal coverage of fox baiting in the Molong RLPB area to demonstrate the perceived effectiveness of current cooperative fox management practices. Molong RLPB was chosen as a case study since it was a key RLPB involved in the 'Outfox' program, and previous fox ecological studies undertaken in the area provide data allowing fox dispersal and potential for immigration to be estimated (Saunders *et al.* 2002a). One of the principal aims of this chapter is to demonstrate the effectiveness of current fox management using scientific method. Currently, the effectiveness is only demonstrated through perception; the number of baits laid, number of landholders undertaking baiting and area of land baited. Such perceptions may not necessarily correlate with the number of foxes killed. Nevertheless the spatial assessment of fox control within a RLPB provides a valuable estimate of the effectiveness of fox control strategies on a landscape rather than individual property scale. This chapter investigates trends in baiting practices, reports levels of coordination amongst landholders and models the effect of fox immigration into baited areas.

5.2 Methods

5.2.1 Study area

The Molong RLPB area is situated on the western side of the central tablelands of New South Wales, encompassing an area approximately 189 km long and between 20 km and 83 km wide at the narrowest and widest points respectively (see Figure 5.1). The area totals 815,382 ha which is divided into 49,149 individual parcels of land within the Orange, Cabonne and Parkes local government areas. The Molong RLPB services a total of 2403 ratepayers (as at 2002) within its boundaries.

The climate is typically temperate with cool to cold winters and warm to hot summers (Saunders *et al.* 2002b). Rainfall is neither winter nor summer dominant but average annual rainfall and reliability declines along an east-west gradient. (see Chapters 1 and 2).

The area produces a diverse range of agricultural goods with the eastern, higher altitude regions predominantly associated with horticultural enterprises such as apple, pear, cherry and wine-grape production with wool, sheep and cattle production and winter cereal cropping more common in the central and western regions (Dwyer 1978; Australian Bureau of Statistics 2003). Most suitable farming and grazing country has been cleared, although some remnant patches of dry sclerophyll forest and woodland remain (Saunders *et al.* 2002b).

5.2.2 Data collection and collation

When land managers are issued with products containing 1080 the details of each transaction must be recorded in the 1080 poison register which is audited by NSW DPI. Each record specifies details including name and property address of the land manager, the number and type of baits purchased, and the area to be poisoned. All records of the landholders undertaking fox control within the Molong RLPB from January 1998 until December 2002 were collated and entered into an Access (Microsoft®) database. Records were checked to ensure that property boundaries and ownership details were accurate through consultation with Molong RLPB and the NSW Department of Lands. The name and property address from the 1080 register were then matched to the property details from the Rural Lands Protection

Board database (TFS2®), and in turn matched to unique property identifiers (comprising either Parish and Portion, Lot and Deposit Plan (DP), or Property identity) through select queries in Valnet®, the cadastral database of the New South Wales Valuer General's Department. The unique property identifiers are spatially referenced to cadastral data, which identifies the appropriate polygon within New South Wales. The cadastral data were then imported into a GIS application (Arcview®) to facilitate spatial analyses.

Landholder enterprise information was collated from land and stock returns collected by Molong RLPB. This information quantifies livestock production for each landholder. New South Wales Department of Environment and Conservation and State Forests provided information on the timing and location of baiting campaigns undertaken on conservation and forest reserves respectively.

5.2.3 Spatial coverage and gaps

Data from individual land parcels were assessed spatially in Arcview® to determine whether each landholder was undertaking fox control individually or in coordination with surrounding neighbours. Landholders were considered to have undertaken coordinated baiting if a neighbouring landholder (a landholder whose block of land was situated not greater than 500m from the boundary) completed a baiting campaign within the same month. A coded Arcview® extension (ID Within Distance®, Jenness Enterprises, August 2003) was used to identify neighbouring properties that had undertaken baiting within the same month. The area of properties baiting within each specified period was calculated using functions in the extension Xtools® (M. Delaune, September 2003).

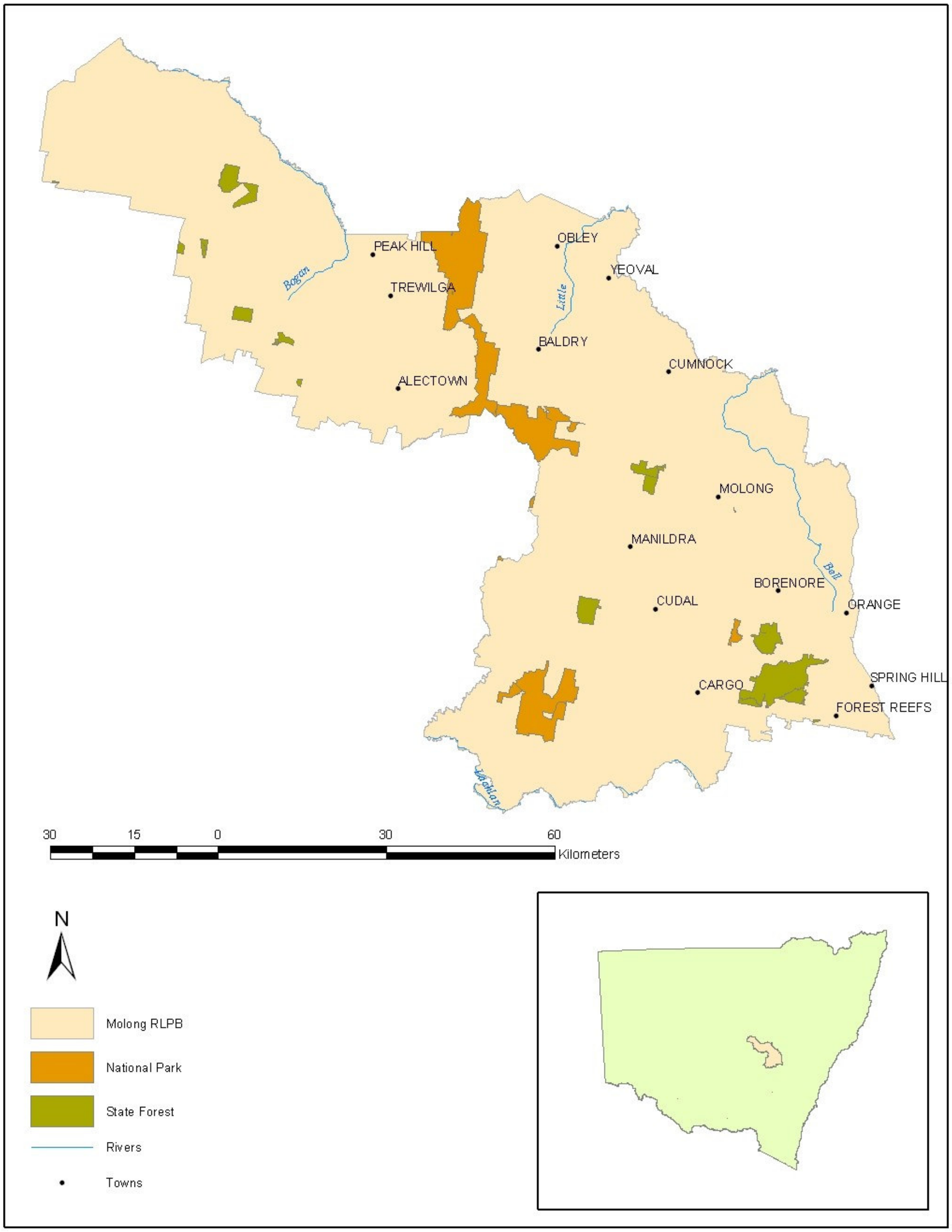

Figure 5.1: Location of the Molong Rural Lands Protection Board within New South Wales (inset)

5.2.4 Bait type and baiting frequency

Landholders purchased either fresh chicken heads or the commercially manufactured Foxoff® from Molong RLPB. Landholders could use fresh meat but had to supply the meat to the RLPB for injection.

A baiting campaign was defined by the supply of baits to a landholder during a month. Baits supplied to a landholder on multiple occasions within the same month were considered to be part of the same baiting campaign; a reasonable assumption given that landholders will often purchase baits to replace those baits that are removed or degraded during a baiting campaign.

5.2.5 Fox immigration into baited areas

The likely effectiveness of fox control for reducing immigration was explored for each continuous baited area by investigating the potential for fox immigration. For modelling purposes it was assumed that areas where fox control had been undertaken were fox-free, and areas where no control was undertaken contained foxes. The potential for immigration is a function of fox density, home range size and distance from the perimeter of the baited area (Trewhella *et al.* 1988). The shape of each land parcel is important; parcels with a high area to perimeter ratio will be less susceptible to immigration. The ability of a baited area to protect a core area was modelled here using the known relationship between dispersal and movement distances and fox home range size.

Trewhella *et al.* (1988) reviewed studies worldwide and quantified the relationship between fox home range size, fox density and recovery and dispersal distances. Dispersal is defined as the movement of an individual from its origin to the place where it reproduces or potentially could have reproduced (Howard 1960; Harris and Trewhella 1988). Dispersal distances (*a, b*) are those derived from juveniles known to have dispersed from their natal home. Fox recovery distances (*c, d*) are those derived from juvenile foxes that move and are subsequently recovered; regardless of whether individuals had completed dispersal or not. For this study, dispersal distances are used to estimate the distance that foxes immigrate into baited areas during the normal, juvenile dispersal period. Recovery distances are used in a similar manner but provide a more conservative estimate of likely dispersal distances. The regression equations derived by Trewhella *et al.* (1988) were specifically:

a. Mean dispersal distance (male) = 2.778 + 4.038(Home range size (km^2))

b. Mean dispersal distance (female) = 3.853 + 2.659(Home range size (km^2))

c. Mean recovery distance (male) = 0.084 + 3.580(Home range size (km^2))

d. Mean recovery distance (female) = 0.745 + 1.422(Home range size (km^2))

Home range sizes were derived from an earlier study at properties located within the Molong RLPB area (Saunders *et al.* 2002a). Based on the 95% Minimum Convex Polygon (MCP) home range estimates of male (3.09 km^2) and female (5.23 km^2) foxes, the recovery distances were calculated as 10.98 km and 8.18 km and dispersal distances as 15.26 km and 17.76 km respectively. Assuming a 1:1 sex ratio, (Saunders *et al.* 2002b) the means of male and female recovery (9.58 km) and dispersal distances (16.51 km) were used to create recovery and dispersal internal buffers within the perimeter of each baited area. Each buffer represents the estimated distance from the baited area boundary that foxes would recolonise during the dispersal period (December-March) within one year; the area remaining is the core area protected from annual immigration. The perimeters of baited areas were defined as the outermost boundary of continuous areas in which baiting was undertaken within the same month.

5.2.6 Built-up area boundaries

The Pesticide Control (1080 Fox Bait) Order 2002 under Section 38 of the Pesticides Act 1999, specifies the conditions of use for 1080 fox baits (Environment Protection Authority 2002). Landholders must handle, use and dispose of baits as per the instructions on the permit. One such restriction specifies that 1080 baits must not be laid within close proximity to urban areas (within 4 km of a village or street with a 70 km/h speed limit) unless the baiting program is planned and agreed to by an Authorised Control Officer (ACO). These restrictions are due to the combination of high non-target susceptibility (domestic dogs) and the wandering habits of many domestic pets (e.g. Barrett 1995).

An assessment of whether landholders were complying with this distance restriction was undertaken by identifying the built-up areas (defined by areas within a 70 km/hr speed limit) within the Molong RLPB and adding an external 4 km buffer to the built-up area perimeter. Baited properties where any part of the property fell within a 4 km radius were identified and counted. An additional external buffer was added at a 2 km radius to investigate the potential risk to domestic pets from cached baits.

5.2.7. Type of enterprise undertaking baiting

Chi-squared analyses were used to compare the proportion of ratepayers from each enterprise (sheep, beef cattle, other stock) that were undertaking fox baiting.

Caveats

Difficulties with linking landholder details from the 1080 register to property identifiers were evident during the matching process. The actual baiting location, not the landholder's residential address is required as part of completing the 1080 register. Despite this, many landholders were providing their residential address rather than the property location where baits were laid. To overcome this, it was assumed that all properties (excluding those within built-up areas) owned by a landholder were baited. This is not an unreasonable assumption but probably results in an overestimate of the area baited.

5.3 Results

5.3.1 Baiting campaigns

A total of 510 individual landholders (representing 21.2% of all ratepayers) carried out fox baiting during the period 1st January 1998 until 31st December 2002. These comprised 508 individual ratepayers and two government agencies, the Department of Environment and Conservation and State Forests. A total of 470 landholders (92.2% of baiters) was successfully linked to the cadastral information while the remaining ratepayers provided insufficient details for their adequate identification.

The number of ratepayers (excluding Government agencies) that baited annually fluctuated during the investigated period from a minimum of 152 in 2001 to 262 in 1999 (Table 5.1). Fluctuations within years were also considerable but the number of landholders baiting generally peaked in autumn and late winter/early spring (Figures 5.2 and 5.3). Similarly, the total number of baits used by landholders during baiting campaigns was highly variable, ranging from 0 baits in October 1998 and November 1999 to over 6,300 in March 2002 (Figure 5.2). The mean number of baits per landholder was reasonably consistent (Table 5.1) indicating little change in number of baits laid per landholder throughout the five-year period (Figure 5.2 and Table 5.1).

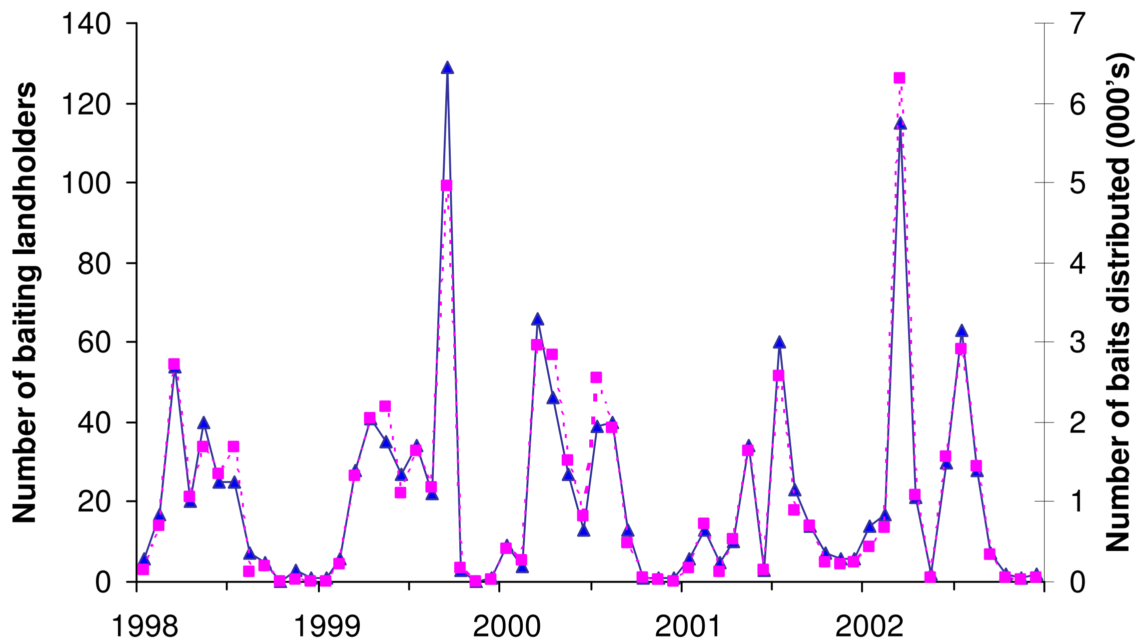

Figure 5.2: Number of landholders baiting (▲) and number of baits distributed to ratepayers (■) within the Molong RLPB area between January 1998 and December 2002.

Table 5.1: The number of landholders baiting, number of baits issued to landholders, area baited and number of baits used per baiting campaign for the Molong RLPB between 1998 – 2002. The area baited represents the area baited at least once during that year. Data relating to Government agencies are shown in parentheses.

Year	1998	1999	2000	2001	2002	Total
Number of landholders baiting	168	262	208	152 (1)	232 (2)	510
Number of baiting campaigns	203	327	260	187 (1)	302 (4)	1279
Number of baits issued	9669	14839	13865	8182	14934	61489
Mean number baits per baiting campaign (±SD)	43.6 (±49.3)	40.9 (±36.0)	47.0 (±40.4)	40.1 (±27.3)	42.9 (±37.1)	42.9 (±38.5)
Hectares baited by ratepayers	119284	191531	156237	115248	160308	742610
Hectares baited by Government agencies	-	-	-	26440	28332	54773

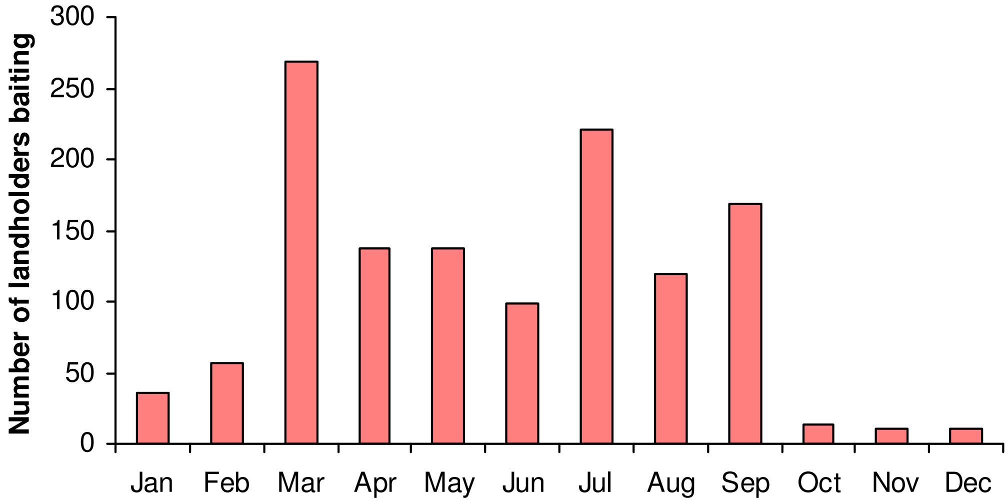

Figure 5.3: The average number of landholders undertaking fox baiting in each month within the Molong RLPB pooled for the period January 1998 until December 2002.

5.3.2 Bait type

Foxoff® were first used by the Molong RLPB in 1998 and soon became popular (Figure 5.4). However, chicken heads are still used in high numbers by the ratepayers of Molong RLPB, despite some concerns regarding their use (see Chapter 4). The majority of landholders purchased only one bait type per baiting program, but some alternated between bait types in subsequent programs.

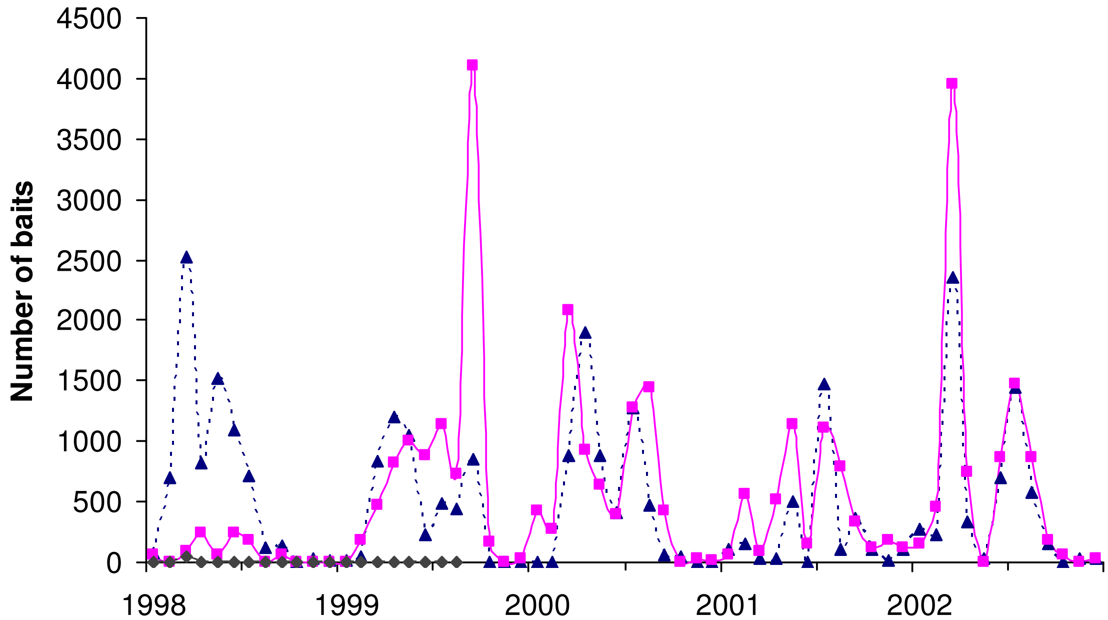

Figure 5.4: Number of Foxoff® (■), chicken head (▲) and meat baits (♦) distributed by Molong RLPB between January 1998 and December 2002.

5.3.3 Baiting coverage

The spatial coverage of baiting in the RLPB area was patchy with large, continuous areas remaining unbaited each year, and from year to year (Figures 5.5 to 5.9).

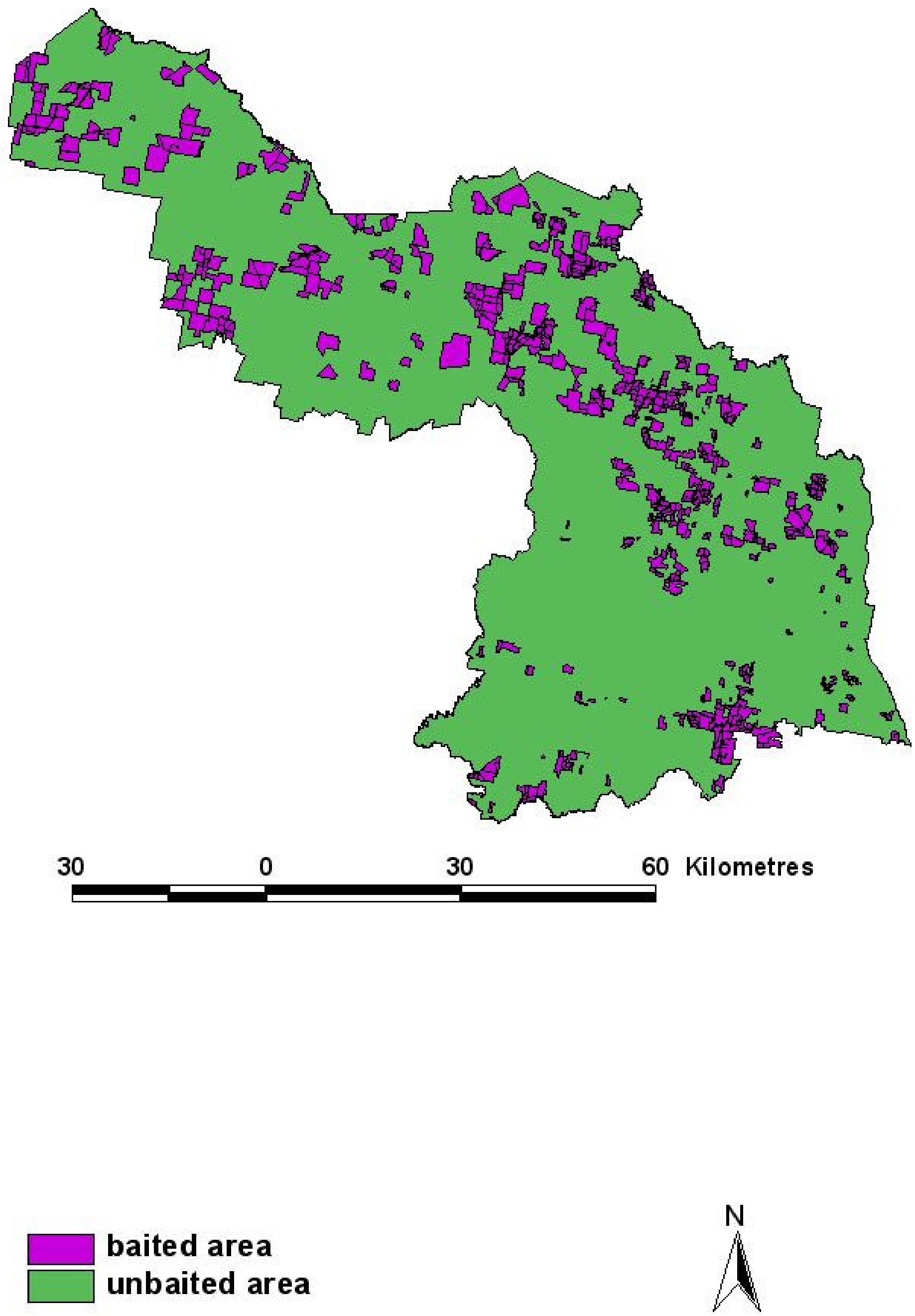

Figure 5.5: The total area of the Molong RLPB baited during 1998

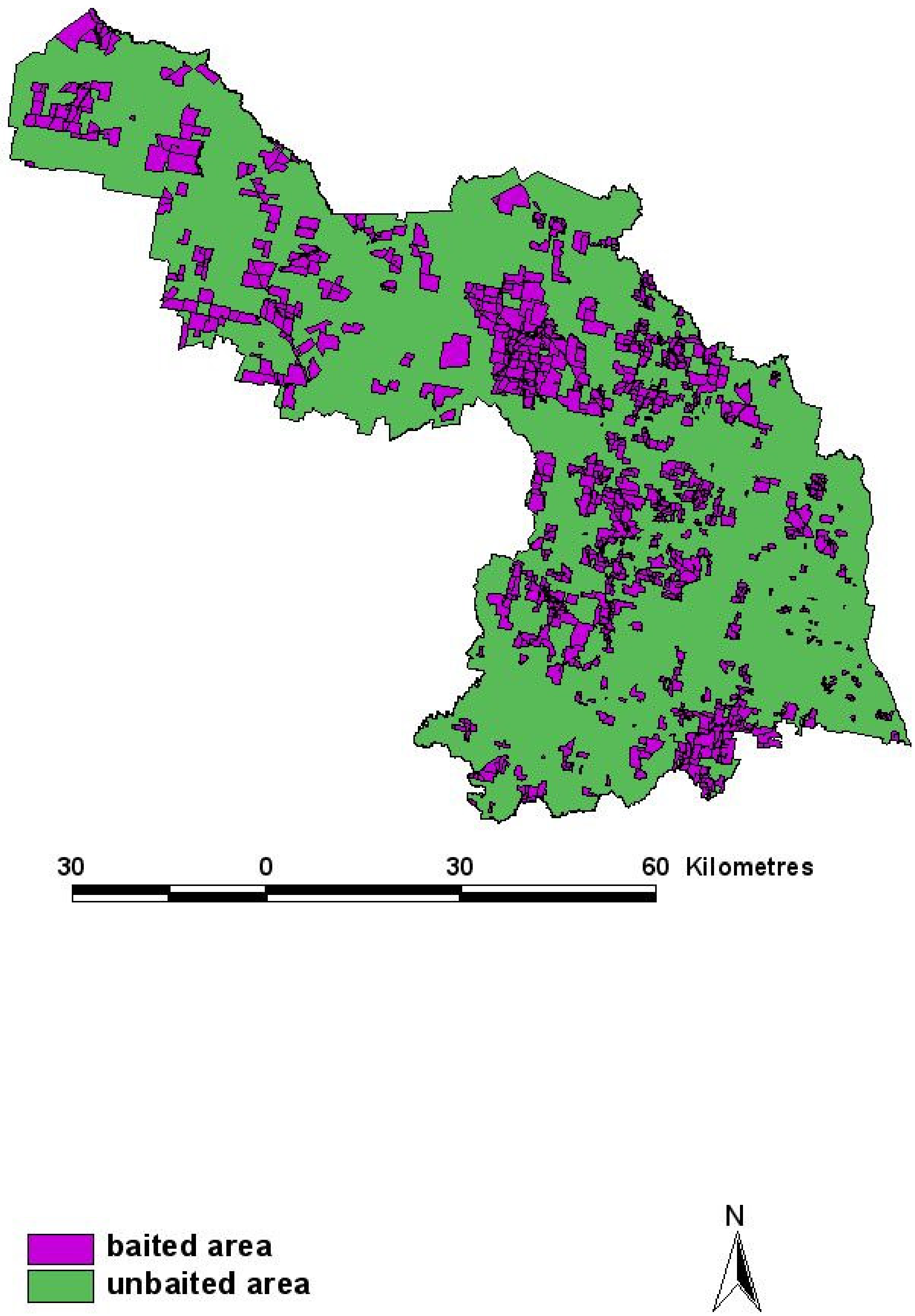

Figure 5.6: The total area of the Molong RLPB baited during 1999

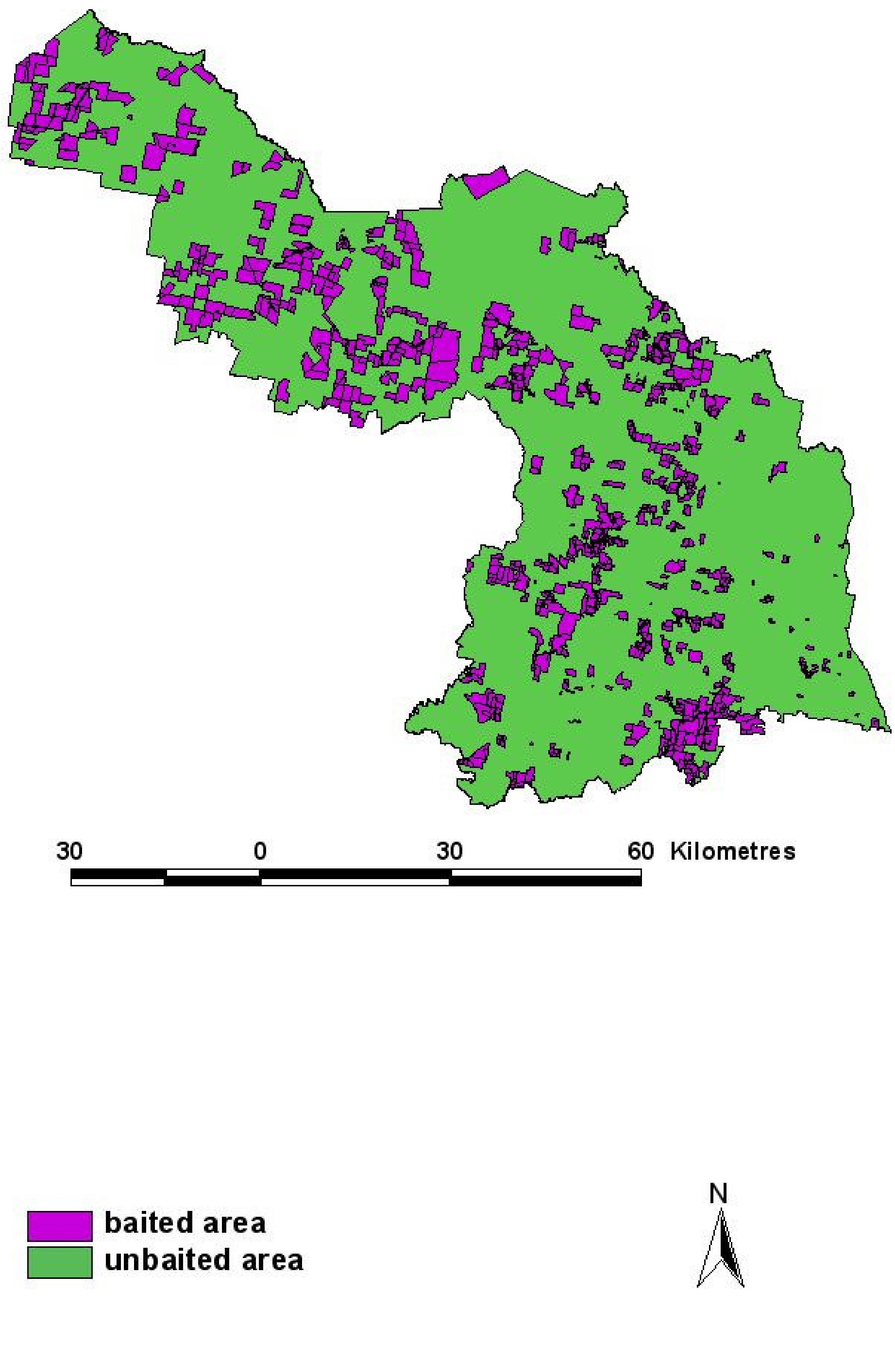

Figure 5.7: The total area of the Molong RLPB baited during 2000

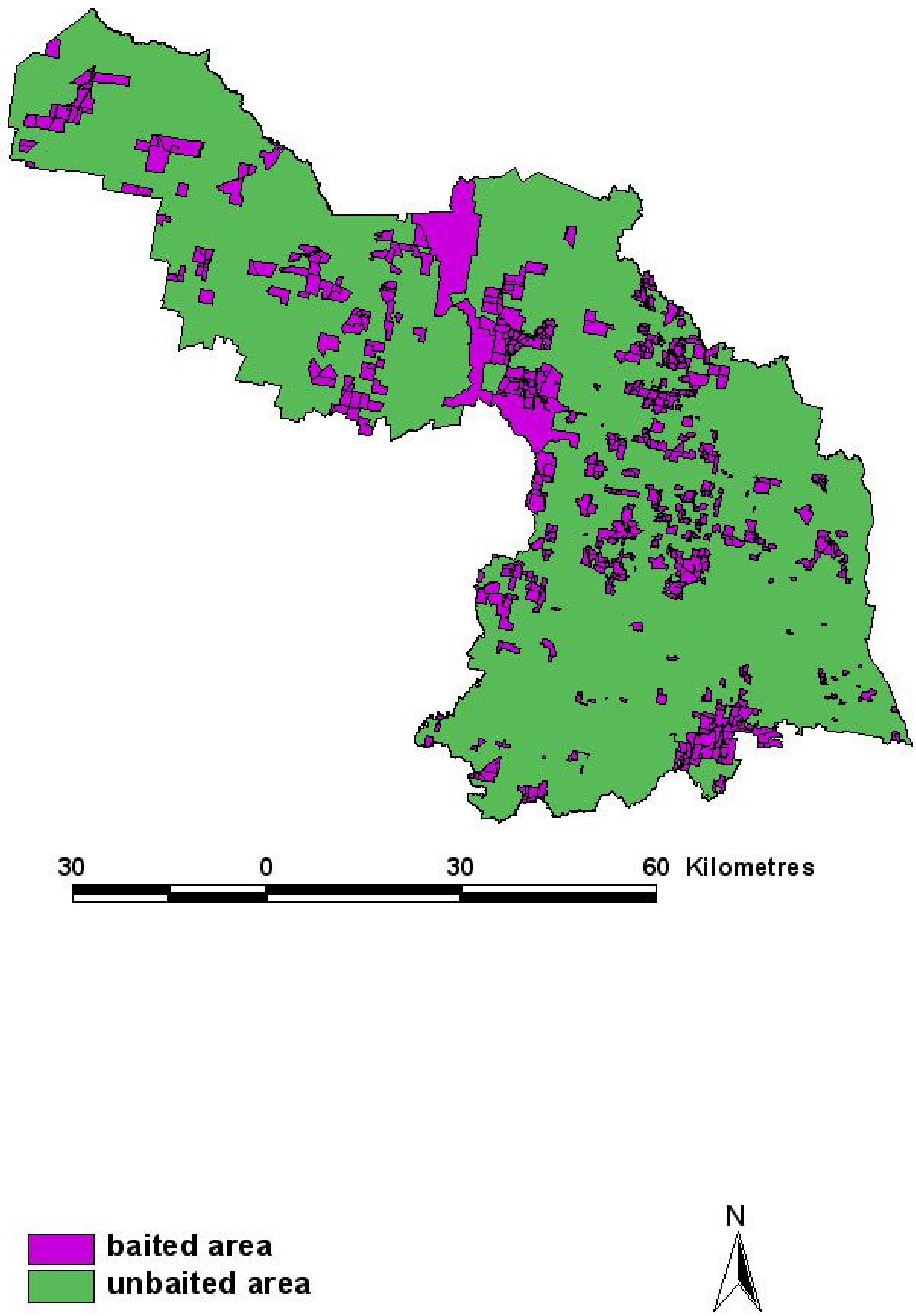

Figure 5.8: The total area of the Molong RLPB baited during 2001

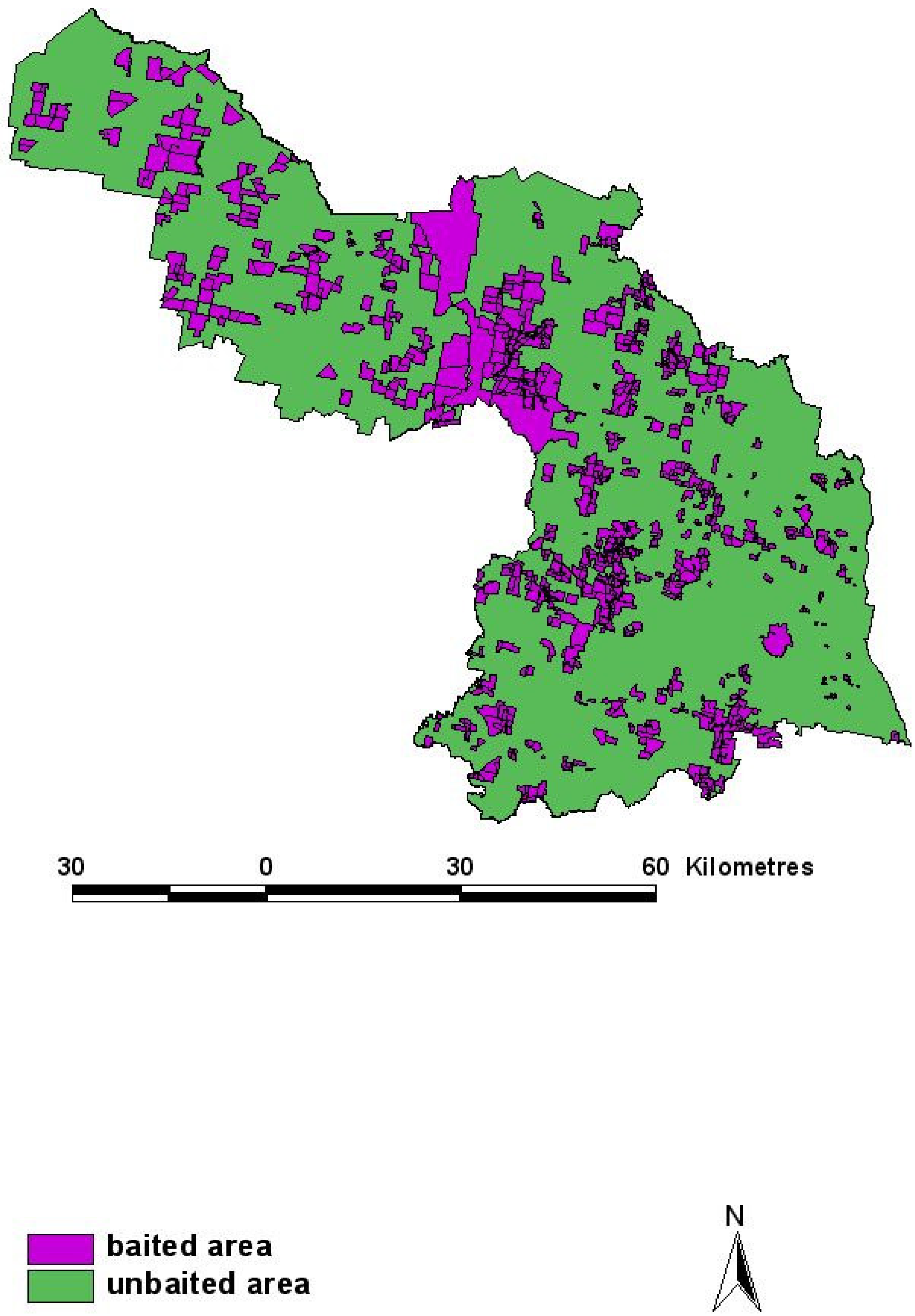

Figure 5.9: The total area of the Molong RLPB baited during 2002

5.3.3.1 Area baited

The area baited by ratepayers fluctuated widely, peaking at 102,896 ha in September 1999 (Figure 5.10). Minimal fox baiting was undertaken by Government agencies during this time, with Goobang National Park (26,400 ha) being baited during April 2001, and February, July and October 2002 and Glenwood State Forest (1,892 ha) being baited in July 2002.

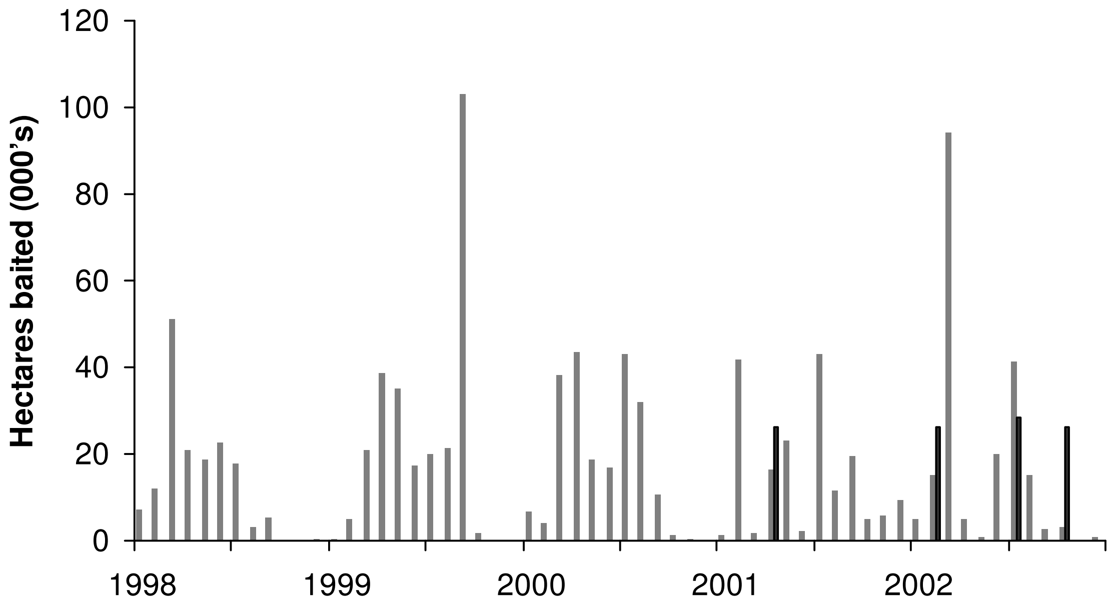

Figure 5.10: Number of hectares baited by ratepayers (grey) and government agencies (black) in the Molong RLPB between January 1998 and December 2002

5.3.3.2 Frequency of baiting

The number of landholders baiting once, twice or ≥ 3 times per year did not vary between years (χ^2= 6 .7114, d.f. = 8, P = 0.57). The majority (>80%) of landholders baited only once per year, with less than 16% baiting twice, and only 3.3% baiting three times or more in the same year (Figure 5.11).

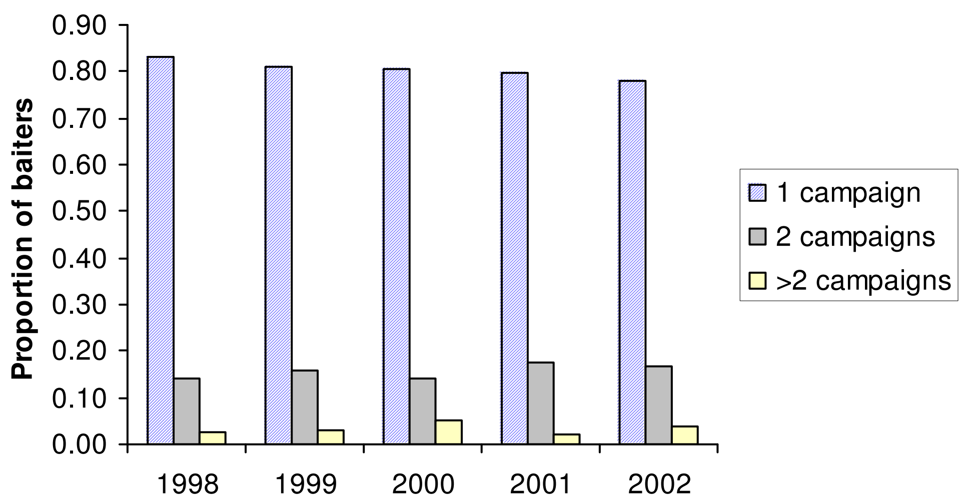

Figure 5.11: The proportion of landholders that completed one, two or greater than two baiting campaigns per annum in the Molong RLPB for the period January 1998 – December 2002.

5.3.3.3 Baiting cooperation

The proportion of ratepayers undertaking baiting in conjunction with their neighbours was generally low between January 1998 and December 2002 (Figure 5.12). Overall, less than half (45%) of baiters had at least one neighbouring landholder undertaking baiting during the same month. When there was coordination between neighbours, the level of coordination was low, the mean number of participants generally ranging between one and two (Figure 5.13). Over half (55%) of those with neighbours participating had only one neighbour, and 25% had two, and only 19% had three or more neighbours.

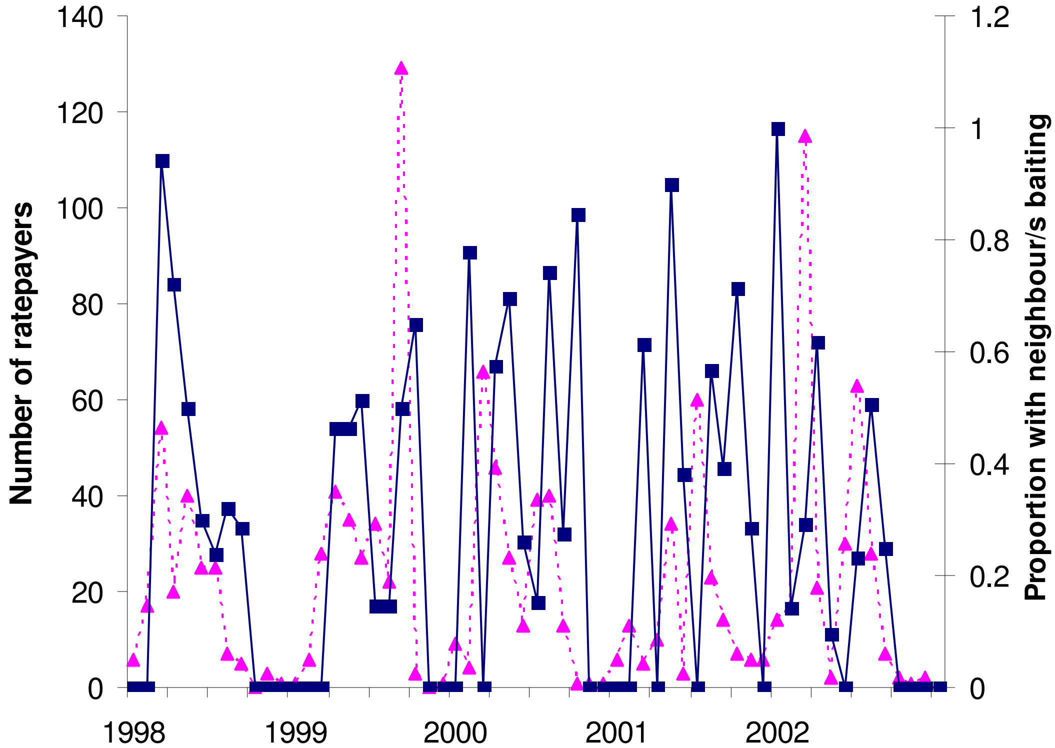

Figure 5.12: The number of ratepayers undertaking baiting (▲) in the Molong RLPB and the proportion of these with neighbours baiting (■) during the 1998 – 2002 period.

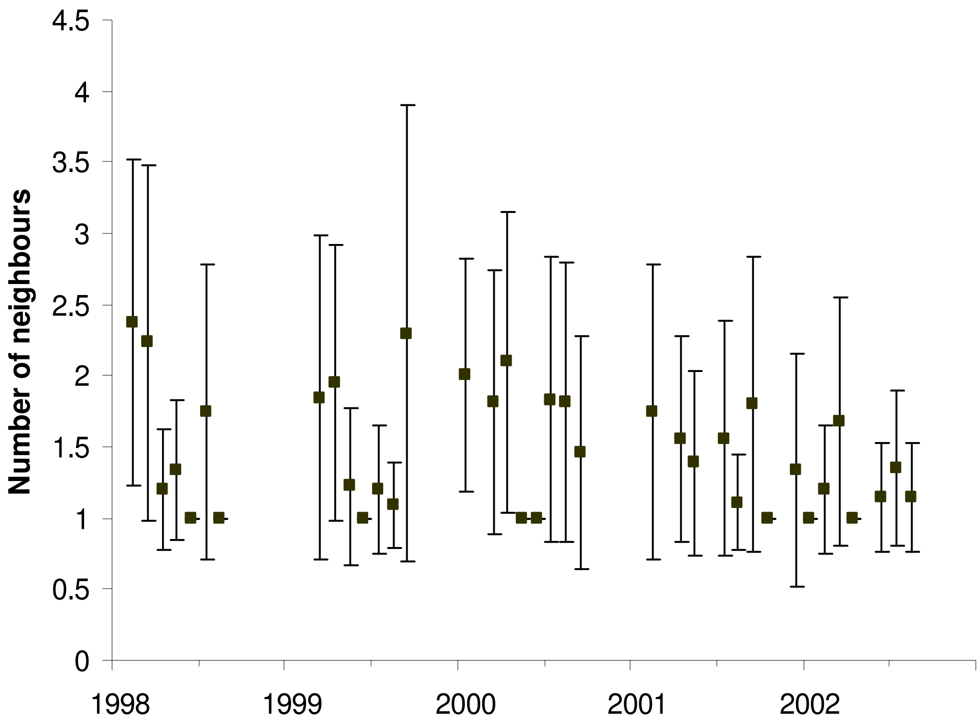

Figure 5.13: The mean number of neighbouring landholders undertaking fox baiting in coordinated baiting campaigns in the Molong RLPB. Error bars indicate standard deviation.

5.3.3.4 Fox immigration

Using the home range estimates from Saunders *et al.* (2002a), the mean dispersal and recovery distances were calculated as 16.51 km and 9.58 km respectively. This indicates that foxes would move and disperse into areas that were situated within 16.51 km of areas harbouring foxes. Assuming that baiting removed all foxes within the baited area, the 'core' areas remaining that were protected from annual juvenile dispersal were estimated as those located greater than 16.51 km from an unbaited area respectively. The recovery distance (9.58 km) was also used to provide a more conservative estimate of fox dispersal distance.

Internal buffers at 16.51 km were added to the perimeter of each continuous baited area for each month, each year and pooled over the five-year study period. No part of any area that had been baited was located greater than 16.51 km from an unbaited area. Similarly, when internal buffers were made using the recovery distance, no part of any area that had been baited was located greater than 9.58 km from an unbaited area. This indicates that there were no baited areas within the Molong RLPB large enough to prevent dispersing juveniles recolonising following baiting operations.

5.3.3.5 Built-up area boundaries

A total of 222 properties had at least part of their properties within a 4 km radius of a built-up area during the period January 1998 until December 2002. Less than one-third of these properties (71) were entirely situated within this 4 km radius. However, 96 properties had at least part of their property within 2 km of a built-up area, with 25 properties entirely situated within 2 km of the boundaries. Figure 5.14 shows the built-up areas with respective 2.0 and 4.0 km radii and the areas that were baited during the study period.

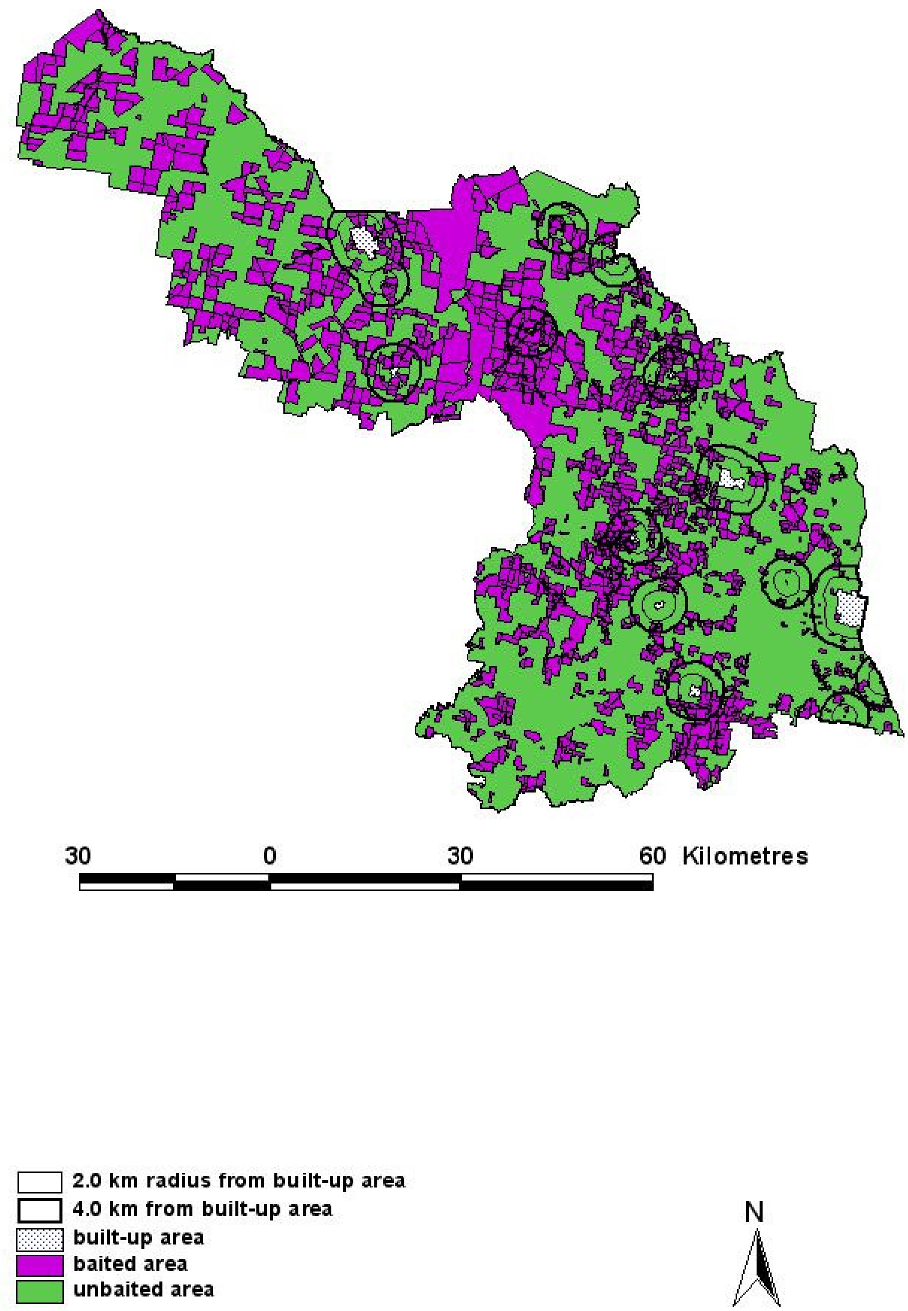

Figure 5.14: The built-up area boundaries, areas within a 2.0 km and 4.0 km radius of these boundaries, and baited areas within the Molong RLPB.

5.3.3.6 Type of enterprise undertaking baiting

Of the 2403 ratepayers within the Molong Rural Lands Protection Board, 581 (24.2%) stock only sheep, 574 (23.9%) beef cattle only, 495 (20.6%) sheep and beef cattle, 22 beef cattle and other species (0.9%), 14 sheep and other species (0.6%). The remaining 717 (29.8%) ratepayers have other stock, such as dairy cattle, undertake other agricultural or horticultural enterprises or undertake no commercial agricultural activities (Figure 5.15).

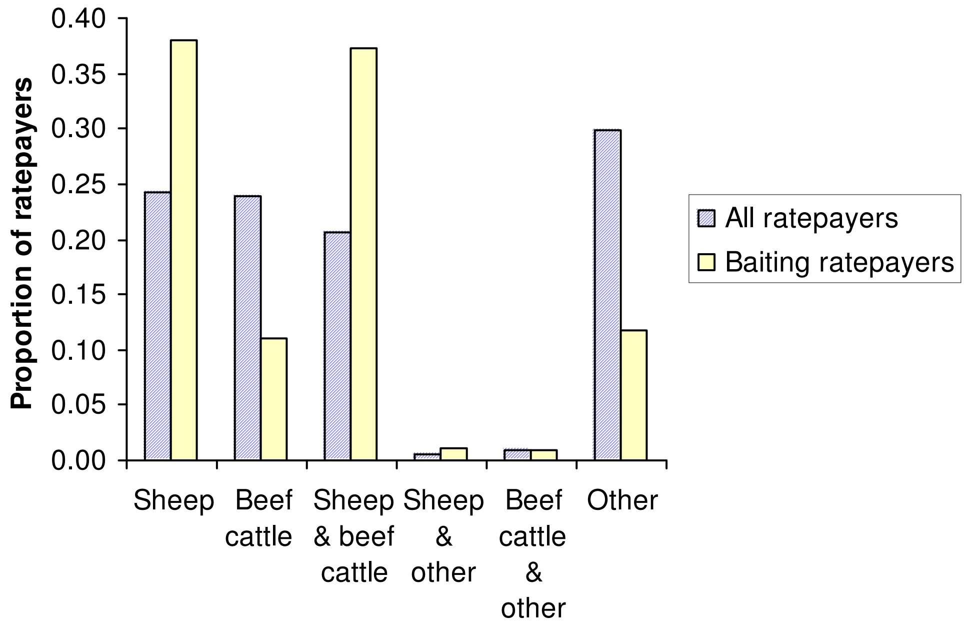

Figure 5.15: The proportion of Molong RLPB ratepayers in each enterprise and the proportion of ratepayers in each enterprise who undertook fox baiting from 1998-2002.

The stock species maintained by ratepayers significantly affected whether they would undertake fox baiting (χ^2 = 326.07, d.f. = 6, P <0.001). A significantly higher proportion of sole sheep producers undertook fox baiting than sole beef cattle producers (χ^2 = 109.70, d.f. = 1, P <0.001) and other enterprises (χ^2= 148.10, d.f. = 1, P< 0.001). These patterns remained highly significant (P <0.001) even after BonFerroni adjustment to correct for multiple comparisons within the same data set. However, there was no significant difference between ratepayers that ran only sheep and those with both sheep and cattle (χ^2= 3.2141, d.f. = 1, P =

0.073). Other comparisons were not undertaken since the sample size was too small for rigorous analyses.

There was no significant difference between the type of enterprise and the season of baiting (χ^2 = 12.25, d.f. = 9, P = 0.20).

5.4 Discussion

The results of this chapter suggest that many landholders within the Molong RLPB are concerned about fox problems and bait regularly with 1080-baits. However, a much larger proportion (78.8%) do not. In this section, I review the factors affecting the success of baiting in the Molong RLPB, and assess whether the present strategy is effective.

5.4.1 Missing records

The data collation and validation process highlighted many deficiencies in the information in the 1080 register. Forty landholders that purchased baits from the Molong RLPB, representing 8% of the total purchasers, could not be identified, despite intensive searches in the Molong RLPB database, Valnet® and communications with staff from Molong and neighbouring RLPBs. Although their details were entered correctly into the 1080 register, these details were insufficient to link with the cadastral property information and hence could not be included in the analyses. This may be due to a number of reasons. For example, the register specifies only that the name and the property address that the poison is supplied to be given, <u>not</u> where the poison is actually laid. An 'agent' can act on behalf of other landholders and only the agents details may be entered into the register. Additionally, landholders may be from other RLPB areas or ownership details may have changed. This lack of consistency in the details entered into the register has serious implications for auditing 1080 baiting operations throughout New South Wales, since, in the event of any audit, there will be many properties that cannot be identified. For auditing purposes, a unique property identifier, such as a Property Identification number (from Valnet®) or an Assessment number (a RLPB identification number), should be presented at the point of sale to allow for the identification of baiting locations. The identity of the purchaser should also be verified through an adequate form of identification, such as a current drivers licence, to check their identity. In Queensland, each landholder must provide an adequate cadastral identifier (usually Lot/Deposit Plan number) at the point of sale. Supplying this cadastral information forms the basis of the Queensland Department of Natural Resources and Mines "PestInfo®" system which is used to monitor bait distribution (P. Paping, Department of Natural Resources and Mines, pers. comm. 2004).

5.4.2 "Outfox the Fox"

Despite concerted efforts to publicise the 'Outfox the fox' program, it appears not to have had sufficient impact to radically improve baiting practices. The general aims of the 'Outfox' program include synchronised baiting within groups, baiting at least twice per year, undertaking baiting when foxes are most susceptible, regularly checking and replacing baits when they are taken, and continued baiting until take declines (Balogh *et al.* 2001). Since the initiation of the 'Outfox' program in early 1999, there has been no obvious increase in the number of landholders, or coordination between landholders, participating in fox baiting. Similarly, there has been no change in the frequency of baiting nor the number of baits used per baiting occasion. This strongly suggests that there is inertia amongst landholders to adopt or change baiting practices. Landholders have been known to resist change, especially when practices have been established and undertaken for long periods. Many landholders, including historical non-baiters, would have been made aware of the program. In addition to some local and regional media coverage, landholders would have been notified through the addition of a brochure attached to the RLPB rates notice and personal communications with RLPB staff or other landholders. Landholders purchasing fox baits were told of the program and asked to encourage surrounding landholders. Further opportunity exists since all neighbours within 1 km of any baited area must be contacted to notify them (>72 hours before) that fox baits will be laid. Alternative strategies, such as undertaking seminars at field days, and liasing with existing groups (e.g. Landcare, Australian Wool Innovation) have been successful in fostering the support and involvement of landholders in coordinated baiting for fox control (Croft *et al.* 2002). Such approaches should be attempted if authorities are serious about improving baiting coordination and practices.

This study demonstrates the importance of planning and undertaking pest management strategically. Such thinking is not new: Braysher (1991, 1993) highlighted the importance of undertaking the strategic approach to pest animal management. The strategic approach relies on planning and undertaking pest control programs to target goals using best practice techniques. This is achieved through defining the problem in terms of pest animal impact, developing and implementing a management plan to reduce the impact, and monitoring and evaluating the outcomes to ensure that they are meeting the required objectives. Pivotal to such adaptive management is the ability to be adaptive when new information is found. Applying such principles to 'Outfox' would mean that the current coordinated approach is not achieving the desired results, and should be modified. The guidelines to such an approach are given in PESTPLAN, a guide to undertaking strategic pest management (Braysher and Saunders 2003).

The 'Outfox' program could be viewed as effective in terms of the number of landholders involved and number of baits laid, but when the baiting coverage, temporal coordination between landholders and likely impact on immigration are taken into account it is probably not achieving the desired objectives. This case study demonstrates the importance of monitoring the performance of pest management programs rather than simply assuming that they are having an effect.

Foxes are well known pests on agricultural and conservation lands, but the extent of the problem they cause is both variable and difficult to measure, especially predation on domestic stock (e.g. Saunders *et al.* 1997a). It is difficult to improve the participation in control programs without being able to demonstrate the benefits of undertaking control through objective scientific studies. Therefore, improving our knowledge of the relationship between density, damage and the impact of control may be the key to increasing participation in baiting programs.

5.4.3 Bait type

Both Foxoff® and chicken heads are commonly used by landholders in Molong RLPB, but very few landholders use fresh meat bait. The popularity of Foxoff® is probably due to its ease of handling and distribution and long shelf life. Molong RLPB encourages the use of Foxoff® since the handling cost is reduced compared to the traditional injection technique necessary for preparation of fresh baits (C. Somerset, Molong RLPB, pers. comm. 2003). Fresh meat baits also spoil more rapidly (see Chapter 3). For this reason, DEC and State Forests exclusively use Foxoff® within the Molong RLPB since its long shelf life makes it ideal for replacement baiting, allowing baiting campaigns to continue for longer periods (J. Neville, Department of Environment and Conservation, and R. Finlay, State Forests, pers. comm. 2003). However, the reduced palatability of Foxoff® compared to other bait types (see Chapter 3) may reduce the effectiveness of these campaigns relative to those utilising other bait types. A compromise may be to encourage landholders to initially lay a fresh bait type, then replace taken or degraded baits with Foxoff®. This would allow campaigns to offer a highly palatable bait initially but continue for longer with the less palatable but degradation-resistant Foxoff®. Additional work should be done to identify and assess the relationship between the handling and distribution cost and palatability of different bait types. For example, a bait type that is highly palatable to foxes may not necessarily be more cost-effective than less palatable bait due to increased handling cost. Improving our understanding of the payoff between bait palatability, handling cost and other considerations are important in improving the cost-effectiveness of fox baiting programs.

5.4.4 Type of enterprise undertaking baiting

The results of this chapter indicate that ratepayers who produce sheep, whether exclusively or in conjunction with other stock, are more likely to undertake fox baiting than those without sheep. This is not surprising, given that foxes are a recognised predator of lambs (Lugton 1987; Greentree *et al.* 2000) thus providing the necessary incentive to undertake control. Conventional sheep joining usually occurs during March-April and December-January resulting in lambs being born in winter/spring or autumn respectively (Lloyd Davies and Devauld 1988; Balogh *et al.* 2001). Lambs are most susceptible to predation during their first few weeks, and landholders appear to concentrate baiting efforts before and during lambing periods (Figures 5.2 and 5.3). However, many ratepayers who exclusively stock cattle, and those without registered stock also still bait, suggesting that foxes are perceived as pests to enterprises other than sheep production. This is supported by a recent survey of primary producers in Queensland that found that landholders from all producer categories surveyed (including beef cattle, horticultural, cropping and dairy) recognised foxes as a significant pest animal (Oliver and Walton 2004). Foxes may injure cattle, particularly calves or birthing cows and damage infrastructure such as watering systems in commercial orchards or vineyards (S. Balogh, NSW Department of Primary Industries, pers comm. 2002). Alternatively, ratepayers may bait to simply cooperate with neighbouring sheep producers or reduce impacts on native wildlife. Many landholders are aware of the environmental damage caused by pest animals (Oliver and Walton 2004) and wildlife conservation may be an important driver for increasing involvement of non-sheep producers in fox baiting campaigns. Regardless, these observations confirm that landholders other than sheep producers are willing to undertake fox baiting, potentially allowing larger areas of land to be baited. A greater understanding of what motivates non-sheep producers to undertake fox baiting may lead to improved strategies to increase participation in fox baiting programs.

Government agencies, especially DEC and State Forests baited only sporadically during the study period, with Glenwood State Forest and Goobang National Park baited on one and three occasions respectively. Fox management by DEC is primarily undertaken under the New South Wales Threat Abatement Plan for predation by the Red Fox (Fox TAP) (NSW National Parks and Wildlife Service 2001). The Fox TAP identifies which threatened species within New South Wales are at greatest risk from fox predation and the sites where fox control is most critical for these species. The plan identifies 81 priority sites for fox control on all types of public and private land across New South Wales, and provides recovery actions for 34 threatened species (11 mammals, 15 birds and eight reptiles) (NSW National Parks and Wildlife Service 2001). The plan relies on collaboration with other agencies, community groups and private landholders to undertake fox control campaigns and/or monitoring of threatened species populations. Within the Molong RLPB, DEC undertake baiting in areas for the benefit of no particular species but rather for the broad aim of biodiversity conservation as recognised by the Fox TAP (J. Neville, Department of Environment and Conservation, pers. comm. 2003). Their campaigns are generally timed to coincide with periods when foxes are most susceptible, which also overlap with the periods when landholders undertake baiting. State Forests have no official agreement to undertake fox baiting within the region but will bait in conjunction with surrounding neighbours if approached (R. Finlay, State Forests, pers. comm. 2003).

5.4.5 Built-up area boundaries

Over 43% of baited properties were at least partly within four kilometres of a built-up area, so that most bait would have been laid on parts of the property outside the 4 km exclusion zone. However, baited properties located within four kilometres (13.9%), and two kilometres (4.9%) of a built-up area may still be exposing domestic animals to unnecessary risk. This is of concern since foxes will cache baits considerable distances from where originally laid (see Chapter 3), and in this situation could potentially move baits even closer to residential areas. Even if campaigns were planned in coordination with an ACO there still lies an inherent risk that domestic animals may be exposed to 1080 bait. Very few 1080 poisonings of domestic dogs are reported, although anecdotal evidence suggests that it is not uncommon (A. Litchfield, Orange Veterinary hospital, pers. comm. 2003). To reduce the potential for non-target deaths, and retain public support for the continued use of 1080, greater care is needed to ensure that ratepayers are baiting as specified by the restrictions on the permit.

5.4.6 Fox immigration

The dispersal models of Trewhella *et al.* (1988) have been used to develop robust spatial models of fox dispersal behaviour (Trewhella and Harris 1988). However, the models are relatively simple and do not account for non-homogenous habitats (such as unfavourable patches) or mortality of resident foxes, which may affect fox dispersal and consequent colonisation. There are few hard barriers to fox dispersal (Harris and Trewhella 1988), and there are none obvious within the Molong RLPB area. The estimated recovery distance (9.58 km) was used rather than the dispersal distance to allow for such variations and provide a more conservative estimate of the likely immigration distance. This estimate is comparable to the mean 11 km dispersal distance measured by Coman *et al.* (1991) in Central Victoria where fox home ranges are similar to those within the Molong RLPB.

A buffer of 10-15 km wide was considered sufficient to reduce fox immigration into baited areas in Western Australia (Thomson *et al.* 2000). But buffers are likely to be narrower where fox density is high given the inverse relationship between population density and recovery/dispersal distances (Trewhella *et al.* 1988). In this study, based on mean recovery distance, no properties involved in fox control, both singularly or in conjunction with neighbours, had any 'core' areas that offered relative protection from fox reinvasion. Even using the more conservative recovery distance (and subsequent immigration estimate), and pooling baited areas across months and years, no baited areas within the Molong RLPB were large enough to have had adequate protection from reinvasion. In addition, buffer areas should undergo constant baiting to ensure that fox density is maintained at low levels, to ensure an effective 'dispersal sink' (Thomson *et al.* 2000). In the Molong RLPB, the majority of landholders bait once per year, with less than 22% baiting on two or more occasions. This suggests that the spatial coverage and frequency of baiting is inadequate to prevent annual immigration into core areas within the Molong RLPB.

The immigration problem may be at least partly due to the small size of properties and hence, a large number of landholders would be required to undertake baiting effectively. Given the average property covers 299.2 ha (SD = 435.0, n = 2403), it would require approximately 108 neighbouring landholders to act as a buffer to protect a 'core' area of one average size property. This level of coordination is logistically very difficult, especially when some landholders refuse to lay 1080 fox baits, due to misconceptions about the toxicity of 1080, perception that foxes are not a problem or fear of non-target deaths, especially of working dogs (C. Somerset, Molong RLPB, pers. comm. 2002). Also, lambing periods are typically not discrete within areas (e.g. Lloyd Davies and Devauld 1988; Balogh *et al.* 2001), varying in timing or length. Lack of synchronisation between landholders may reduce the likelihood that involved parties will agree to a period when baiting should be undertaken (Saunders *et al.* 1997a). This is a problem in the Molong RLPB since there is considerable variation in timing of baiting campaigns across each year, and from year to year (Figures 5.1 and 5.2).

This study supports Thomson *et al.* (2000) in concluding that buffer zones would be impractical where small parcels of land are to be protected. An alternative strategy for these areas could include baiting more frequently (or more prolonged baiting) to counter immigration. Such a strategy is applied in many smaller nature reserves in Western Australia where ground-based fox baiting is undertaken 4 times per year (R. Armstrong, Conservation and Land Management, pers. comm. 2002) as part of the Western Shield program (Armstrong 1997). The current frequency of baiting in the Molong RLPB is well below this level, but given the relatively small average property size, it may be easier to increase the frequency of baiting rather than attempting to control foxes over a surrounding area.

Baiting coverage and frequency may be insufficient presently in the Molong RLPB to reduce fox density for extended periods, but seasonal reductions in fox density may be all that is required to reduce predation on domestic stock. Lambs and goat kids are known to be at greatest risk from fox predation in the first weeks after birth up until marking. Landholders within the Molong RLPB appear to be undertaking baiting to reduce fox density when prey is most susceptible, which may be a more efficient strategy to reduce damage than widespread and frequent control campaigns. This strategy may be more applicable to agricultural enterprises where young animals are most at risk than conservation areas where many species are susceptible as juveniles and adults. However, if 'one shot' or short-term campaigns are to be successful at reducing predation upon susceptible prey, then the program should be of sufficient duration to ensure that fox density remains low while prey remain susceptible. However, immigration by foxes may be instantaneous once baiting campaigns are completed (see Molsher 1999). Typically campaigns continue for periods of one to two weeks (Saunders *et al.* 1995); where immigration may be virtually instantaneous, baiting campaigns lasting up to two weeks may be insufficient to reduce fox density for long enough to effectively reduce predation on lambs and goat kids. More investigation is required to determine whether seasonal reductions of fox density are as efficient and effective at reducing agricultural damage than intensive control campaigns.

Other studies support the suggestion that current baiting techniques may be deficient in reducing fox density and associated impacts for long periods. For example, Greentree *et al.* (2000) experimentally tested the relationship between lamb predation and fox control in south-eastern Australia. Three levels of fox control were undertaken (nil control, once per year and three times per year) and the associated rates of lamb predation and fox density were measured. No significant difference was found in the lamb predation rates between the three levels of control, and there was no significant difference in fox abundance between control and treatment sites. Immigration of foxes into the baited area was suggested as a possible cause (Greentree *et al.* 2000), despite a large area comprising of both core and surrounding buffer zones being baited (300 km^2). However, despite the involvement of many landholders, buffer zones only extended up to 3 km from the perimeter of the core areas, which may have been insufficient to adequately reduce fox immigration. Fox home ranges within the Greentree *et al.* (2000) study area are similar to those in the Molong RLPB area (Berghout 2001; Saunders *et al.* 2002a), and hence immigration potential would be similar. Results from this study and those of Greentree *et al.* (2000) and Thomson *et al.* (2000) suggest that immigration is an important factor in reducing the effectiveness of baiting.

Recent evidence from Western Australian research indicates that fox populations have some capacity to respond to decreases in density through compensatory mechanisms such as increased litter size and rates of juvenile survival (Marlow *et al.* submitted). This suggests that populations would recover to original (pre-control) densities within 2 years. Foxes appear to compensate for population control through both immigration into, and compensatory responses within, baited areas.

5.5 Conclusion

If such a large effort is required to make broadscale baiting effective, then the use of buffer zones may not be an appropriate strategy. This supports the conclusions of Thomson *et al.* (2000) that buffer zones may be more appropriate for situations where a large ‘core’ is to be protected (perhaps where endangered prey is to be protected), since the ratio of core area to buffer decreases disproportionately with the core area. Therefore, the use of buffer zones may be inappropriate to protect properties typical of central-western New South Wales; in these circumstances it may be more appropriate to bait smaller areas more frequently. Despite this, co-coordinating baiting programs with neighbouring landholders should still be encouraged, especially where block sizes are small, to reduce ‘edge effects’ between baited and non-baited areas.

The current strategy of disseminating information through RLPBs is not resulting in changing baiting practices. It appears that greater or more effective publicity and communication is required to initiate change to current landholder baiting practices.

This study is unique because it investigates the effectiveness of current baiting campaigns scientifically through assessing the spatial coverage and timing of baiting campaigns and their likely affect at reducing fox immigration. In doing so it demonstrates how important it is to improve our understanding of the way that baiting programs are implemented. This is important since typical measures of the success of baiting campaigns rely on easily quantifiable terms, such as the number of people involved or the number of baits laid rather than a scientific assessment based on how the project is achieving its objectives. Such an approach should be undertaken in our strategies for pest management in Australia.