CHAPTER 7

COST-EFFECTIVENESS OF BAITING OPERATIONS

7.1 Introduction

Strategies for managing pest animals are traditionally assessed for their effectiveness, with less consideration given to the efficiency or cost of achieving the desired effect (Hone 1994). However, the basic economic problem of limited resources and choosing between many viable options applies, by necessity, to pest management (Bicknell 1993). Economic analysis of competing options is therefore useful to aid in decision-making relating to pest control (Moberly *et al.* 2004).

The management of foxes on agricultural and conservation lands in Australia relies heavily on poison baiting (see Chapter 1). A survey of New South Wales Rural Lands Protection Boards (RLPBs) in 2002 indicated that baiting was the most popular control technique for foxes, amounting to 74% of control effort (West and Saunders 2003). Foxoff® was the most common bait type used in New South Wales, comprising over 48% of baits used in 2001. Ten percent of RLPBs used baited chicken wingettes by 2001, despite this bait type being introduced only in 1998. When respondents were asked to rank the most effective bait types, the perceived effectiveness of most bait types closely matched their proportional use. For example, 10% of respondents perceived wingettes to be the most effective bait type, matching the percentage of the respondents who used wingettes. However, Foxoff® was used by 48% of all respondents, but was perceived to be the most effective bait type by only 27% of respondents (West and Saunders 2003). This suggests that other factors may be important in the decision to use Foxoff®, apart from perceived effectiveness. These may include the cost-effectiveness of the bait, its extended shelf and field longevity, or the lack of costs in bait preparation and handling that are associated with the 1080 injection process required for fresh bait types.

Ideally, the costs and benefits of undertaking fox baiting should be assessed to determine if control is worthwhile; i.e do the benefits of control exceed the costs? In many cases, due

largely to lack of data and inadequate modelling of density:damage relationships, the benefits from reducing fox density are not easily quantified, or cannot be reliably estimated and parameterised (see Greentree *et al.* 2000). Additionally, many outcomes from particular inputs and strategies are not always economically quantifiable (Moberly *et al.* 2004). It is therefore difficult to use cost-benefit techniques to perform an economic analysis of baiting practices. The level of input spent on management programs is generally easier to quantify than the benefit derived; where the benefits from undertaking control cannot be easily estimated, strategies should be assessed on the cost required to achieve a given level of output. Such assessments can be termed cost-effectiveness analyses.

Cost-effectiveness analysis is one measure that can be used to compare the efficiency of different methods of control (Hone 1994). Rather than using cost-benefit analysis to quantify and subsequently assess the need to undertake an objective, cost-effectiveness analysis is used primarily to determine the least expensive way to meet the objective (Bicknell 1993). Given that fox baiting is commonly undertaken on agricultural and conservation land for protection of susceptible prey (see Chapter 5), cost-effectiveness analysis would be a suitable means to economically assess the choice of baiting strategy to be used within these campaigns.

Factors such as the bait type, density, longevity and uptake together with bait placement, presentation technique, duration of placement, and replacement strategy all influence the efficiency and effectiveness of a baiting campaign. It is beyond the scope of this chapter to explore all possible combinations of these factors. However, aspects of baiting including bait longevity (Chapter 3), bait caching and palatability (Chapter 4) will influence the characteristics of baiting campaigns and ultimately their cost-effectiveness. Additionally, since the objective of baiting operations is to reduce fox density, the ultimate measure of effectiveness would be to assess the cost per fox removed.

This chapter assesses the cost-effectiveness of using different bait types in central-western New South Wales based on their relative cost, longevity and palatability. Although these data were collected in this region the analyses have obvious applications to similar regions across New South Wales and Australia. These issues are investigated to determine the most

appropriate strategy for practitioners, depending on the duration of the baiting campaign and the relative importance of other issues. Such issues include the ease of use, the relative storage, handling and replacement required and non-target or environmental concerns associated with the longevity and caching of bait material. This case study approach is used to develop a preliminary decision tree model to assist practitioners to choose the most appropriate strategy for use in typical conditions encountered in the central tablelands environment.

7.2 Methods

7.2.1 Bait types - Description

Foxoff® is commercially manufactured by Animal Control Technologies Pty Ltd (Somerton, Victoria). The precise formulation is known only to the manufacturer but it appears to be a mix of meatmeal and animal fat (tallow) with some attractants. It is available in two sizes, 60 g (Foxoff®) and 35 g (Foxoff® Econobait). The Foxoff® Econobait (hereafter known as Foxoff®) is by far the most popular and is usually the type sold by RLPBs in New South Wales (C. Lane, RLPB State Council, pers. comm. 2003). Foxoff® may be purchased in any quantity from the RLPB; since it is packaged in trays containing 30 baits, purchases are usually comprised of single or multiple trays.

Day-old chicks are produced by poultry hatcheries for either layer or meat chicken production. Those that are external to requirements (usually males) are culled, as are those with deformities, poor health or general condition. Despite their name, day-old chickens may be culled up to several days after hatching. The majority of these are destroyed but some are frozen and sold for pet food, especially for feeding reptiles (e.g. snakes). Day-old chicks usually weigh between 40 and 60 g.

Chicken wingettes (hereafter known as wingettes) are the wings of meat chickens and are sold separately for the catering industry. Wingettes are the entire chicken wing with the shoulder (drummette) removed. Wingettes weigh 40-80 g, depending on the breed and condition of the processed bird.

7.2.2 Bait preparation

In NSW only licensed authorities may purchase commercially manufactured bait directly from the manufacturer. These authorities are usually RLPBs, although in certain circumstances, conservation agencies (such as NSW Department of Environment and Conservation) may have the authority to purchase Foxoff® directly from the manufacturer for use on crown land. Private landholders may purchase or receive baits only from a licensed authority, and this is usually from a RLPB.

7.2.3 Costs

The cost of bait is dependent upon whether it is purchased wholesale (i.e. by the RLPB) or retail (by the consumer, i.e. landholder). Therefore the wholesale price of bait mostly represents the actual purchase cost of the material while the retail price accounts for additional storage costs, production costs and profit associated with selling the bait. RLPBs purchase the bait (Foxoff®) or bait substrate (freshly prepared bait type) and are responsible for selling bait to landholders.

For consistency, prices used in the analyses below are all current 2004 (July) prices used by the Molong RLPB. Where Goods and Services Tax (GST) applies all costs are given inclusive of GST.

7.2.3.1 Bait type

Foxoff® costs $0.88 per bait when purchased (at wholesale prices) as part of a 'Farmpack'. Foxoff® is purchased as a ready-to-use product and is 1080- impregnated. Foxoff® typically retails for $1.00 per bait to contribute towards the storage and distribution costs (C. Lane, RLPB State Council, pers. comm. 2003 and C. Somerset, pers. comm. Molong RLPB 2004).

Day-old chicks cost $0.20 per unit (wholesale). Wingettes are sold by weight; depending on the weight of each unit (~40-80 g) the cost of each wingette varies between $0.125 and $0.25. I used a mean cost of $0.19 per unit in the analyses here.

As fresh-prepared baits, day-old chicks and wingettes must be injected with 1080. 1080 solution is relatively cheap but the time and labour costs involved in storage, preparation and distribution of these bait types can be considerable. As a result, RLPBs typically sell wingettes for approximately $0.60 per unit to assist in covering these costs (C. Somerset, pers. comm., Molong RLPB 2004). Day-old chicks are not a registered bait type and therefore no sale prices are available. However, given that the wholesale purchase price of day-old chicks is similar to wingettes, $0.60 per unit would be a reasonable estimate.

7.2.3.2 Bait longevity - cost per day

The 1080 in bait can be lost through the contribution of one or more of the following:

- defluorination by bacteria, fungi and other microbes,
- leaching by rainfall,
- consumption by sarcophagous insects, or
- conversion to inorganic fluoride compounds

(Korn and Livanos 1986; Kramer *et al.* 1987; McIlroy and Gifford 1988; Fleming and Parker 1991; Saunders *et al.* 2000; Twigg and Socha 2001; this study).

The rate of decline or degradation of 1080 and the subsequent period that baits remain lethal to foxes vary with these factors and bait type (see Chapter 3). Bait must remain toxic for long enough to ensure that resident foxes will find and consume a lethal dose. If bait degrades too rapidly for foxes to have this opportunity, it may reduce the efficacy of the baiting program (see Chapter 2). Additionally, reduced longevity would require bait to be replaced more often in continuous baiting programs, thus reducing cost-effectiveness.

The cost-effectiveness in terms of the cost of presenting lethal bait per day is a useful comparative measure between specific bait types. With knowledge of the estimated lethal lifespan (i.e. period that bait retains at least 0.65 mg 1080, approximate LD_{50} for a 5 kg fox) (see Chapter 2) and unit cost of bait, the mean cost per day that a specific bait type would remain lethal to foxes can be estimated. Incorporating both the wholesale and retail bait prices represents the cost to conservation agencies and landholders respectively. This effectively

standardises how much it costs to present lethal bait (of each bait type) per day. A comparison of this figure between bait types can determine the relative cost of using the bait types.

7.2.3.3 Baiting campaigns – bait uptake and bait replacement

Baiting campaigns are usually undertaken for 1-3 weeks (see Chapter 5), dependent on the practitioner's preferences. Bait should be retrieved or replaced before the 1080 content reaches sub-lethal doses. Results from degradation trials indicate that the longevity of bait varies with the type of bait (Chapter 3). Therefore, the type of bait used in a baiting campaign will determine the period after which it should be replaced. Taking this into account, the number of baits for each of the bait types to be replaced during baiting campaigns lasting from one to four weeks will be estimated using the degradation data.

The total purchase cost of the bait used in baiting campaigns is derived from the per unit bait price and the number of baits required. The purchase price of bait is more or less fixed by the supplier (RLPB) but it does increase periodically following the price of raw materials (C. Somerset, Molong RLPB, pers. comm. 2004). The number of baits required will depend on the number of baits initially laid, the duration of the baiting campaign, and the number of baits removed during the campaign if a replacement baiting strategy is used.

The number of baits initially laid in a baiting campaign again depends on the personal preferences of the practitioner and is usually determined by the size of the area to be protected. The mean number of baits used per campaign in the Molong RLPB between 1998 and 2002 was 42.9 but was highly variable (SD = 38.5). Regardless, the mean (43 baits) will be sufficient for the purposes of this analyses.

Replacement baiting is one practice that will influence the number of baits used per campaign. Replacement baiting is where baits are checked regularly (usually at 2-5 day intervals) and fresh bait is laid when bait is taken. If baiting programs continue for extended periods, 'old' bait is also removed and replaced with fresh bait. The rate of bait take will directly affect how many baits need to be replaced as they degrade to contain sub-lethal doses. To determine the effect that bait take and replacement baiting may have on the need to

retrieve and replace bait, I simulated the number of baits that need to be replaced for a baiting campaign. Each simulation used an initial number of baits laid (43), a variable rate of bait uptake (10, 25 or 50% of available baits), checking/replacing interval of 3-4 days and variable duration of the baiting campaign (1, 2, 3 or 4 weeks) to estimate the number of baits of each bait type that need to be replaced. This allowed me to estimate the effect that these variables (bait type, bait uptake, and duration of the baiting campaign) have on the number of baits that need to be replaced and, therefore, the relative cost of the campaign using each bait type.

7.2.3.4. Bait consumption – relative cost per bait consumed

The costs of presenting lethal bait (per day) for each bait type is useful to compare the costs of presenting bait in terms of longevity, but it does not account for the palatability of the bait. Specific bait types may rank highly in terms of cost vs. longevity, but this will mean little if the bait is unpalatable to the target species. Therefore, any assessment of the relative cost-efficiency of the different bait types should also consider bait palatability.

To incorporate this aspect, it is necessary to have meaningful data on the palatability of the bait types. As palatability is related (inversely) to caching (Van Polanen Petel *et al.* 2001), the data collected as part of the caching study (Chapter 4) were used to indicate the relative palatability of the bait types. Thus the percentage of each bait type consumed from those removed in the toxic trials was compared to the purchase cost of the bait to determine the relative cost-effectiveness of the bait types on a cost per bait consumed basis.

Results from the caching trials (see Chapter 4) indicate that the bait type significantly influences whether the bait will be eaten or cached when taken. In the non-toxic bait trials, there were significant seasonal peaks in caching within study sites but the relationship was not consistent (or significant) across both sites. Since toxic caching trials were not undertaken in all seasons, the percentage of baits (of each bait type) that are consumed was assumed to be consistent across all seasons; the percentage of each bait type taken that was cached was assumed to be the mean from the toxic trials. This is a reasonable assumption given the lack of seasonal differences in caching on the non-toxic trials.

7.2.3.5 Bait procurement and distribution costs

The time (labour) and travelling (vehicle) costs associated with purchasing, laying, checking, replacing and retrieving should be considered when assessing the cost of using different bait types. To purchase bait, the landholder must travel to his/her local RLPB. This represents both a travel (vehicle) cost and time (labour cost), which is largely dependent on the distance that must be travelled. These costs are termed as off-site costs since they are incurred largely whilst travelling off the baiting site. Once the baits have been procured, the travel and time required to lay baits will depend on the placement strategy and the distance travelled whilst laying baits. Checking, replacing and retrieving baits also entail travelling and time costs on the baiting site; these are termed on-site costs.

Given that the time and labour required for laying and checking each bait type will be very similar for each bait type, I assumed that the on-site costs associated with these activities would be the same. However, there are differences in the time it may take to replace bait where there is a disproportionate number of baits of one type needing to be replaced (i.e. day-old chicks and wingettes degrade at a faster rate than Foxoff® and therefore must be replaced more frequently). Therefore, an extra labour cost was added in recognition of the additional time needed to replace degraded bait during checking/replacing occasions. Where appropriate, these differences were quantified by adding extra time (labour cost) to the on-site costs.

The slight difference between replacing a disproportionate number of degraded baits of one bait type in the on-site costs may be compounded by the additional off-site costs required to procure the replacement bait. Foxoff® bait may be legally stored for up to 4 weeks after purchase of the bait (Environmental Protection Authority 2002), enough for most baiting campaigns. But the fresh bait types can only be stored temporarily under refrigeration for a few days (<5) before bait spoils. If any additional wingette or day-old chick baits were required throughout the campaign after this period, then these must be purchased.

Here, I estimate the cumulative number of trips required for the procurement of bait (off-site costs) and the physical replacement of bait (on-site costs), together with the travelling and time costs associated with these trips. Each simulation uses the time and travelling costs

estimated for typical baiting campaigns (durations of 1, 2, 3 or 4 weeks and checking/replacement interval of 3-4 days). The on-site costs of time (labour) and travelling (vehicle) for laying and checking bait (with or without replacing degraded bait) are calculated through estimating the time (in hours) and distance travelled (km) for a standard baiting campaign (43 baits). Travel costs are calculated from the total running costs per kilometre for a diesel 4WD. Labour cost are based on the gross hourly wage of an agricultural labourer. The off-site costs of time (labour) and travelling (vehicle) for procuring bait from the RLPB are largely dependent on the distance the practitioner must travel to reach the RLPB. This distance is calculated by averaging the minimum and maximum distance that practitioners must travel within the Molong RLPB to procure bait. The additional labour time required at different rates of bait uptake was not considered important since it would represent an additive cost consistent for all bait types.

7.2.3.6 Total campaign costs and cost per bait consumed

When assessing the cost-effectiveness of different strategies, it is important to account for both the cost of bait purchase and the cost of bait procurement and usage. The total costs of undertaking a baiting campaign will depend on the number of baits used, campaign duration, checking and replacement strategy and bait procurement and distribution costs. The cumulative cost of the bait used was derived from the number of baits that are removed or degraded, at given bait uptake rates (10, 25, and 50%) and campaign durations (7, 14, 21 and 28 days) (see Section 7.2.3.3). The travelling and time expenses were calculated from the total labour and vehicle cost associated with procurement and distribution/usage of bait (Section 7.2.3.5). The total of these costs were compared for the different bait types.

When the total costs of undertaking a campaign are compared to the number of baits consumed (Section 7.2.3.4), the total cost per bait consumed can be calculated. This is perhaps the most useful measure of cost-effectiveness since it accounts for the total economic costs incurred per bait consumed. These costs are calculated for given bait uptake rates and campaign durations for each bait type.

Sensitivity analyses

The results of sections *7.2.3.2* to *7.2.3.4* will vary depending on the purchase cost of the bait. Thus, sensitivity analyses were undertaken to examine how resistant the above relationships were to fluctuations in the purchase price. In each case, I evaluated the percentage increase/decrease in the purchase price of the each bait type that was required to alter the observed relationships among bait variables.

Sensitivity analyses were not undertaken for the bait procurement and distribution costs because fluctuations in these costs would only affect the absolute values and not the relationships between the variables.

7.2.4 Decision tree analyses

Decision trees provide a highly effective technique to assist in decision making processes. They present the problem in a clear, objective manner so the options and the consequences of each option can be identified and compared (Buzan 1993). Decision tree analyses are especially suited to problems that require the best alternative to be chosen quickly, while still considering all the known advantages and disadvantages (Schuyler 2001).

The basis of the decision tree presented here is to provide a conceptual model of what factors should be considered in undertaking baiting campaigns (regionally specific but with obvious application elsewhere). The following results, together with other considerations, are presented to determine the optimal baiting strategy for a given situation.

7.3 Results

7.3.1 Bait longevity - cost per day

On the NSW central tablelands and western slopes, Foxoff® baits remain lethal to foxes for an average of 2.1 weeks (14.7 days) after burial, with 95% remaining lethal for at least 1.0 weeks (7 days) and 95% degrading to below sub-lethal levels by 5.0 weeks (35 days). Wingettes degrade at a faster rate, retaining 0.65 mg 1080 for a mean of only 1.1 weeks (7.7 days), with

95% remaining lethal for 0.5 weeks (3.5 days) and 95% becoming sub-lethal after 1.8 weeks (12.6 days) (see Table 3.9, Table 7.1).

No data are currently available on the degradation rate and expected lifespan of 1080- injected day-old chicks. Given that they are the same substrate (chicken) as wingettes it is not unreasonable to assume that the expected lifespan is similar. Day-old chicks could potentially last longer as their lack of abattoir processing may reduce bacterial contamination (see Adam and Moss 1995). Alternatively, they may last for shorter periods given that bacterial processes within their contained digestive tract may accelerate breakdown. Under most trial conditions they appear to remain structurally viable for similar periods as wingettes (M. Gentle pers. obs.). Therefore, in the absence of actual estimates, data relating to wingettes will be applied here to day-old chicks. However, where cost data are indentical only data for wingettes shall be presented.

The retail cost, or the price that landholders pay when purchasing baits from the RLPB, ranges between $0.60 and $1.00 for each wingette and Foxoff® bait, respectively. Day-old chicks would cost an estimated $0.60 each. Using the retail cost and the mean period that each bait type would remain lethal to foxes (rounded to the earlier whole day), the average cost per day for Foxoff® baits during the period they remain lethal is 7.1 cents (see Table 7.1). However, the cost ranges between 2.9 and 14.3 cents depending on whether the bait remains lethal for 35 or 7 days, respectively. Wingettes and day-old chicks are estimated to be more expensive, costing on average 8.6 cents for each day that they remain lethal to foxes.

Based on the wholesale purchase price, by contrast, the mean cost per day to present wingettes (2.7 cents) and day-old chicks (2.8 cents) is considerably cheaper than Foxoff® (6.3 cents).

Table 7.1: The cost per day (cents) for the period that Foxoff®, wingettes and day-old chicks remain lethal to foxes (i.e. containing >0.65 mg 1080). For comparative purposes, the cost per day ($) for a baiting program using 43 baits is shown for both retail [R] and wholesale [W] prices.

Bait type	Bait cost [retail/wholesale]	Days >0.65mg 1080 (95% CI)	Cost day^{-1} (cents) (95% CI)	Cost per day per program using 43 baits (95% CI)
Foxoff®	$1.00 [R] $0.88 [W]	14.7 (7.0 – 35.0)	7.1 (14.3-2.9) 6.3 (12.6-2.5)	$3.05 ($6.15-$1.25) $2.71 ($1.08-$5.42)
Wingette	$0.60[R] $0.19[W]	7.7 (3.5 – 12.6)	8.6 (20.0-5.0) 2.7 (6.3-1.5)	$3.70 ($8.60-$2.15) $1.16 ($2.71-$0.65)
Day-old chick	$0.60[R] $0.20[W]	7.7 (3.5 – 12.6)	8.6 (20.0-5.0) 2.8 (6.6-1.6)	$3.70 ($8.60-$2.15) $1.20 ($2.84-$0.69)

Records from Molong RLPB indicate that the average number of baits used in baiting campaigns between 1998 and 2002 was 42.9 (Table 5.1). This equates to a retail cost per day for undertaking an average baiting campaign (i.e. 43 baits) of $3.70 for wingettes and day-old chicks and $3.05 for Foxoff®. For wholesale, the price differential is reversed.

Sensitivity analyses

Using the mean cost per day, a retail price increase of 20% (to $1.20) would be required before Foxoff® became as cost-effective as the fresh bait types. Alternatively the retail price of wingettes or day-old chicks would have to fall by greater than 17% (to 49 cents) to become more cost-effective than using Foxoff.

Based on wholesale prices, Foxoff® would have to fall to 50 cents, a 43% reduction, to become equal to or more cost-effective as the fresh-bait types. Alternatively, the price of wingettes and day-old chicks would have to increase to greater than 44 cents per unit (>132% rise) to match the cost-effectiveness of Foxoff®.

7.3.2 Baiting campaigns – bait uptake and bait replacement

The number of baits needing to be retrieved and replaced before degrading to sub-lethal levels would vary depending on the bait type and the duration of the campaign (see Table 7.2). Foxoff® baits need to be replaced about every 14 days; a three-week campaign would not require bait replacement until day 14. Once replaced, these baits would remain toxic until day 28. Consequently, campaigns lasting for 1-2 weeks do not require any bait to be replaced on the basis of degradation. Replacing baits at the end of a 14 day period should suffice for both 3 week and 4 week campaigns. In contrast, wingettes and day-old chicks should be replaced every 7 days; baiting campaigns that last over one week would require baits from the previous week to be replaced. Therefore the number of wingette and day-old chick baits needs to increase in weekly increments.

Table 7.2: The cumulative number of baits required during an average baiting campaign (43 bait stations) lasting 7, 14, 21 and 28 days. The cumulative retail [R] and wholesale [W] costs of the bait material are also shown for comparative purposes.

Bait type	Mean days >0.65 mg 1080	Duration of campaign and cumulative number of baits used			
		7 days	14 days	21 days	28 days
Foxoff®	14.7	43 $43 [R] $37.84 [W]	43 $43 [R] $37.84 [W]	86 $86 [R] $75.68 [W]	86 $86 [R] $75.68 [W]
Wingette	7.7	43 $25.80 [R] $8.17 [W]	86 $51.60 [R] $16.34 [W]	129 $77.40 [R] $24.51 [W]	172 $103.20 [R] $32.68 [W]
Day-old chick	7.7	43 $25.80 [R] $8.60 [W]	86 $51.60 [R] $17.20 [W]	129 $77.40 [R] $25.80 [W]	172 $103.20 [R] $34.40 [W]

Where practitioners replace baits that are removed in addition to those that are sub-lethal the number of baits used increases (Table 7.3). As a demonstration, the number (Fig 7.1) and relative cost (Table 7.3) of using each bait type that needs to be retrieved during replacement baiting (every 3-4 days) is presented for given campaign durations (1-4 weeks) and rates of bait take (10, 25, 50%).

Table 7.3: The cumulative number of baits required to undertake baiting and replace degraded or removed baits during a baiting campaign (43 bait stations) lasting 7, 14, 21 and 28 days at 10, 25 and 50% bait uptake rates. The cumulative retail prices of the bait material are also shown for comparative purposes.

		Duration of campaign			
	Bait type	7 days	14 days	21 days	28 days
Cumulative number of baits used at bait uptake rates of (10%), {25%}, (50%) respectively and when baits are replaced every 3-4 days	Foxoff®	47.3 {53.8} (64.5)	55.9 {75.3} (107.5)	95.5 {113.8} (154.5)	109.8 {142.1} (200.2)
	Wingette	47.3 {53.8} (64.5)	94.2 {105.5} (123.6)	140.8 {156.1} (181.4)	187.2 {206.0} (238.9)
	Day-old chick	47.3 {53.8} (64.5)	94.2 {105.5} (123.6)	140.8 {156.1} (181.4)	187.2 {206.0} (238.9)
Cost of bait used – retail price = [R] *wholesale price* = [W]	Foxoff® [R] =$1 [W] = $0.88	$47.30 {$53.80} ($64.50) *$41.60* *{$47.34}* *($56.76)*	$55.90 {$75.30} ($107.50) *$49.19* *{$66.26}* *($94.60)*	$95.50 {$113.80} ($154.50) *$84.04* *{$91.04}* *($135.96)*	$109.80 {$142.10} ($200.20) *$96.62* *{$125.05}* *($177.94)*
	Wingette [R] = $0.60 [W] = $0.19	$28.38 {$32.28} ($38.70) *$8.99* *{$10.23}* *($12.25)*	$56.52 {$63.30} ($74.16) *$17.90* *{$20.05}* *($23.48)*	$84.48 {$93.66} ($108.84) *$26.75* *{$29.66}* *($34.47)*	$112.32 {$123.60} ($143.34) *$35.58* *{$39.14}* *($45.93)*
	Day-old chick [R] = $0.60 [W] = $0.20	$28.38 {$32.28} ($38.70) *$9.46* *{$10.76}* *($12.90)*	$56.52 {$63.30} ($74.16) *$18.84* *{$21.10}* *($24.72)*	$84.48 {$93.66} ($108.84) *$28.16* *{$31.22}* *($36.28)*	$112.32 {$123.60} ($143.34) *$37.44* *{$41.20}* *($47.78)*

Relatively more wingettes or day-old chicks than Foxoff® would be required during a replacement baiting program at all levels of bait uptake and campaign duration. However, as for a non-replacement baiting program over seven days the most cost-effective bait alternates every week (retail prices) (Table 7.3). Over a 7 day campaign, the cost of using Foxoff® is more expensive than the two fresh meat baits but over a 14 or 28 day campaign the difference between using these bait types is negligible. However, based on the wholesale cost of purchasing the bait substrate it is more cost-efficient to use wingettes and day-old chicks than Foxoff® over all time periods.

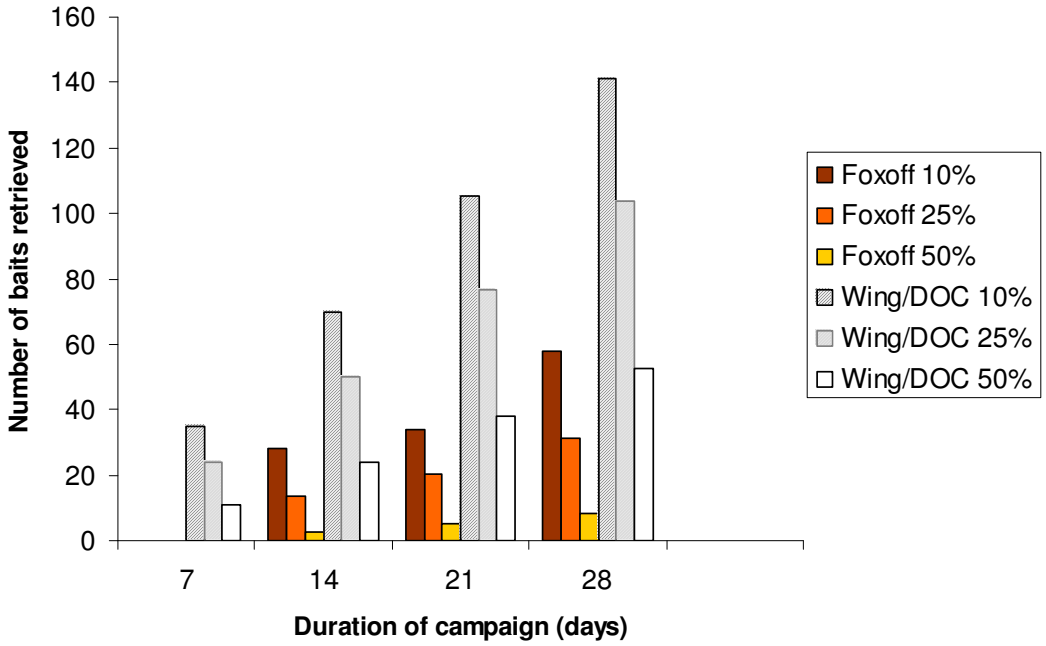

Figure 7.1: The cumulative number of baits needing to be retrieved during a replacement baiting program (43 baits laid and checked/replaced every 3-4 days) at bait uptake rates of 10, 25 and 50% (4.3, 10.75 and 21.5 baits, respectively removed every 3-4 days). DOC = day-old chick, Wing = wingette.

Sensitivity analyses

Based on retail prices, for baiting periods lasting 7 days or less, at all levels of bait uptake, it would cost an extra 66% of the fresh bait purchase price to use Foxoff®. Over a 14 day campaign Foxoff® baits are less expensive, although the margin is slim (1.1% of Foxoff® cost). This margin increases to 19% and 45% though, as the rate of bait uptake increases (25

and 50% respectively). The same relationship occurs after 21 and 28 days; the additional cost of using Foxoff® relative to the fresh bait types is 13.0, 21.5 and 42% for 10, 25 and 50% uptake levels, respectively, for a 21 day campaign. Over 28 days Foxoff® is cheaper by 2.2, 15 and 39.7% for 10, 25 and 50% uptake rates, respectively.

Regardless of campaign duration and rates of uptake it is always more cost-effective to use wingettes (>172% saving) or day-old chicks (>158% saving) than Foxoff® based on wholesale prices.

7.3.3 Bait consumption – relative cost per bait consumed

In the toxic bait caching trials, significantly more Foxoff® baits (74.3%) were cached when taken by foxes compared to day-old chicks (26.2%) and wingettes (43.1%). Given that there was no significant difference between the percentage of day-old chicks and wingettes cached, the percentages of these two bait types cached were pooled (35.5%). The percentage of toxic cached baits that was subsequently recovered averaged only 13.6% and was not significantly different between the bait types (Chapter 4). Accounting for this, the mean percentage of day-old chicks/wingette and Foxoff® baits that were eaten after being taken was 69.4% and 35.8% respectively. This equates to only one Foxoff® bait being consumed from approximately every 2.8 Foxoff® baits removed. Wingettes and day-old chicks require only 1.4 baits to be removed for every bait consumed (Table 7.4).

Table 7.4: The mean percentage of Foxoff®, wingette and day-old chick baits consumed from those taken in the toxic bait trials and the cost of each consumed bait relative to those that were taken.

Bait type	Bait cost [R = retail, W = wholesale]	Mean percentage of baits eaten (cached)	Number of baits taken for 1 to be consumed	Cost bait^{-1} consumed from those taken
Foxoff®	$1.00 [R] $0.88 [W]	35.8 (64.2)	2.79	$2.79 $2.46
Wingette	$0.60[R] $0.19[W]	69.4 (30.6)	1.44	$0.86 $0.27
Day-old chick	$0.60[R] $0.20[W]	69.4 (30.6)	1.44	$0.86 $0.29

Based on the retail cost of purchasing bait, an estimated $2.79 worth of Foxoff® baits is taken for every bait consumed. This is more than three times the cost of using wingettes or day-old chicks, which require only $0.86 worth of bait to be taken for every bait consumed. Based on the wholesale prices, Foxoff® ($2.46) is even more expensive relative to wingettes and day-old chicks ($0.27 and $0.29, respectively).

7.3.4 Baiting campaigns - cost of bait consumed

The above calculations demonstrate that differences in the purchase cost and palatability between bait types can considerably affect the cost per bait consumed. However, the duration of the baiting campaign and 'lethal longevity' of bait will affect the need to replace bait, and therefore the cost. The rate of bait uptake will also affect the number of baits that need to be replaced; high levels of bait uptake will mean that fewer degraded baits need to be replaced. In consideration of this issue, the numbers of baits that are consumed for the number of baits taken for a given campaign duration (1-4 weeks) at 10, 25 and 50% bait uptake rates (from Table 7.3) are shown in Table 7.5.

Table 7.5: The cumulative number of baits consumed during a baiting campaign (43 baits) lasting 7, 14, 21 and 28 days at 10, 25 and 50% bait uptake rates (e.g. 10% of baits consumed during each checking period). The cumulative retail and wholesale prices of the bait material are also shown for comparative purposes.

		Duration of campaign			
	Bait type	7 days	14 days	21 days	28 days
Cumulative number of baits consumed at bait uptake rates of 10%, {25%}, (50%) respectively when 43 baits are initially laid and baits are checked/replaced every 3-4 days	Foxoff®	3.16 {7.91} (15.82)	7.70 {15.39} (30.79)	11.55 {23.1} (46.18)	15.40 {30.79} (61.6)
	Wingette	5.97 {14.92} (29.84)	11.94 {29.84} (59.68)	17.91 {44.76} (89.53)	23.87 {59.68} (119.37)
	Day-old chick	5.97 {14.92} (29.84)	11.94 {29.84} (59.68)	17.91 {44.76} (89.53)	23.87 {59.68} (119.37)
Cost per bait consumed – retail price = [R] *wholesale price* = [W]	Foxoff® [R] =$1 [W] = $0.88	$14.96 {$6.80} ($4.08) $13.16 {$5.98} ($3.59)	$7.26 {$4.89} ($3.49) $6.39 {$4.31} ($3.07)	$8.27 {$4.93} ($3.35) $7.28 {$4.34} ($2.95)	$7.13 {$4.62} ($3.28) $6.27 {$4.07} ($2.89)
	Wingette [R] = $0.60 [W] = $0.19	$4.75 {$2.16} ($1.30) $1.50 {$0.69} ($0.41)	$4.73 {$2.12} ($1.24) $1.50 {$0.67} ($0.39)	$4.72 {$2.09} ($1.22) $1.49 {$0.66} ($0.39)	$4.70 {$2.07} ($1.20) $1.49 {$0.66} ($0.38)
	Day-old chick [R] = $0.60 [W] = $0.20	$4.75 {$2.16} ($1.30) $1.58 {$0.72} ($0.43)	$4.73 {$2.12} ($1.24) $1.57 {$0.71} ($0.41)	$4.72 {$2.09} ($1.22) $1.57 {$0.70} ($0.40)	$4.70 {$2.07} ($1.20) $1.56 {$0.69} ($0.40)

The cost per bait consumed is calculated from the number of baits required to present lethal bait during each campaign length, considering bait longevity and replacement for the given uptake rates.

When the number of baits consumed and cost per bait consumed for a given uptake are considered, there is a major discrepancy between the fresh meat types and Foxoff®. Foxoff® baits cost more than wingettes/day-old chicks for all campaign durations and rates of bait uptake. The difference between using Foxoff® and the fresh meat baits is greater for campaigns lasting 7 days or less.

The cost per bait consumed decreases with increasing rates of bait uptake; this is simply due to increased numbers of baits being consumed and the reduced cost of replacing degraded baits that are not consumed.

7.3.5 Bait procurement and distribution costs

Each trip on-site for a baiting campaign using 43 bait stations would require travelling approximately 19 km to accommodate bait stations spaced at 200-300 m intervals, including a travelling distance to reach the baiting locations within the site. Laying bait is more labour intensive than checking (without replacing degraded) bait, with approximately 5.5 hours needed compared to 3.5 hours respectively. When checking bait, an estimated 30 minutes additional time would be needed to replace degraded bait compared with periods when only removed bait is replaced (M. Gentle pers. obs.). The cost of these parameters was then estimated from labour and total vehicle running costs (see Table 7.6).

Landholders would have to travel on average between 5 and 95 km (one-way) to obtain baits from the Molong RLPB (i.e. offices in Molong and Peak Hill) (see Figure 5.1). Given the even distribution of landholders across the board district, I chose a total travelling distance of 95 km per trip (47.5 km each way) as an appropriate compromise. The total time to travel this distance, and collect bait from the RLPB would total approximately 1.5 hours. The costs estimated from these parameters are estimated in Table 7.6.

Table 7.6: Cost of parameters associated with one trip for either procurement (off-site) or use (on-site) of baits for a baiting program (43 baits).

		Travelling cost			Labour cost			Total cost
Task	Cost class	Vehicle cost (per km)	Distance travelled (km)	Total	Time (h)	Hourly rate	Total	
Laying bait	On-site	$0.7196	19	$13.67	5.5	$14.44	$79.42	$93.09
Procuring bait	Off-site	$0.7196	95	$68.36	1.5	$14.44	$21.66	$90.02
Checking (replace degraded)	On-site	$0.7196	19	$13.67	4.0	$14.44	$57.76	$71.43
Checking (degraded not replaced)	On-site	$0.7196	19	$13.67	3.5	$14.44	$50.54	$64.21

Sources: Vehicle costs based on the total average running cost for a diesel 4WD (Nissan Patrol) (National Road and Motoring Association 2004). The labour cost hourly rate is based on that of an agricultural/horticultural labourer (Australian Bureau of Statistics 2002).

The costs of each task based on the labour and travel costs (from Table 7.6) were assessed based on the cumulative tasks required for each bait type when undertaking baiting campaigns for 7, 14, 21 and 28 days duration (see Table 7.7).

Table 7.7: The cumulative number of trips required to undertake baiting and replace degraded or removed baits on the baiting site (on-site) and to purchase fresh bait from the RLPB (off-site) for a baiting campaign (43 bait stations) lasting 7, 14, 21 and 28 days when baits are replaced every 3-4 days. The cumulative prices of the travelling and labour costs and their totals are also shown for comparative purposes. Note: data for day-old chicks are not presented but are identical to wingettes.

		Duration of campaign			
	Bait type	7 days	14 days	21 days	28 days
Cumulative number of trips on-site and [off-site]	Foxoff®	3 [1]	5 [1]	7 [1]	9 [1]
	Wingette	3 [1]	5 [2]	7 [3]	9 [4]
Cumulative labour cost of trips on-site and [off-site]	Foxoff®	$180.50 [$21.66]	$281.58 [$21.66]	$389.88 [$21.66]	$490.96 [$21.66]
	Wingette	$180.50 [$21.66]	$288.80 [$43.32]	$397.10 [$64.98]	$505.40 [$86.64]
Cumulative vehicle cost of trips on-site and [off-site]	Foxoff®	$41.01 [$68.36]	$68.35 [$68.36]	$95.69 [$68.36]	$123.03 [$68.36]
	Wingette	$41.01 [$68.36]	$68.35 [$136.72]	$95.69 [$205.08]	$123.03 [$273.44]
Cumulative labour and vehicle cost on-site, [off-site] and **Total cost**	Foxoff®	$221.51 [$90.02] **$311.53**	$349.93 [$90.02] **$439.95**	$485.57 [$90.02] **$575.59**	$613.99 [$90.02] **$704.01**
	Wingette	$221.51 [$90.02] **$311.53**	$357.15 [$180.04] **$537.19**	$492.79 [$270.06] **$762.85**	$628.43 [$360.08] **$988.51**

The cumulative number of trips required on-site is the same for all bait types for a given campaign duration. For campaigns of up to 7 days duration only one trip off-site to the RLPB is required for all bait types. However, accounting for the need to replace the fresh bait types every 7 days, an additional off-site trip is required to procure this bait every week for campaigns over 7 days duration. This is not required for Foxoff® since it is shelf-stable and may be stored (legally) for up to one month from purchase. Therefore, for campaigns up to 4 weeks duration only one off-site trip is required for Foxoff® compared to four for the wingettes and day-old chicks.

These differences are reflected in the travelling (labour and vehicle) costs. The on-site travelling costs are the same for all bait types. However, the off-site costs increase each week for the fresh bait types with the increase in procurement trips required. These off-site costs for using the fresh bait types therefore represent a 200, 300 and 400% increase over Foxoff® for baiting campaigns lasting 2, 3 or 4 weeks respectively. This is a considerable difference, especially after 4 weeks ($90.02 vs. $360.08 respectively).

The additional time needed to replace the fresh bait type more regularly is reflected in the on-site labour costs for each bait type. For campaigns lasting greater than 7 days, the difference in labour cost indicates the difference between weekly (fresh bait types) and fortnightly (Foxoff®) replacement (see 7.3.2).

7.3.6 Total campaign costs and cost per bait consumed

Considering the cost of purchasing, procuring and distributing/checking/replacing bait, the total cost of undertaking baiting varies with bait type, rate of bait take and duration of the campaign (Table 7.8). For example, 7 day campaigns using wingettes cost a total of $339.91 at 10% bait take but increase to $350.23 at 50% bait take. These costs increase to $593.71 and $611.35 respectively after 14 days, as a function of the number of baits replaced and the additional procurement of fresh baits.

Based on the total campaign cost, it is cheaper to present wingettes and day-old chicks than Foxoff® for campaigns up to 7 days duration. The price of Foxoff® would have to fall by

40%, or alternatively, the price of the fresh bait types would have to increase by 66% for cost of presenting the commercial and fresh bait types to be equal. At all other campaign durations, it is cheaper to present Foxoff®. A substantial increase (>170, >110 and >250%) in the price of Foxoff® would be necessary to make them equally or less efficient at 14, 21 and 28 days respectively than the fresh bait types.

Table 7.8: The cumulative total cost of undertaking baiting for an average baiting campaign (43 baits) lasting 7, 14, 21 and 28 days at 10, 25 and 50% bait uptake rates. Data based on the total cumulative labour and vehicle cost and the cumulative cost of bait required to replace degraded or removed baits during the baiting campaign. Note: data for day-old chicks are not presented but are identical to wingettes.

		Duration of campaign			
	Bait type	7 days	14 days	21 days	28 days
Cumulative total cost at bait uptake rates 10%, {25%}, (50%)	Foxoff®	$358.83 {$365.33} ($376.03)	$495.85 {$515.25} ($547.45)	$671.09 {$ 689.39} ($730.09)	$813.81 {$846.11} ($904.21)
	Wingette	$339.91 {$343.81} ($350.23)	$593.71 {$600.49} ($611.35)	$847.33 {$856.51} ($871.69)	$1100.83 {$1112.11} ($1131.85)

Using the total costs (Table 7.8) and the number of baits of each bait type consumed for given bait uptake rates (Table 7.5) the cost per bait consumed was calculated (see Table 7.9). The results indicate that the cost per bait consumed varies dramatically with the duration of the campaign, the level of bait uptake and the bait type chosen. At all presented campaign durations and bait uptake levels, the fresh bait types are more cost-effective than Foxoff®, although the difference between the fresh and commercial bait types decreases with increased campaign duration.

Table 7.9: The cumulative total cost per bait consumed for an average baiting campaign (43 baits) lasting 7, 14, 21 and 28 days at 10, 25 and 50% bait uptake rates. Data based on the total cumulative labour and vehicle cost, the cumulative cost of bait required to replace degraded or removed baits during the baiting campaign, and the number of baits consumed during the campaign. Note: data for day-old chicks are not presented but are identical to wingettes.

		Duration of campaign			
	Bait type	7 days	14 days	21 days	28 days
Cumulative total cost per bait consumed at bait uptake rates 10%, {25%}, 50%)	Foxoff®	$113.55 {$46.19} ($23.76)	$64.40 {$33.48} ($17.78)	$58.10 {$29.84} ($15.81)	$52.84 {$27.48} ($14.68)
	Wingette	$56.94 {$23.04} ($11.74)	$49.72 {$20.12} ($10.24)	$47.31 {$19.41} ($9.74)	$46.12 {$18.63} ($9.48)

7.3.7 Decision tree analyses

The practical implications of the results derived through the economic analyses are summarised in the decision tree in Figure 7.2. This presents the main considerations for deciding the most appropriate baiting strategy to use based on the longevity, palatability, procurement and distribution costs and *retail* cost of the respective bait types, together with storage and handling considerations associated with using each bait type. The retail cost was used since this better represents the total costs involved in the bait manufacture and also the cost incurred by landholders. The decision of which technique to use will ultimately depend on the replacement strategy used, the duration of the baiting campaign, and handling, non-target and cost-effectiveness considerations. Table 7.10 provides a description and summary of the issues and decisions to be made for each node in the decision tree.

Table 7.10: Description and notation for factors considered important in decision-making for baiting campaigns for foxes on the central tablelands of New South Wales.

Factor	Description	Notation	Details
Campaign duration	The number of days that baits are presented	< 7days; 7-14 days, >7 days; >14 days	As per description in 7.2.3.3
Cost-effectiveness	The cost of baiting per unit of output	Min cost per lethal bait presented	The minimum cost ($) of presenting bait lethal to foxes
		Min cost per bait consumed	The minimum cost ($) of bait required for every bait consumed (from those that are taken)
		Min total cost per bait consumed	The minimum cost per bait consumed considering procurement, usage, and bait presented
Minimum cost criteria	The minimum cost associated with undertaking baiting	Min cost of bait procurement	The minimum cost ($) of procuring bait from RLPB
		Min cost of bait usage	The minimum cost ($) of bait laying, checking and replacing
		Min total cost	The minimum cost of campaign considering procurement, usage, and bait presented
Non-target safety	Issues associated with the susceptibility of non-target species consuming the bait	Min persistence	The shortest period of bait longevity and therefore, withholding period
		Min caching	The bait type/s that are cached in the smallest proportion
		Min uptake	The bait type with reduced uptake by non-target animals
Replacement	Descriptor for whether removed or degraded bait is replaced during campaign	Replacement; No replacement	As per description in 7.2.3.3
Handling	Issues associated with the storage, handling or use of bait	Min number of baits required	The minimum number of baits required during a baiting campaign
		Min replacement	The minimum number of degraded baits to be replaced during a baiting campaign
		Min number of procurements	The minimum number of off-site trips required during a baiting campaign
Longevity	Lethal longevity of bait presented	Longevity	Bait presented remains lethal to foxes for campaign period.

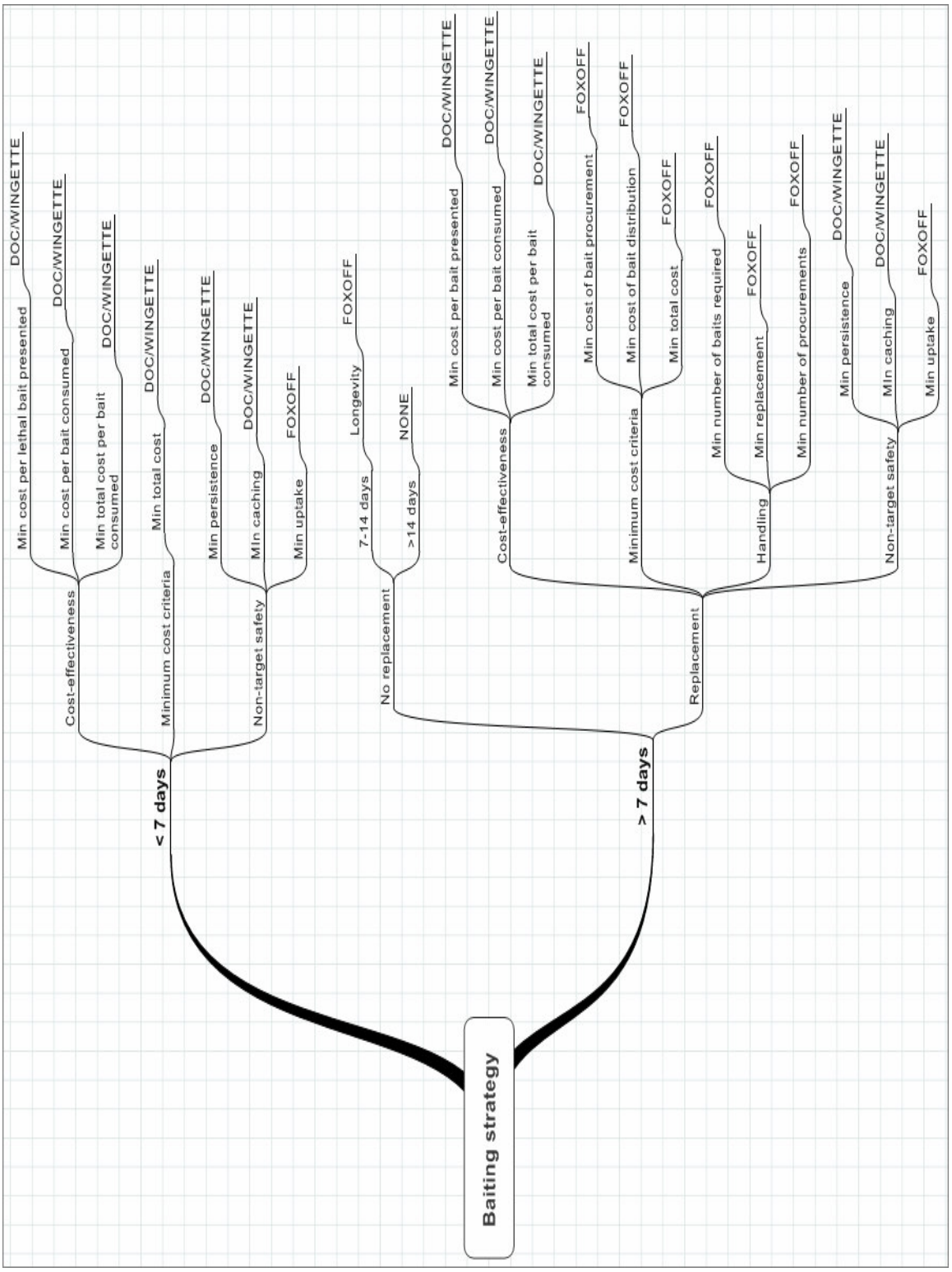

Figure 7.2: Decision tree illustrating the issues and sequence of decisions to be made in choosing the appropriate bait type for a fox baiting campaign. Bait types include DOC = day-old chick, WINGETTE = chicken wingette and FOXOFF = Foxoff®.

The decision tree is unusual in that, at each node, the route to be taken is not always a simple dichotomous choice. Additionally, a choice made at one node may not be mutually exclusive from another decision. This reflects the real life complexity of the issue in that it is often a choice between multiple, unrelated factors that indicates which decision should be made at each branch of the tree. The relative weighing given to each factor by the practitioner will ultimately influence the decision taken.

Given that the decision to undertake fox baiting has already been made, the choice is divided into two main categories depending on the duration of the baiting campaign (<7 days or >7 days). For campaigns lasting less than 7 days the next critical decision is whether cost-effectiveness, minimum cost or non-target safety is more important. Following from these, the relative importance of subsets of each factor to the decision-maker will provide the most appropriate choice of bait type. For campaigns continuing for greater than 7 days the decision to undertake replacement baiting or not (i.e. to replace bait that is removed or degraded) is a critical choice (see section 7.3.2).

It is important to note that not all issues are presented in all scenarios. For example, handling is not considered as an issue for campaigns lasting up to 7 days since both Foxoff® and day-old chicks/wingettes will last at least 7 days before becoming sub-lethal. Therefore there will be no difference in the time and labour associated with either strategy. Other issues are treated in the same manner; where there is no difference between the bait types in the respective strategy, the issue is not presented.

Examples

The optimum bait type to use for a replacement baiting campaign lasting <7 days is reliant upon the goal of the decision-maker. If the most important consideration is to achieve the maximum cost-effectiveness (measured as the minimum cost per lethal bait presented or minimum cost per bait consumed) or minimum total cost then day-old chicks or wingettes should be used. If non-target species safety is the most important consideration, especially to minimise caching, day-old chicks or wingettes should be the bait type chosen. However, if

non-target species safety is to be achieved by a reduction of bait uptake, Foxoff® should be preferred.

If handling is the most important issue for baiting campaigns continuing for >7 days, then Foxoff® will have advantages in handling and reduced replacement, and reduced number of procurement trips compared to day-old chicks/wingettes. In contrast, the higher overall cost of purchasing Foxoff® ($1 per bait compared to $0.60) means that it is more cost-efficient to present day-old chicks or wingettes when only the bait cost is considered. If the total cost of bait purchase, procurement and distribution is considered, Foxoff® would be the more cost-efficient on the basis of minimum cost. However, wingettes and day-old chicks would be the more cost-efficient if the total cost of bait purchase, procurement and distribution per bait consumed is considered.

7.4 Discussion

The results of this chapter suggest that the cost of purchasing, procuring and using each bait type, in addition to the palatability and longevity of bait types, should be considered in determining the most appropriate bait type to use in the management of foxes. The results indicate further that the total costs associated with presenting each bait type may not necessarily be the best indication of the most cost-effective bait, especially when the palatability of bait is considered. However, it is also recognised that there may be other considerations more important than simply cost-effectiveness that may influence the decision of which bait type to use.

Considerations not included in the analyses are the costs of bait storage and preparation. The cost of preparing the fresh bait types will be greater than for Foxoff® baits since the commercially manufactured bait is purchased ‘ready to use’ and does not require injection with 1080 (See Chapter 3). Additionally, the product is shelf-stable and may be stored at room temperature for long periods without degradation (Staples *et al.* 1995). The fresh bait substrates may be stored frozen for long periods but should not be re-frozen once prepared (injected with 1080). The use of fresh bait types incurs an additional storage cost associated with freezing (i.e. purchase and use of a -10^0C freezer). These and other costs associated with

the injection of bait, including labour, equipment and the disposables required to mix, inject and store the 1080 solution should also be considered, as should the wholesale prices of the commercial and fresh bait types. However, it was assumed that the retail prices best represent the total preparation costs since the difference between the wholesale and retail price of the fresh bait types is proportionally greater than that of Foxoff® to account for these costs (C. Somerset, Molong RLPB, pers. comm. 2003). It is difficult to determine the cost of many items required for injection of 1080 solution given that that many of these items last indefinitely and will have extended lifespans. Therefore, using the retail price to account for these costs was deemed the best compromise.

There are other miscellanous costs associated with undertaking baiting campaigns that will contribute to the total costs that are not included in the analyses. These would include the labour and expenses (e.g. telephone calls) for notifying neighbours of the intention to bait, the cost of purchasing and distributing warning signs and any consumables used during bait laying, and checking and disposal of bait. These will increase the total costs of undertaking baiting campaigns. However, since they are consistent across all bait types used, the costs would be additive and not affect the cost-effectiveness relationships between bait types.

Another cost is not obvious, but probably worth mentioning. This is the 'missed opportunity cost', or the cost of undertaking baiting operations and not other activities. It is difficult to value these costs since they will be influenced by factors including the type of enterprise and workload at the time of baiting, which vary between properties and even between seasons. However, the opportunity costs of undertaking baiting will reflect the relative ranking of the bait type and replacement strategy used, as identified earlier, since the opportunity cost is proportional to the labour component associated with these factors. These costs are additive to the total baiting costs and should be considered when choosing between baiting strategies.

This chapter assesses the relative cost of undertaking different baiting strategies given that the decision to undertake fox baiting has already been made. In many cases foxes may not be causing significant damage and therefore control may not be required. For example, rates of lamb predation are variable and losses to individual producers ranging between 0 and 30%

have been reported (Lugton 1987; Lugton 1993b; Greentree *et al.* 2000; Heydon and Reynolds 2000; White *et al.* 2000; Moberly *et al.* 2003). Ideally, practitioners should undertake a strategic approach, determine if management is required and then develop an appropriate response. The basis of strategic pest management is to define the problem in terms of damage (agricultural or environmental) before developing, implementing and monitoring the progress of an appropriate plan (Braysher 1993; Braysher and Saunders 2003). This approach will ensure that landholders undertake management only if it is required, and the outcomes of management are monitored in terms of damage reduction rather than just the reduction in pest density.

Given the decision to bait has been made, the analyses outlined here seek to identify the minimum cost associated with undertaking each baiting strategy without assessing the potential benefit (i.e. reduced predation) derived from reductions in fox density. The marginal benefit resulting from reductions in fox density is difficult to estimate since the relationship between fox predation, fox density, and fox control has not been reliably assessed (Moberly *et al.* 2004). Additionally, variations in flock size, flock genetics and health, management practices, availability of alternative prey and other factors influencing predation (see Greentree *et al.* 2000; Moberly *et al.* 2003) would affect the practical application of the conclusions in this study. These factors are not considered here, but are recognised as essential considerations to efficiently allocate resources to fox management.

It is important to note, finally, that the preliminary decision tree model determining the appropriate bait choice was developed from studies undertaken on the central tablelands of New South Wales. In other regions, additional or alternative considerations may become important and affect the outcomes of the model. For example, the choice of bait type may be restricted in less altered environments with particular non-target species and specific bait types. Spotted-tailed quolls (*Dasyurus maculatus*) are known to readily consume chicken and are successfully trapped using chicken wings (P. Cremasco, Department of Natural Resources and Mines, pers. comm. 2004). Foxoff® baits appear to be less preferred because their palatability to quolls is low (Kortner *et al.* 2003) and, therefore, would be recommended for use where quolls are present. Such an issue has been included in the decision tree (minimum

uptake by non-target animals) even though none are present on the central tablelands area. The application of and conclusions drawn from the preliminary model should, therefore, be restricted to the central tablelands area where it was developed.

7.4.1 Bait longevity - cost per day

Foxoff® baits, on average, retain a lethal dose of 1080 for longer than wingettes, and most probably day-old chicks. Despite the fact that that the retail price per unit of Foxoff® ($1) is greater than that of the fresh bait types (both $0.60), its greater longevity means that it is more cost-efficient at presenting a lethal dose based on retail cost per day (7.1 cents/day) than either day-old chicks or wingettes (8.6 cents/day). Where the main consideration of the baiting campaign is to lay bait once only and at the lowest possible cost per day that it remains lethal, then Foxoff® is more cost-efficient than the fresh bait types.

These figures are based on the average period that baits remain lethal, and given degradation of individual baits is highly variable, there is likely to be considerable overlap between these estimates. For example, the cost/day estimates derived from the 95% confidence intervals range from 2.9 – 14.3 cents for Foxoff®, and 5.0 – 20.0 for day-old chicks and wingettes. This variation in the calculated cost per day would have few implications for actual baiting campaigns, if baits were replaced before any became sub-lethal. However, this is not always practical, and therefore the mean period that they remain lethal was used here to reflect the real life situation.

Using the wholesale purchase price of the bait material, day-old chicks and wingettes (2.5 and 2.6 cents per day respectively) are more cost-efficient than Foxoff® (6.0 cents per day). However, this indicates the cost to the authorised distributor only of purchasing the bait material, whether it is injected with 1080 (Foxoff®) or not (fresh bait types). As mentioned earlier, the additional costs involved in the preparation of the bait (including labour, materials and consumables) are not reflected in this price and should be considered in comparing between wholesale prices.

The cost per day relationship between bait types is reasonably robust to fluctuations in the purchase price of the bait. Retail price rises of at least 20% would be required to equal or improve the mean cost per day of the alternative bait types.

7.4.2 Baiting campaigns – bait uptake and replacement

The need to replace baits before they reach sub-lethal 1080 concentrations depends on the bait type and the duration of the baiting campaign. The most-cost efficient bait type (in terms of presenting toxic bait at the lowest bait purchase cost) alternates between the fresh and commercial bait substrates every 7 day period. For short (up to 7 day) campaigns at bait uptake rates of 10%, day-old chicks and wingettes are cheaper to purchase; it would cost an extra 66% of the fresh bait purchase price to use Foxoff® and does not require any replacement. If baiting campaigns continue for up to 14 days it is only slightly cheaper to purchase Foxoff® (99% of the fresh bait price) since it does not need replacing within this period. Presenting wingettes/day-old chicks for a 21-day campaign will cost only 87% of the price of using Foxoff. For a 4-week campaign it is again slightly more cost-efficient to purchase Foxoff® (98% of the fresh bait price).

As bait uptake increases, the relative cost differences both within and between bait types increase. This is due to the interaction of bait longevity, bait uptake and the replacement strategy on the numbers of baits that need to be replaced. The above examples were calculated using strategies where removed or degraded bait was replaced with fresh bait every 3-4 days and the rates of bait take continued at the same rate (10, 25 and 50%) for the entire campaign period. At higher rates of bait uptake there are more baits being removed by foxes, resulting in proportionally less degraded baits needing to be replaced. Also, as the duration of the campaign increases the cumulative number of baits removed also increases – including an increasing proportion of the 'fresher' baits laid to replace earlier-removed baits. Therefore, the increasing difference between the commercial and the fresh bait types is due to the compounding effect of the number of baits needing to be replaced as a result of bait degradation and removal (see Figure 7.1).

This chapter demonstrates that the replacement baiting strategy can make large differences to the number of baits required, and therefore cost, in baiting campaigns. It also demonstrates that the number of baits to be replaced in campaigns of typical duration (1-4 weeks) varies according to the bait type used. Replacing baits that are removed or degraded may result in a considerably greater number of baits being used in a campaign compared to replacing only degraded baits (Table 7.3 vs Table 7.2, respectively). The additional costs associated with this strategy will also vary with the bait type used. If additional baits are to be laid then the typical costs associated with checking and laying the baits will be the same for both fresh and commercial bait types. Foxoff® bait may be legally stored for up to 4 weeks after purchase of the bait (Environmental Protection Authority 2002), enough for most baiting campaigns. But the fresh bait types can be stored temporarily and only under refrigeration for a few days (<5) before bait spoils. If any additional wingette or day-old chick baits are required throughout the campaign after this period, then these must be purchased. This would require travelling to and from the supplying RLPB; for a 4 week baiting campaign this would mean three additional trips – this could be a large additional cost both in time and travelling costs, as well as in missed opportunity costs.

7.4.3 Bait consumption – relative cost per bait consumed

It is important to have an understanding of the relationship between bait palatability and cost; a relatively inexpensive bait may be either cost-efficient if highly palatable or cost-*in*efficient if unpalatable. Likewise, more expensive bait may be more or less cost-efficient than a lower-priced bait if it is more or less palatable. Analyses of the price of each bait type in comparison to its palatability indicate that Foxoff® has a considerably higher cost per bait consumed, based on the purchase price of bait, than either wingettes or day-old chicks. Based on the retail price, it is greater than 3 times more expensive to achieve the same result with Foxoff® than wingettes or day-old chicks. This increases to an 8-fold difference when the wholesale price is used. Therefore, the use of day-old chicks and wingettes for fox baiting is considerably more cost-efficient than Foxoff® with respect to the cost of the bait type.

The proportion of each bait type consumed from those taken has been translated to the cost per bait eaten. However, given that foxes may find and consume multiple baits within the

same night (Chapter 2) the number of baits eaten is not directly proportional to the number of foxes killed. Consequently the real cost per fox killed is likely to be greater than the cost per bait eaten.

This analysis fails to consider other costs that may be associated with using bait with relatively low palatability. For example, it may be necessary to lay additional baits to achieve the same levels of bait consumption as the more palatable bait types. The costs are not only the purchase of additional bait material but the cost of distributing, checking and retrieving the additional baits. Such costs can be considerable (Saunders *et al.* 1997a) and would probably be in excess of those spent on bait material alone. Using Foxoff®, a bait with lower palatability, would therefore add economic costs to baiting practices compared to the more palatable and cheaper day-old chicks or wingettes.

Despite this observation, the strategy of laying additional low palatability baits like Foxoff® to increase consumption to levels of day-old chicks or wingettes may be inherently flawed. Presenting additional baits ('food') (by increasing the number of baits available to individual foxes) may result in increased caching as a response to the temporary food surplus (Vander Wall 1990). Therefore caution is needed in interpreting these conclusions.

Not all the additional costs associated with using less palatable bait like Foxoff® are economically quantifiable. For example, the many Foxoff® baits that are cached by foxes may offer a significant hazard to non-target animals, including farm dogs, long after the baiting campaign is finished. The percentage of Foxoff® baits cached is considerably greater than either wingettes or day-old chicks and therefore the associated risk is higher. Additionally, since Foxoff® baits degrade at a slower rate than wingettes (and probably day-old chicks), cached baits will remain toxic for longer, compounding the risk (see Chapter 3). The withholding period would be greater, perhaps restricting the ability to work such areas.

In addition, there may be greater potential for bait aversion to occur through consumption of degraded bait containing sub-lethal doses of 1080 (see Chapter 2). This may affect the

efficiency of future baiting practices. Again, this is another potential cost that needs to be considered in comparing bait types.

7.4.4 Bait procurement and distribution costs

The results demonstrate that the travel and labour costs associated with procuring, laying, checking and replacing bait are considerable and constitute a large proportion of the total campaign cost. Although the actual dollar value will fluctuatate with the labour and travel costs, the influence of using the different bait types upon these costs is important. These influences are often unrecognised when choosing an appropriate bait type but may affect the procurement and distribution costs of a baiting campaign.

Bait that degrades rapidly will require replacing at more regular intervals than bait with greater longevity. The costs related to this replacement include an additional purchase, labour and travelling cost involved with procuring fresh bait as well as extra labour time replacing bait on site. Choosing bait with greater longevity will reduce the procurement and labour costs only where the duration of the campaign is greater than the longevity of the alternative bait type. For example, there are no differences in these costs between Foxoff® and the fresh bait types for a 7 day campaign, but for longer campaigns Foxoff® becomes more efficient.

It is important to note that the actual cost difference between using these bait types will increase or decrease with greater or less travelling distance and time respectively. However, the relative need to undertake procurement and bait replacement will remain the same, regardless of the actual costs.

7.4.5 Total campaign costs and cost per bait consumed

When the bait procurement and distribution costs are considered in combination with the cost of purchasing bait, the total cost of the campaign can be estimated. The results demonstrate that the cost of bait purchase may be the most important determinant of the total campaign cost for short-term campaigns. However, where degraded bait must be replaced, the additional costs associated with this replacement far exceed those of purchasing bait with greater

longevity. Therefore, the total costs of presenting Foxoff® may exceed those of the fresh bait types for campaigns up to 7 days duration, but not for campaigns of longer duration.

These relationships will change as the number of baits purchased increases. This is noted by the reduced difference between the total costs of using Foxoff® and the fresh bait types at higher rates of bait uptake (Table 7.8).

The relationships also change when the palatability of the bait type presented is considered. The total cost associated with each bait consumed indicates that, at all presented campaign durations and bait uptake levels, the fresh bait types are more cost-effective than Foxoff. The difference between the fresh bait types and Foxoff® is again greater for short campaigns, but decreases with campaign duration.

The total cost per bait consumed is perhaps the most definitive measure of cost-effectiveness since it accounts for the total labour, vehicle and bait purchase cost for every bait consumed. Such an objective measure of performance would be useful for comparing between control programs since it accounts for the total costs involved with achieving a desired outcome. Ideally, future assessments of cost-effectiveness should account for bait palatability, in addition to the costs of presenting the bait for an objective measure of comparing baiting strategies.

7.4.6 Other considerations

The total costs associated with using each bait type or strategy are difficult to estimate. The monetary inputs are relatively straightforward, but other considerations may be equally or more important in deciding which strategy to use. For example, comparing the type of helicopter used for aerial shooting of feral pigs could be made on the basis of cost per hour but this may fail to take into account issues such as operator safety that vary with the type of helicopter chosen (Saunders 1993). Issues such as this may override any cost considerations and could ultimately be the most important determinant in deciding which strategy is more suitable. Thus it should be recognised that practitioners may use particular baiting practices for reasons apart from cost-effectiveness.

7.4.7 Decision tree analyses

The decision tree model is a useful tool to highlight the several factors that may affect choice of bait types. However, it is only a preliminary model and can be modified to encompass advances in knowledge.

The weighting that each particular item is given by the decision-maker will ultimately affect the final decision. If cost is the issue, this can be easily predicted using the above cost-effectiveness modelling. However, the risk from increased caching, in addition to increased longevity for Foxoff®, may prove to be the deciding factor against its use for many landholders who recognise the risk (to domestic dogs and other non-targets) associated with its use.

The results of this study should be useful for further cost-effectiveness analyses given information about the losses suffered from fox predation and the density:damage relationship. For example, if the relationship between fox density and damage is known the benefit from undertaking control can be calculated, as can the likely cost of reducing animal density to required levels.

In addition, not all techniques are available for use by landholders in all areas. Since RLPBs are responsible for overseeing the distribution of bait to landholders within their administrative area (see Chapter 4), decisions made by individual RLPBs may limit the availability of techniques to practitioners. The availability of bait material, storage and handling, and personal preference by the practitioner may all influence the decision of what techniques will be available and/or undertaken by landholders in fox baiting campaigns.

7.5 Conclusion

This chapter has demonstrated the need to consider bait palatability in addition to the total costs associated with presenting bait (including labour and travelling costs) when assessing the cost-effectiveness of baiting operations. It also suggests that other considerations may be equally or more important when choosing an appropriate bait type to use. Additionally, accounting for the palatability of the bait and the total cost associated with presenting bait

should also provide a more useful means to compare baiting programs with other forms of control. However, it is important to note that the measures of cost-effectiveness presented in this chapter only represent an initial step in an economic analysis of pest control. For control to be economically worthwhile, the cost of undertaking control should not exceed the benefits derived from undertaking control (Moberly *et al.* 2004). Given that the relationship between pest abundance and damage may not be linear, the cost-effectiveness of control needs to be assessed with respect to reduction in pest damage, not abundance.