Management of new deer populations in Northland and Taranaki

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ABSTRACT

Over the last decade, many new populations of deer, mainly red deer (*Cervus elaphus scoticus*), but also wapiti (*C. e. nelsoni*), sika (*C. nippon*), fallow (*Dama dama dama*), and sambar (*C. unicolor unicolor*) deer, have established in the wild in the previously deer-free areas of Northland and Taranaki in New Zealand. Deer regularly escape from farms, but in about 85% of cases the animals are quickly recaptured. No new populations established via escapes in the areas where deer farming is banned in either region. The Department of Conservation (DOC) has been largely successful in eradicating those populations that were not recaptured by the farmers. Illegal liberations of deer pose a more serious problem, and two sika herds have established in eastern Northland in an area where deer farming is banned. Deer farmers were surveyed on the status of their farming enterprises and on the number, size, and causes of any escapes, and on their views on the potential threats to conservation and bovine Tb issues that new deer populations pose. In 42 escape events reported by farmers, an average of 13 deer escaped per incident. In 33 cases where a cause was identified, human error was blamed in 30%, damage to fences in 30%, the rest resulting from inadequate fences. Between June 1997 and May 2000, DOC killed 74 deer in 18 areas in Northland, eradicating all but one herd (sika in Russell Forest). Between June 1997 and June 2001, DOC killed 323 deer in 20 areas in Taranaki, eradicating 8 herds. The eradication programmes for new populations of deer should be continued in Northland and Taranaki, and extended to other deer-free areas north of Auckland, on the Coromandel Peninsula, and on Banks Peninsula. The time spent on different activities related to prevention and eradication of new wild deer populations should be recorded as either 'proactive' or 'reactive' for either escapee populations or illegal liberation populations, so that a cost–benefit analysis of the two strategies can be developed for each situation.

Keywords: deer, deer farming, new populations, illegal liberations, escapes, surveillance, control, eradication

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1. Introduction

In recent years new deer populations have established in previously deer-free areas in Northland and Taranaki. This has led the New Zealand Department of Conservation (DOC) and other agencies to intensify their surveillance of deer farming in these areas, and to initiate programmes to remove any wild populations that have established. These programmes have been conducted with funding and/or other forms of support from the Animal Health Board (AHB), the local branches of the Deer Farmers' Association, and, for Northland, the Northland Regional Council. The Science & Research Unit of DOC commissioned Landcare Research, Lincoln, to survey deer farmers to review the causes of new deer populations, to summarise the Department's actions, and to consider management options to reduce the risk of new populations occurring.

2. Background

Wild populations of one or more of the seven species of deer that are present in New Zealand have established over about 125 000 km^2 (66%) of New Zealand (Fraser et al. 2000). Wild deer have historically been largely absent from areas such as Northland, the Coromandel Peninsula, and Taranaki, but since the late 1980s there have been an increasing number of deer seen in parts of these areas as a consequence of animals escaping from deer farms or from illegal liberations (Fraser et al. 2000).

The forests of Northland and Taranaki are not without introduced herbivores (possums (*Trichosurus vulpecula*) in all, and feral goats (*Capra hircus*) in many). But these species are often the subject of extensive control operations in both areas (Department of Conservation 1998, 1999), and it would be counter-productive to control one ungulate (feral goats) only to have them replaced by another (deer). Therefore, new deer populations represent a significant threat to conservation values in the two areas (Nugent et al. 2001a, b). New populations of deer also present a risk to the farming industry through the potential maintenance and transmission of bovine tuberculosis (Tb) to other wildlife (possums and ferrets) and to livestock (Alspach 1993; Nugent et al. 2001a). It is perhaps not a coincidence that areas free of wild deer in New Zealand have also remained free of Tb in possums, i.e. deer (as an amplifying host) may be the link between Tb in cattle and Tb in possums (Morris & Pfeiffer 1995; Lugton et al. 1998).

The management response to the new deer populations has been both proactive and reactive. Proactive management, aimed at reducing the risk that new populations will become established, has been attempted by legal and social instruments. Deer farming is prohibited by regulation in parts of both Northland and Taranaki (see Figs 1 and 2). Where it is permitted, farming is regulated under the Wild Animal Control Act 1977, particularly section 12, which requires farmers to obtain a permit to farm and to maintain adequate fences. Fencing standards on deer farms are prescribed generally in the Wild Animal Control Act. DOC is currently developing more comprehensive standards and

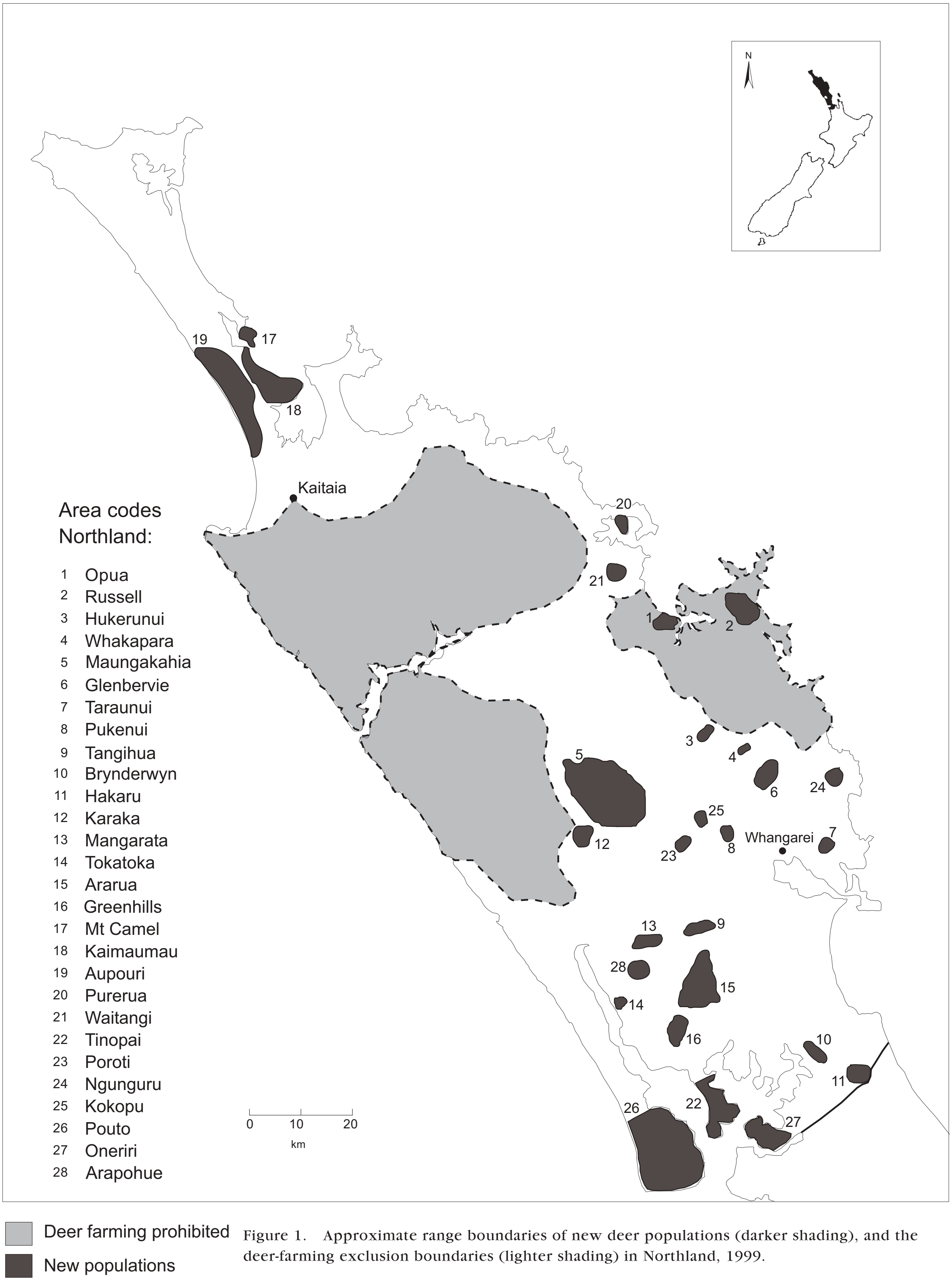

Figure 1. Approximate range boundaries of new deer populations (darker shading), and the deer-farming exclusion boundaries (lighter shading) in Northland, 1999.

Figure 2. Approximate range boundaries of new deer populations (darker shading), and the deer-farming exclusion boundaries (lighter shading) in Taranaki, 1999.

inspection procedures that will be a prerequisite for farmers to obtain approval to farm deer, and as a guide to DOC managers' inspections in areas where escaped deer pose an additional risk. Finally, public and stakeholder awareness of the problem is reinforced in proactive planning documents such as the local Conservation Management Strategies and Regional Pest Management Strategies. Reactive management, aimed at dealing with the new populations as they are discovered, has focused on surveillance, early detection, and on eradicating any populations discovered.

3. Objectives

The objectives are to reduce the risk that new deer populations will establish in Northland and Taranaki, and to improve the chance that any that do establish will be detected and removed by:

- describing the main causes of farm escapes and illegal liberations of deer
- reviewing methods for the early detection of new deer populations
- reviewing control techniques most suited to eradicating new deer populations
- developing a ranking system and procedures to identify priorities for managing new deer populations by proactive and reactive strategies.

4. Methods

A national survey of the distribution and mode of establishment of newly established introduced wild animal populations was conducted between 1993 and 1996 (Fraser et al. 1996, 2000), and the data from Northland and Taranaki were updated for this review using information provided by local DOC staff and various unpublished reports. In addition, all deer farmers in Northland and Taranaki were surveyed using a postal questionnaire in 1999 (Appendix 1). This survey was used to assess the scale and type of deer farming operations in each region, the frequency and causes of farm escapes, farmers' views on escaped deer, the threats they posed, and DOC's management responses. A total of 125 questionnaires were posted to all members of the Northland (n = 75) and Taranaki (n = 50) Deer Farmers' Association, from which 58 responses (32 from Northland and 26 from Taranaki) were returned.

From June 1997 to May 2000 for Northland, and from June 1997 to July 2001 for Taranaki, data on DOC's operational activities were collected as staff attempted to eradicate some of the new populations of deer. Monthly reports were provided on the effort spent on planning, administration, inspecting deer farms, surveillance of suspected new herds, liaison and communication with stakeholders, training staff, deer control, and other 'miscellaneous' activities for each region. DOC staff also provided a standardised record for each deer killed that included the species, the area where it was killed, how it was killed, its reproductive status and sex, and whether it had an ear tag (or a hole in an ear) indicating it had been farmed. They also supplied a lower jawbone from which we determined its age (using tooth eruption or dental cementum layers: Fraser & Sweetapple 1993). Additional information was gleaned from each Conservancy's annual wild deer reports (e.g. McKenzie 1997, 2000) and from periodic operational reports.

5. Results

5.1 NATURE AND SCALE OF DEER FARMING

There were 1.192 million deer farmed in New Zealand in 1996, of which only 11 000 and 13 000 were farmed in Northland and Taranaki, respectively (New Zealand Official Yearbook 2000). Currently, the national farmed herd is claimed to be about 2.06 million (Nugent et al. 2001a). In Northland, 136 deer farming permits have been issued since 1980 and in 1997, 93 farmers were farming deer (McKenzie 1997). In Taranaki, c. 130 deer farming permits have been issued since 1971, and there were c. 118 deer farms in 2001 (L. Stanley, pers. comm.).

According to our 1999 survey, the 32 Northland farmers who replied held 8700 deer and the 26 Taranaki farmers who replied held 3820 deer.

The mean number of deer held on farms was higher in Northland than in Taranaki (Table 1). While some enterprises in both areas are minor (i.e. five farms in Northland and six in Taranaki hold < 50 deer), others are more substantial businesses: 12 farms in Northland and 5 in Taranaki hold > 300 deer.

Respondents had been farming deer for between 2 and 21 years (mean = 9.5). Red deer (*Cervus elapus scotius*) were clearly the most commonly farmed species, although wapiti (*C. e. nelsoni*) and red/wapiti hybrids were also common (Table 2).

TABLE 1. NUMBER OF DEER OF ALL SPECIES HELD ON FARMS IN NORTHLAND AND TARANAKI IN 1999.

	NORTHLAND	TARANAKI
Mean herd size	272	147
Median herd size	216	70
Range	9–900	9–550

TABLE 2. NUMBER OF FARMS HOLDING DIFFERENT TYPES OF DEER IN NORTHLAND AND TARANAKI IN 1999.

TYPE OF DEER HELD	NO. FARMS IN NORTHLAND	NO. FARMS IN TARANAKI
Red deer	15	16
Wapiti	1	0
Red deer, wapiti, and hybrids	15	5
Red deer, fallow, and rusa[1]	0	1
Fallow deer	1	1

[1] (*Cervus timoriensis*)

5.2 EXTENT OF NEW DEER POPULATIONS

Between 1993 and 1996, 30 and 10 new deer populations were reported in Northland and Taranaki, respectively (Fraser et al. 1996). In Northland, 10 new populations (7 red deer, 2 fallow deer (*Dama dama dama*), and 1 wapiti) had resulted from farm escapes, 4 (3 red deer and 1 sika (*C. nippon*)) were attributed solely to illegal liberations, 1 (red deer) resulted from escapes following an accident while transporting deer, and 12 (10 red deer and 2 fallow deer) had unknown origins. A further 3 new populations (all of red deer) were believed to have originated from both farm escapes and illegal liberations in the same area. In Taranaki, 1 new population (red deer) resulted from a farm escape, 7 (3 red deer, 3 fallow deer, and 1 sika) were attributed to illegal liberations, and 2 (1 red deer and 1 sika) are believed to have resulted from natural dispersal from adjacent wild herds.

In the current study, 28 new populations were identified in Northland (Fig. 1). Only two of these herds, the sika populations at Opua and Russell, which both originated from illegal releases, were within the areas where deer farming is prohibited. The range sizes of these new herds varied from 360 ha to 24 148 ha, with an average of 3700 ± 2040 (95% C.L.) ha. Most (18) covered less than 2000 ha and only three (all red deer) extended over 10 000 ha. Overall, deer populations in Northland inhabited an area of c. 103 000 ha.

In Taranaki, 26 new populations were identified in the current study, with none being recorded within the deer-farming exclusion zone (a 7-km-wide buffer around Egmont National Park) (Fig. 2). The range sizes of these herds varied from 112 ha to c. 11 175 ha, with an average of 3329 ± 1177 ha. Only the Makino red deer herd occupied more than 10 000 ha, and the total range of all herds was c. 80 000 ha.

Since the data collection phase of this project was completed, evidence of three new deer populations in Taranaki has come to light (L. Stanley, pers. comm.): one for red deer in the Waipapa catchment, and two for fallow deer in the Mt Messenger and Maikaikatea areas.

5.3 ESCAPES FROM DEER FARMS

In Northland and Taranaki, 13 of 32 and 14 of 26 respondents, respectively, reported that they have had escapes of deer from their farms, with 12 of the 27 farmers reporting escapes having had more than one incident (Table 3). Most escapes involved a small number of deer (36 of the 42 events reported involved < 10 deer), but the remaining six events involved 20 or more animals. The largest escapes involved 70 red deer in Northland and 270 red deer/wapiti hybrids in Taranaki. In most cases all deer were recaptured and returned to captivity (Table 4).

The causes of escapes were provided for only two of the three farms with three escape events. In both cases, only two of the three events could be attributed to human error. For only one of the nine farms with two escape events, could both escapes be attributed to human error. For the remaining 15 escape events, only five were due to human error with the remainder attributed either to weather damage to fences, malicious damage, or unknown.

TABLE 3. NUMBER OF ESCAPE EVENTS REPORTED FROM DEER FARMS IN NORTHLAND AND TARANAKI.

NO. OF ESCAPE EVENTS	NORTHLAND	TARANAKI
None	19	12
1	7	8
2	5	4
3	1	2

TABLE 4. NUMBER OF DEER INVOLVED IN 20 ESCAPE EVENTS FROM NORTHLAND DEER FARMS AND IN 22 ESCAPE EVENTS FROM TARANAKI DEER FARMS, AND THE % OF TIMES ALL ANIMALS WERE RECAPTURED AND RETURNED TO CAPTIVITY.

	NORTHLAND	TARANAKI
Minimum no. of deer escaping	1	1
Maximum no. of deer escaping	70	270
Average no. of deer escaping	10	16
% of times all were recaptured	85%	86%

Failure in fences was the main cause reported for the 33 escape events where a cause was identified. Ten escapes were due to human error (gates were left open or unlatched), and 11 were due to inadequate fences (the deer jumped the fence: twice when stags were fighting, and once when an animal was frightened by a helicopter). Ten events were due to fence failure following damage in storms. The nine escapes where a cause was not known are likely to have been due to animals jumping fences, as farmers would presumably have noticed open gates or damaged fences (Table 5).

TABLE 5. MAIN CAUSES OF REPORTED DEER ESCAPES IN NORTHLAND AND TARANAKI.

CAUSE	NO. OF ESCAPE EVENTS	
	NORTHLAND	TARANAKI
Human error: gates left open	5	5
Human error: escaped during handling	0	2
Inadequate fences: jumped fence	4	4
Inadequate fences: jumped when fighting	0	2
Inadequate fences : jumped when scared	0	1
Unknown (inadequate fences?)	6	3
Damaged fences	5	5

5.4 FARMER AWARENESS OF CONSERVATION AND AGRICULTURAL THREATS

Most farmers were aware of the threats wild deer posed to conservation values and as possible vectors of bovine Tb. However, this awareness was greater among Northland farmers than Taranaki farmers. In Northland, all respondents reported that they were aware of the conservation threat posed by wild deer in the area, and 61% viewed the threat as serious or extremely serious. However, in Taranaki only 81% of respondents said they were aware of a conservation threat, and only 28% thought the threat serious or extremely serious (Table 6).

In Northland, 100% of respondents were aware of the Tb issue, with 74% believing it to be a serious or extremely serious problem; only 92% of Taranaki respondents were aware of a problem and only 50% thought it serious or extremely serious. Many farmers in both areas (24% in Northland and 40% in Taranaki) thought the Tb threat from wild deer was 'not very serious'. There was a significant difference between the two regions in the level of support for the eradication programmes against escaped or illegally liberated deer ($\chi^2 = 18.2$, d.f. = 1, $P < 0.0001$), perhaps a reflection of the farmers' different perceptions of the adequacy of information provided (Table 6).

In both regions fewer than 70% of respondents reported having a Deer QA Manual. This manual describes the minimum operating standards that a deer farmer must meet to achieve accreditation under the New Zealand Game Industry Board's Deer QA On-Farm Programme. It includes operating standards for facilities such as boundary and internal fences and gates for both the 'non-risk/non-regulated' areas and the 'risk/regulated' areas. Despite the fact that more than 30% of the farmers did not have a manual, most thought that they complied with current regulations, and most (over 80%) reported that they checked boundary fences and gates at least monthly.

TABLE 6. DEER FARMERS' RESPONSES TO A QUESTIONNAIRE ON DEER FARMING AND RELATED ISSUES.

QUESTION	% OF RESPONDENTS ANSWERING POSITIVELY[1]	
	NORTHLAND	TARANAKI
Do you have a Deer QA manual?	69	60
Are you aware of the specific fencing regulations for Regulated/At-risk areas?	88	81
Are you aware of bans on farming some deer species in the region?	75	69
Do your fences, gates, pens comply with current regulations?	94	92
Are you aware of the Tb risk posed by wild deer?	100	92
Are you aware of the conservation risk posed by wild deer?	100	81
Do you support DOC's eradication operations?	90	36
Has DOC/AHB provided sufficient information about the eradication campaigns?	47	32

[1] While the total numbers of respondents to the questionnaire were 32 and 26 for Northland and Taranaki, respectively, not all respondents answered all questions; therefore, the percentages presented are calculated from the number of responses to each specific question.

5.5 EARLY REPORTING OF NEW DEER POPULATIONS

It is obviously important that any new population of deer, whether from escaped animals or from an illegal liberation, is dealt with before the animals disperse and/or breed. Farmers' first reaction to an escape of their deer has generally been to attempt to recapture the animals, and in most cases they have been successful in this (Table 4). The risk is that if they wait too long to report the c. 15% of events they do not solve themselves, or do not report them at all, a new wild population may establish, disperse, breed, and so be more difficult to eradicate.

Unreported escapes and illegal liberations of deer are generally first noticed by members of the rural community, so any formal reporting system to management agencies needs to be widely known and accessible to such people. In Northland, DOC has a toll-free number (0800 FIND DEER), which reports to the deer project coordinator through a cellphone, a pager, and a message centre. Mischievous and 'crank' calls were an initial problem, but these were reduced by tracing such calls. Typically, DOC Northland receives about four calls each month and checks the reports within 24 hours. This system has already resulted in the successful recapture of several mass deer escapes, i.e. it encourages farmers to report early and not just rely on their own devices, and is visible evidence that management agencies are taking the problem seriously.

In Taranaki, a toll-free hotline (0800 4DEERS) was established in 1998/99, and is supported with a range of publicity material on the threats posed by new deer populations, the responsibilities of deer farmers, and the ways in which people could support the DOC-led campaign to keep Taranaki forests free of deer. In 1998/99, 7339 pamphlets and stickers were sent to all rural post office box holders in the region, followed by media publicity and meetings with various interest groups. The publicity material was updated in 2000/01, particularly to include the Animal Health Board's logo to reinforce the risks deer pose to the Tb-free status of the region. Since the hotline was established, the number of deer-related calls has halved from c. two each month, presumably because there are fewer new events to report, and because the close communication between the hunting team and local land owners has ensured early notification and quick solution of any new escapes (L. Stanley, pers. comm.).

5.6 SURVEILLANCE AND MONITORING OF NEW OR REMNANT DEER POPULATIONS

The best method and search design to detect low-density deer populations will depend on the circumstance of each case and nature of the question being asked. In this section we first discuss the different questions faced by managers, and then summarise the advantages and disadvantages of different methods to detect and survey low-density deer populations.

5.6.1 Different questions—different methods

Detection/surveillance: Are any deer present or has an eradication attempt succeeded? The answer to this question requires just enough effort to confirm the presence of at least one deer, after which either the 'detection/surveillance' phase would stop and some management action (a survey of how many and where they are, or a control operation) would begin or continue. The problem in both parts of the question is one of balancing the intensity of the survey against the risks of being wrong—deer were really present but were not detected, or eradication was falsely claimed. The solution to this problem, search design, and detection probabilities are discussed below.

Population monitoring: Deer are present but how many and where are they? This question requires a full survey of the whole area known or suspected to have deer. The usual methods in New Zealand are to use randomly located faecal pellet transects (Baddeley 1985), but in the case of low-density and/or patchy new deer populations a stratified design is recommended, i.e. more transects would be located in areas known or suspected to have most deer.

5.6.2 Methods to detect deer

Information from the public: In the simplest case, managers might believe deer are present if the informant is reliable or enough independent reports are received. However, managers usually require more certainty judging by the effort Northland and Taranaki managers invested in 'area inspections and surveillance' (see section 5.8), although much of this time may be aimed at assessing numbers and distribution rather than just confirmation of presence (see Table 7).

Deer sign: Sign of deer (Challies 1990) is more common than the deer that make it, so looking for faecal pellets, footprints, browse, or other sign is the usual way deer are first detected. Deer defaecate about 20 times each day and the pellet groups can last for many months (Nugent et al. 2001a). However, a problem with faecal pellets is that they are similar to those of feral goats and sheep, which are common in the deer-free areas of Northland and Taranaki. Therefore, the most reliable evidence will be some physical proof such as a carcass or a jawbone (which can also be aged as evidence of possible breeding), or hair samples, which can be identified to a species.

Deer sightings: The cheapest way to attempt to confirm the presence of deer is to send in hunters to look for sign or animals, or to actually hunt them. Spotlighting, aerial surveys, or the use of dogs may all increase the probability of detection under appropriate circumstances. Expert hunters should be able to prioritise their effort by predicting the most likely areas where deer would live, or they may know where animals were reported.

For patchy forest and low scrub, an aerial survey with lightweight helicopters flying at dusk or dawn is probably the best option. For tall, continuous forest, use of ground hunters, usually with trained dogs, is the best option.

Thermal infrared cameras: Infrared video cameras (FLIR) detect the body heat of warm-blooded animals when this is above that of surrounding material. Their use has been tested in New Zealand as a method of estimating deer numbers (Wilde 2000). This trial was conducted in a 15-ha paddock of mixed pasture and forest containing 80 fallow deer. Under optimal conditions (flying at dawn, between 550 and 1110 m above the ground, over GPS-determined transects that covered the whole area with no overlaps) between 31 and 146 deer were counted—the overcounts being due to deer moving during the helicopter flyovers and so being double counted (Wilde 2000).

The FLIR system cannot detect deer through forest canopy, and from the trial results appears to be too variable to be of use to estimate numbers with good precision. However, it appears to be useful in detecting the presence of deer, at least when a reasonable number are present. The worst case under optimal conditions detected 87% of the deer present (Wilde 2000).

5.6.3 Search design and detection probabilities

None of the above methods are capable of detecting the presence of one or more deer all the time under most realistic search intensities, so managers are often left with the question 'does the absence of evidence mean that deer are really absent?' In most cases managers have to accept some degree of uncertainty when answering this question, but they may wish to be able to assess how uncertain they are. To do this, they will require a measure of the detection probability attained by different survey methods and designs—basically managers need to detect any deer in any patch searched with a high degree of certainty (e.g. the FLIR system appears to allow at least 87% detection probability), and search each patch in an area in some rational way and order.

Female red deer have variable home ranges of c. 1–2 km^2 in forested habitats (Nugent & Fraser 1993), although it is not known if colonising animals behave in the same way. Of the deer present in Northland and Taranaki, fallow deer are likely to have the smallest home ranges, then sika, then red deer, and males of all species have larger ranges than females (Challies 1990). Therefore, to increase the certainty that deer are present, a survey would need to ensure no home-range-sized patches were left uninspected if no deer were confirmed in the most likely sites. That is, survey grids should be about 1 km^2, or survey transects should be no more than 1 km apart.

Formally designed surveys are more expensive but may increase the probability of detection or confirmation of absence. Where deer numbers are suspected to be low and/or distribution is very patchy, a systematic survey is likely to be the optimal way to detect presence or absence of deer, prioritised for the presence case in much the same way as the informal survey. Where numbers are thought to be higher and/or distribution more general, a random survey is likely to be the optimal method of detecting deer (and estimating numbers) but, again, to confirm absence, it is essential that all sites are covered, otherwise a negative claim would have to attach a measure of confidence.

Choquenot et al. (2001) have modelled the effort required (E) to detect the presence of at least one animal in a sparse population (stoats in this case, with the effort being number of traps) with a given degree of confidence (c) over an area (A) where the sampling method would detect their presence in a proportion of times (d).

$$E = (1 - (1 - c)^{1/d}) (A - (d/2)) + 1$$

For detecting deer, the measure of effort might be thought of as the number of 100-ha blocks within an area that were searched for deer. The model shows that the effort required to detect at least one animal increases exponentially as the density of animals decreases, and increases with the level of confidence required.

5.7 METHODS TO ERADICATE LOW-DENSITY DEER POPULATIONS

There are three necessary (Parkes 1990) and three desirable (Bomford & O'Brien 1995) strategic management rules that must be met before any population can be eradicated. The rules that must be met are (a) all animals must be put at risk, (b) they must be killed faster than they can replace their losses at all densities, and (c) immigration must be zero. The desirable rules are that (d) most people must agree with the effort, (e) the benefits must outweigh the costs, and (f) survivors should be rapidly detected. Most of these rules can be met for the new deer populations in Northland and Taranaki. However, two rules are unlikely to be met. The risk of new escapes or liberations remains, so some ongoing costs to reduce this risk or to deal with new animals will be needed. It is also likely that eradication will be falsely claimed after some operations that will have to be reactivated once deer numbers become obvious. Many ungulate populations have been eradicated from New Zealand (Parkes 1990, unpubl. data) and in nearly all cases this was achieved finally through various forms of ground hunting.

Many techniques are available to deal with new deer populations. Clearly, the best and cheapest option is for farmers to immediately muster or lure any escaped deer back behind their fences, which they appear to be able to do in most cases (Table 4). Permanent 'jump in' or 'walk in' devices should be considered for deer farms with regular escapees. Failure to recapture escapees or illegal liberations require that the deer be killed.

Typically, managers have begun lethal solutions with aerial hunting (which doubles as a technique to detect the presence of deer) followed by various forms of ground hunting (which doubles as a technique to estimate the distribution and approximate density of deer). More specialised control methods are usually only indicated if animals survive all attempts to kill them via these normal methods.

Aerial hunting is a well-developed control method for ungulates in New Zealand, and is commonly used to harvest deer for game meat (Challies 1990; Parkes et al. 1996). Although this method is most successful in non-forested habitats, it is often possible to shoot animals in forests either through the canopy or when the animals are using slips, river terraces, or other 'open' habitats.

The various forms of ground hunting, with single or teams of hunters with or without dogs to locate or bail the animals, are also well-developed techniques for control of ungulates (particularly feral goats) in New Zealand. Traditional sustained-control ground hunting allocated a single hunting block to a single hunter (and dogs). However, this method allows a proportion of animals to escape any encounter with the hunter (however good he or she is) and rapidly teaches surviving animals to become very wary, a problem when eradication is the aim. Team hunting is one way to decrease the proportion of animals that escape their first encounter with the hunters. It was trialled against deer and chamois in the South Island in the 1950s (Batcheler & Logan 1963), but has improved considerably in recent years in campaigns against feral goats with the use of dogs (trained for the purpose) and the availability of radio communication devices to keep the hunters in contact one with another (Parkes et al. in press).

The use of radio-telemetered animals released into the control area to act as Judas animals to lead the hunters (either on foot or in a helicopter) to any of their conspecifics is now a standard method, particularly useful for social species. In New Zealand it has been used operationally for controlling remnant feral goat populations (e.g. in the Shotover catchment in Otago: R. Thomas, pers. comm.), and experimentally to track feral pigs used as sentinels of bovine Tb (G. Nugent, pers. comm.). The technique has two purposes, either to locate survivors of eradication campaigns, or to identify when new animals have arrived in an area.

Trapping deer in fenced pens, often with radio-telemetered gates to save on the need for frequent inspection, is a common method used to live-capture wild deer for domestication in New Zealand.

Deer can also be poisoned by aerial baiting (Daniel 1965), and between about 30% and 93% of deer are usually killed during aerial 1080-baiting campaigns aimed mainly at possums (e.g. Fraser & Sweetapple 2000; Nugent et al. 2001a). Widespread application of 1080 baits is expensive, but the method might be of use against localised populations of deer that could not be killed by other means. Similarly, the use of 1080 gels smeared on leaves of palatable plant species as baits has successfully reduced high-density white-tailed deer populations on Stewart Island by over 90% (Challies & Burrows 1984), and a moderate-density red deer population in the central North Island by 78% (Sweetapple 1997). It is likely to be less successful against low-density populations where food is abundant, and is unlikely to eradicate such populations, as shown by the failed attempt to eradicate the colonising populations of red deer on Secretary Island (Tustin 1977).

5.8 CURRENT ERADICATION CAMPAIGNS

5.8.1 Allocation of resources

The time spent on work related to each eradication operation and the fate of the herd was recorded between June 1997 and May 2000 for Northland, and June 2001 for Taranaki (Appendix 2). A total of 26 670 hours was spent on the programme (12 504 in Northland and 14 166 in Taranaki), with about 24% of the effort being spent on controlling the deer as opposed to 33% being spent on finding out where the deer were.

A more detailed breakdown of labour and operating costs was available for 2000/01 from Taranaki (Table 7). The annual budget of $100 000 (50% from DOC and 50% from the Animal Health Board) allowed 48 red deer and 107 fallow deer to be killed. Three new farm escapes involving 44 red deer were notified, and all of the five animals not recaptured were killed (L. Stanley, pers. comm.).

In Northland, deer were killed in 18 of the 28 areas inspected, resulting in their eradication from all but one area, the sika deer herd in Russell Forest (Appendix 2). In Taranaki, deer were killed in 19 of the 26 areas inspected, resulting in their eradication from 8 areas (Appendix 2). Note that identification of discrete herds was more difficult in Taranaki than in Northland.

A two-pronged approach to keep areas free of deer is being implemented. The current division of time (Appendix 2) indicates that most effort is put into reactive strategies, with 'control' and 'surveillance' accounting for over 60% of the effort, and less into proactive strategies, with 'inspection', 'farm inspection', and 'liaison' accounting for only about 7% of the effort. However, in total it is not clear how the

TABLE 7. EFFORT (HOURS) AND OPERATING COSTS FOR THE DEER ERADICATION PROGRAMME IN TARANAKI FOR THE 2000/01 YEAR.

Staff costs (mostly under planning, inspections, and administration) and overheads are not included in the operating budget figure.

TASK		EFFORT (HOURS)	% OF TOTAL
Planning			346
7.1			
General inspections		16	0.3
Surveillance		703	14.4
Deer farm inspections		63	1.3
Liaison		151	3.1
Control effort:		1886	38.6
1. Deer traps	23		
2. Ground hunting	1524		
3. Spotlight hunting	160		
4. Foliage bait poisoning	19		
5. Aerial hunting	160		
Travel		675	13.8
Down time for rain, etc.		557	11.4
Administration		489	10.0
Total operating budget			$102457

effort was partitioned between the two strategies, so the question remains 'is the risk that new deer populations will establish permanent populations reduced most cost-effectively by actions that reduce the chances of escapes or liberations, or by actions that remove those that do establish, or (most likely) by some balance between the two strategies?' A better categorisation of activities to distinguish between these two strategies needs to be developed.

Logically, proactive management would seem the best approach to the escaped deer problem but, because catching the people who deliberately release deer is difficult, reactive management is likely to be the best approach to the illegal liberation problem.

5.8.2 Deer killed

During the initial 3 years of the campaigns, data were collected for 74 and 99 deer from Northland and Taranaki, respectively. Red deer and red/wapiti hybrids comprised the majority (76%) of the deer killed in Northland, while fallow deer were the main species (62%) killed in Taranaki (Table 8). Females were twice as common (in the autopsied samples) as males in both regions (χ^2 = 4.38, P = 0.036, and χ^2 = 18.68, P < 0.001 for Northland and Taranaki, respectively; Table 8). Only in the sika deer killed in Russell Forest did males outnumber females.

The mean ages of the 49 and 96 deer whose lower jaws were collected were 3.7 and 3.3 years for Northland and Taranaki, respectively. The median ages of these samples were 2 years and 1 year for Northland and Taranaki, respectively. The mean ages of males were lower than those for females in both areas (2.1 versus 5.2 in Northland and 2.1 versus 3.8 in Taranaki) (Mann–Whitney U test, Z = 2.92, P = 0.003 and Z = –1.90, P = 0.057 in Northland and Taranaki, respectively).

TABLE 8. SEX RATIOS OF DEER SPECIES KILLED IN NORTHLAND AND TARANAKI.

SPECIES	NORTHLAND			TARANAKI		
	MALES	FEMALES	TOTAL	MALES	FEMALES	TOTAL
Red deer	15	35	50	13	18	31
Wapiti	0	1	1	0	0	0
Red × wapiti	1	4	5	0	6	6
Sika	11	5	16	0	1	1
Fallow	1	1	2	15	36	61[a]
Total	28 (38%)	46 (62%)	74	28 (28%)	61 (62%)	99[a]

[a] Includes 10 animals for which the sex was not recorded.

Ten of the deer killed in Northland (all red deer) and 10 of those killed in Taranaki (9 red deer or hybrids and 1 fallow deer) had ear tags or holes in their ears indicating past tags. Deer with a hole in their ear (4 of the 20) may have lost tags naturally, or this may be a symptom of illegal release. Those without signs of tags may be wild-born progeny of the original escapees, illegally released animals or, occasionally (as for some deer in Taranaki), the result of natural dispersal from wild populations. In both areas, the mean age of deer that had been tagged was higher than of those without tags, but not significantly so. The oldest animals without evidence of ear tags were aged 11 and 15 years in Northland and Taranaki, respectively.

The pooled data on the age of 145 deer shot and aged from both regions show most (65% and 57% from Northland and Taranaki, respectively) are 2 years old or younger. However, most of the females of breeding age (2 years or older) were either pregnant or lactating (Table 9). These data, together with the overall mean and median ages and the mean ages for deer with and without ear tags, provide strong evidence of breeding populations in both areas.

During the field operations in Northland, several dead fawns were found and some appeared to have had heavy infestations of ticks—presumably cattle ticks (A. Gardiner, pers. comm.). These are not common on deer elsewhere in New Zealand (Challies 1990) and may be a cause of higher fawn mortality among wild deer in Northland than elsewhere in New Zealand.

TABLE 9. SUMMARY OF THE REPRODUCTIVE STATUS OF ADULT FEMALE DEER OF DIFFERENT SPECIES SHOT IN NORTHLAND AND TARANAKI.

	NORTHLAND (n = 19)			TARANAKI (n = 38)		
	RED	WAPITI & HYBRIDS	SIKA	RED	WAPITI & HYBRIDS	FALLOW
No. females ≥ 2 y	11	4	4	7	4	27
% pregnant	18	0	50	29	75	56
% lactating	73	75	0	0	50	26

5.9 PRIORITIES FOR MANAGING NEW DEER POPULATIONS

Most (75%) of the escapes from farms (where farmers admitted a cause) appear to be either 'acts of God' or human error and, as such, are not preventable by any increase in inspection or enforcement activity by DOC staff. The remaining 25% of events were due to inadequate fences, and so might be prevented by setting or enforcing higher standards of fencing in risk areas. DOC has drafted a set of standard operating procedures for deer farming that include an inspection process that should improve sub-standard farming practices.

Dealing with the escapes and illegal introductions that are not preventable requires reactive management. The priorities for this are:

- Rapid detection of new populations.
- Rapid recapture of most escaped deer by farmers, but early notification of an escape irrespective of claims that all were recaptured should be encouraged.
- Rapid response and eradication.
    - Probably most important where illegal liberation is the suspected cause, largely because proactive management (enforcing the law) is very difficult.
    - As the culprits are rarely identified and prosecuted, eradication is the best form of discouragement.

Whether some new populations should take priority over others for eradication is determined by what species is involved, where the animals are, and who pays. In terms of the main deer species likely to be involved, the order of priority should be sika, then red deer, then fallow deer. The rationale for this is their relative potential for impact on conservation values (Hoffman 1985; Fraser 1996), propensity to disperse (Nugent et al. 2001a), and difficulty of hunting (Davidson & Fraser 1991). A key consideration for the 'where they are' element of this exercise is an assessment of the conservation values at risk. For DOC, the priorities could be set according to the systems used in the feral goat control plan (Department of Conservation 1998), or in the new Measuring Conservation Achievement (MCA) system when that is adopted (Department of Conservation 2001).

6. Discussion

The eradication programmes in Northland and Taranaki have, to date, been largely successful in eradicating deer: 27 of 28 new populations identified in Northland have been eradicated; 8 of 26 new populations identified in Taranaki have been eradicated, 14 are considered to be still present, and the status of a further 4 is unknown. Whether these programmes could have been conducted more efficiently is unclear, but the careful collection of operational data should allow managers to improve this over time—given that the problem will be ongoing. Furthermore, there is merit in extending the current eradication programmes to include other deer-free areas north of Auckland, on the Coromandel Peninsula, and on Banks Peninsula if these are to be maintained as deer-free areas also. Feral goats are now at low or zero densities in these areas and it makes sense to also exclude deer in order to maintain the benefits of removing ungulate impacts on the vegetation communities.

It is unlikely that recreational hunting could eradicate anything but the most vulnerable new deer populations, but it is likely that encouraging recreational deer hunting in Northland and Taranaki will lead to expectations that a hunting resource should be maintained. Therefore, recreational hunting of deer should not be considered as a control tool and, furthermore, should be actively discouraged in these regions.

In Northland, red deer, wapiti, and their hybrids are the main species farmed, and escapes from farms formed the main source of new populations. Two of the populations established by illegal liberations were sika deer, a species rarely farmed in New Zealand. It is likely that these animals came from the wild populations in the central North Island, where bovine Tb is present in parts of their range. In Taranaki, fewer new populations established from farm escapees and more from natural dispersal or from illegal liberations, and fallow deer featured more often. The no-farming (of deer) zones recently established both in Northland and Taranaki have limited the potential for new populations of deer to establish in several key conservation areas in these regions.

Our survey of deer farmers indicated that most respondents were aware of the problems posed by wild deer, but that many of these same respondents did not fully support DOC's eradication programmes. The attitudes of some people may be improved by better or more targeted information from agencies (most respondents did not consider that they had received sufficient information from DOC and the AHB). Some deer farmers may also be suspicious of DOC's motives, and this will need to be overcome by good communication, by peer pressure and, as a last resort, by making them aware of their legal obligations. Finally, some farmers will also be deer hunters and may wish to see wild herds establish.

Deer farmers probably reflect the same range of views on wild deer as are held by the wider population (Department of Conservation 2001; Fraser 2001). However, the fact that most respondents to our questionnaire said that they were aware of the potential Tb risk posed by new populations of wild deer, but fewer of them supported DOC's eradication programmes, indicates a lack of awareness among them as to the actual risks posed to their own and other farmers' operations by new populations of Tb-infected wild deer. New populations may be infected with Tb if they originate from deer taken from areas where Tb is endemic in the wild population. The risk of transmission of Tb to farmed deer is very high if wild deer mix with farmed deer. However, direct contact between Tb-infected wild deer and farmed deer is not the only concern with respect to the establishment of populations of Tb-infected wild deer. Recent evidence suggests that cattle do not transmit Tb to possums, but deer may do so; and once Tb is established in the possum population, an ongoing Tb-infection route is established as possums do transmit Tb to cattle (Lugton et al. 1998).

7. Recommendations

The authors recommend that:

- The eradication programmes for new populations of deer be continued in Northland and Taranaki, and extended to other deer-free areas north of Auckland, on the Coromandel Peninsula, and on Banks Peninsula.
- The time spent on different activities related to prevention and eradication of new wild deer populations be recorded as either 'proactive' or 'reactive' for either escapee populations or illegal liberation populations, so that a cost–benefit analysis of the two strategies can be developed for each situation.
- Recreational hunting of deer should not be considered as a control tool in Northland and Taranaki and, because of potential expectations by recreational hunters, be actively discouraged in these regions.
- Fencing standards and other related requirements for deer farming in 'at-risk' areas be more stringent than elsewhere. Farms reporting three or more escapes should be inspected more frequently to see if the risks can be reduced.

8. Acknowledgements

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Appendix 1

NEW POPULATIONS OF DEER IN THE WILD IN NORTHLAND

DEER FARMER SURVEY

Note: Your answers to this questionnaire will be anonymous. The unique number identifier at the top right of this page (required for checking respondents in case follow-up is necessary) will be removed before any data are analysed. All responses will be pooled and no individuals will be identified in the reporting of the results.

[PLEASE TICK THE APPROPRIATE BOXES]

1 Are you currently farming deer on your property?

☐ yes ☐ no

2 Please list each deer species held (include hybrids separately) and the numbers of each.

species: ____________________ number: __________
species: ____________________ number: __________
species: ____________________ number: __________

3 How long have you been farming deer in the Northland area?

____ years

4 Do you have a copy of the Deer QA On-Farm Programme manual?

☐ yes ☐ no

5 Given that Northland could be gazetted as a "Regulated / At-Risk Area" for deer farming, are you aware of the specific fencing regulations for such Regulated / At-Risk Areas?

☐ yes ☐ no

6 Do your boundary fences, gates, etc. comply with the current regulations in your area?

☐ yes ☐ no ☐ not sure

7 How often do you perform checks of your boundary fences, gates, etc. on your farm?

☐ weekly ☐ monthly ☐ quarterly ☐ yearly

8 Are you aware of the restrictions on farming certain species of deer in the Northland area?

☐ yes ☐ no ☐ not sure

9 Are you aware of the bovine Tb threat posed by wild deer and other potential Tb vector species in the Northland area?

☐ yes ☐ no

10 How serious do you consider the Tb threat in the Northland area?

☐ extremely serious ☐ serious ☐ not very serious ☐ insignificant

11 Are you aware of the conservation threats posed by wild deer in the Northland area?

☐ yes ☐ no

12 How serious do you consider the conservation threat posed by wild deer in the Northland area?

☐ extremely serious ☐ serious ☐ not very serious ☐ insignificant

13 Do you support the DOC-led activities aimed at removing all deer from the wild in the Northland area?

☐ yes ☐ no

14 Do you consider that the relevant organisations such as the Department of Conservation and the Animal Health Board (including the RAHC) provide you with sufficient information on their activities and the rationale for any deer-related programmes with respect both to deer farming (including the potential risks) and wild deer eradication in the Northland area?

☐ yes ☐ no

15 Please list all the organisations which have directly provided you with information relevant to the current wild deer control programme in the Northland area?

____

16 Have you ever had any escapes of deer from your property?

☐ yes ☐ no

If your answer was "yes", please answer questions 17 and 18. If your answer was "no", please go straight to question 19.

17 How many separate instances of deer escapes have you had since commencing farming deer in the Northland area?

______ escapes

18 For each of these escapes, please list the number of animals involved in each escape, the cause of the escape, and the number of deer subsequently recaptured.

no. escaped: _____ cause: ____________________ no. recaptured: _____
no. escaped: _____ cause: ____________________ no. recaptured: _____
no. escaped: _____ cause: ____________________ no. recaptured: _____

19 In your experience, please rank the following potential causes of deer escapes in terms of their importance ("1" FOR MOST IMPORTANT, "2" FOR SECOND MOST IMPORTANT, "3" FOR THIRD MOST IMPORTANT, ETC.). Please write the numbers in the boxes.

☐ acts of nature (e.g., fallen trees across boundary fences)

☐ inadequate fencing and other deer handling facilities

☐ lack of maintenance (to otherwise adequate fences, etc.)

☐ accidental occurrences (e.g., leaving gates open)

☐ malicious damage (e.g., cutting of fences)

20 If you wish to provide comment on any aspects of the wild deer problem in Northland, please use the space below. We would welcome your input.

____

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Thank you very much for your cooperation in completing this questionnaire. Please use the postage-paid reply envelope to return the questionnaire to Landcare Research by **31st March 2000**

Appendix 2

TIME SPENT ON DEER ERADICATION, NUMBERS OF DEER KILLED, AND STATUS OF HERDS BY AREA, IN NORTHLAND BETWEEN JUNE 1997 AND MAY 2000, AND IN TARANAKI BETWEEN JUNE 1997 AND JUNE 2001.

The categories used for time spent are: 1, planning; 2, area inspection; 3, surveillance; 4, farm inspections; 5, liaison and communications; 6, administration, training, and other miscellaneous tasks; 7, control. Abbreviations for fate of herd are: E, eradicated, P, present, ?, unknown. Deer species: wap. = wapiti, hyb. = red × wapiti hybrid, fal. = fallow.

HERD	AREA	DEER	FATE OF	NO.	CATEGORY (HOURS)							
	(ha)	SPECIES	HERD	KILLED	1	2	3	4	5	6	7	TOTAL
Northland												
Opua	1005	sika	E	–	–	–	182	6	42	–	–	230
Russell	3215	sika	P	16	76	–	1339	–	104	–	412	1931
Hukerunui	720	red	E	1	–	–	16	–	8	–	–	24
Whakapara	360	red	E	1	–	–	32	–	–	–	16	48
Maungakahia	17410	red	E	6	–	–	176	24	119	–	414	733
Glenbervie	2135	red	E	1	–	–	88	–	3	–	31	122
Taraunui	790	red	E	4	–	–	17	–	–	–	15	32
Pukenui	775	?	E	–	–	–	27	–	–	–	–	27
Tangihua	1355	?	E	–	–	–	24	–	–	–	8	32
Brynderwyn	1410	?	E	–	–	–	282	–	44	–	17	343
Hakaru	3680	red	E	2	8	–	237	–	27	–	54	326
Karaka	1550	red	E	1	–	–	17	–	–	–	8	25
Mangarata	1250	red, wap.	E	8, 1	8	–	291	10	18	–	124	451
Tokatoka	535	red, hyb.	E	2, 1	–	–	25	–	8	–	–	33
Ararua	6640	red, hyb.	E	8, 4	–	–	915	–	47	–	109	1071
Greenhills	1990	red	E	3	–	–	85	–	4	–	522	611
Mt Camel	1060	red	E	1	–	–	110	–	–	–	70	180
Kaimaumau	6095	red	E	2	32	–	349	172	43	58	286	940
Aupouri	11450	red	E	4	8	–	68	41	3	–	92	212
Purerua	700	fallow	E	2	–	–	35	–	10	–	–	45
Waitangi	1225	?	E	–	4	–	17	–	9	–	–	30
Tinopai	6511	?	E	–	–	–	94	–	37	–	15	148
Poroti	885	red	E	1	–	–	11	–	25	–	50	86
Ngunguru	1290	?	E	–	–	–	12	–	24	–	–	36
Kokopu	680	?	E	–	–	–	19	–	–	–	–	19
Pouto	24148	red	E	6	–	8	196	11	21	–	144	380
Oneriri	3111	?	E	–	–	–	88	–	21	–	3	112
Arapohue	1650	?	E	–	–	–	11	–	1	–	16	28
Unspecified	–	–	–	–	–	24	8	35	–	16	–	83
Conservancy					1638	8	55	468	581	1416	–	4166
TOTALS	103625			74	1774	40	4826	767	1199	1490	2406	12502
%					14.2	0.3	38.6	6.1	9.6	11.9	19.2	
Taranaki												
Kotare	3920	sika	P	–	10	16	220	–	18	–	328	592
Panirau	2560	sika	E	19	38	60	650	–	3	–	171	892
Moki	2265	red	E	3	–	25	182	–	–	–	197	404
Makino	11175	sika	E	1	–	12	287	–	12	16	478	805
Waitaanga	1313	red, fal.	E	6, 1	–	8	322	4	36	–	560	930
Ohura	1140	red	P	–	33	–	182	–	12	–	86	313
Whitcliffs	3110	red	E	4	–	–	–	2	–	–	–	2

HERD	AREA	DEER	FATE OF	NO.	CATEGORY (HOURS)							
	(ha)	SPECIES	HERD	KILLED	1	2	3	4	5	6	7	TOTAL
Taranaki *continued*												
N.Waitaanga	735	red, fal.	P	1, 5	–	24	290	14	41	–	217	586
Matau	2610	red, fal.	P	6, 19	37	–	163	–	34	–	13	247
Rawhitiroa	5110	fallow	P	8	6	–	84	–	10	–	–	100
Bunns/Miles	2455	fallow	?	12	16	–	21	–	9	–	13	60
Te Wera	4370	red, fal.	P	1, 4	67	9	182	–	–	–	38	296
Waitotara	1390	fallow	?	–	–	–	–	–	–	–	18	18
Tarere	7780	red, fal., sambar	P	16, 46, 1	13	–	326	–	8	–	112	459
Puniwhakau	?	fallow	P	6	8	–	32	–	43	–	38	121
Hutiwai	9620	red	P	–	8	–	86	–	–	–	48	142
Maikaikatea	1810	red	?	6	–	–	–	–	4	–		4
Toi	155	red	?	2	15	–	216	–	2	–	93	326
Uruti	2045	fallow	P	11	–	56	8	–	5	–	49	127
Tangarakau	520	red	E	–	–	–	–	–	–	–	1	1
Okara	8850	fallow	E	10	–	–	–	–	–	–	8	8
Otumokuru	7275	fallow	P	26	–	20	150	–	9	–	79	258
Patea	?	fallow	P	41	–	56	–	–	9	–	184	249
Whenuakura	2665	red, hyb., fal.	P	6, 26, 53	87	22	120	–	38	–	201	468
Rerekino	640	fallow	E	1	–	–	–	–	–	–	–	–
S. Taranaki	–	?	P	–	34	–	128	–	–	16	30	208
Unspecified	–	red, fal.	–	5, 18	44	11	134	10	26	2358	392	3072
Conservancy	83790				400	4	178	25	193	2730	25	3555
TOTALS				323[a]	816	323	3961	55	513	5120	3379	14167
% of total					5.8	2.3	28.0	0.4	3.6	36.1	23.9	

[a] Total kill comprised 220 fallow deer, 56 red deer, 26 red ´ wapiti hybrids, 20 sika deer, and 1 sambar deer. Following the analysis and write-up of these deer kill data, we received a further 16 deer kill records for the period July 2001 – February 2002. They comprised 4 fallow deer kills from Maikaikatea, 3 fallow deer kills from Otumokuru, 1 fallow deer kill from Uruti, and 4 red deer, 2 red ´ wapiti hybrid, and 2 fallow deer kills from Whenuakura.