The effect of recreational hunters on deer populations in Pureora Conservation Park

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CONTENTS

Abstract

Manaaki Whenua - Landcare Research investigated recreational hunting and red deer population dynamics in Pureora Conservation Park (Pureora CP) for the Department of Conservation. The principal objectives were to demonstrate the use of recreational hunting data for the routine monitoring of hunting effort, deer density, and deer condition, to compare the cost-effectiveness of deer density indices based on standard recreational hunting data with those based on traditional faecal pellet surveys, and to determine the impact of recreational hunting on the deer population. Hunting return data was gathered between summer 1988/89 and winter 1993 to assess hunting patterns, hunting effort, and indices of hunting success (e.g., sighting and kill rates). Deer jawbones provided by recreational and commercial hunters were used to assess the sex ratio, age structure, and condition of deer populations in Pureora CP and to compare the harvests from recreational and commercial hunting. Faecal pellet surveys of ungulates (deer and goats) and pigs were conducted in 1992 and 1993. A postal survey of recreational hunters was conducted in 1993 to assess hunter demography, experience, hunting patterns, and their views on present and future management of hunting in Pureora CP. The PC-based database system developed for this study provided managers with quick and easy access to a large amount of information. Results suggest that deer numbers in Pureora CP have remained stable over the period of this study. In the north, animal control is effected by recreational hunters alone, while in the south recreational and commercial hunting combine. Greater recreational hunting effort in the northern blocks has resulted in lower numbers of deer there, despite the lack of commercial hunting effort that is present in the southern blocks. The recreational harvest is male-biased (56% stags), with most deer in the younger age classes (>75% were <5 years old). The predominance of stags in the recreational harvest suggests its "control value" is less than it could be. In comparison with the biased sex ratio of the recreational harvest, commercial hunters kill equal numbers of stags and hinds. Therefore, although recreational and commercial hunters kill similar numbers of deer in the south, the commercial kills have a greater impact on the productivity of the deer population. The average age of deer shot by commercial hunters (2.3 years for stags, 2.9 years for hinds) is considerably younger than for deer shot by recreational hunters (almost 4 years for both sexes). Faecal pellet densities were generally higher in the southern hunting blocks and were correlated with the deer density indices based on sighting and kill rates. However, the cost of the faecal pellet surveys (c. $43,000) was approximately four times the annual cost of gathering hunter diary information. Therefore, monitoring deer populations using information from hunter diaries is more cost-effective than faecal pellet surveys. This study indicates that DoC should use recreational hunter data to monitor hunting effort and deer densities in Pureora CP (and other similar areas).

1. Introduction

Manaaki Whenua - Landcare Research, Christchurch, studied the relationship between recreational hunting and the dynamics of red deer populations in Pureora Conservation Park (Pureora CP) for the Department of Conservation (DoC) between July 1989 and December 1994. The major theme of this research was the collection and use of information on animal sightings and kills supplied by recreational hunters and comparison of deer-density indices based on this information with those based on traditional faecal pellet counts.

2. Background

The red deer (*Cervus elaphus scoticus),* pig (*Sus scrofa*), and goat *(Capra hircus)* populations in Pureora CP are important resources for recreational hunters, and the northern part of the Park is a designated Recreational Hunting Area (RHA). A large area in the southern part of the Park (c. 55% of the total area) is used by commercial hunters for helicopter-based venison recovery. Bovine tuberculosis (Tb) is endemic in deer and possum populations in Pureora CP, although its prevalence in deer varies considerably in different areas of the Park.

In the past, information on wild animal populations and recreational (and to a lesser extent commercial) hunting has not been consistently collected, and has rarely been used as a basis for management decisions. Previous work in the Oxford and Blue Mountains RHAs (Henderson & Nugent 1989; Nugent 1990, unpubl. FRI contract reports) has shown that information supplied by recreational hunters can be used to monitor both hunting effort and deer densities using indices of hunting success (e.g., sighting and kill rates). However, both these areas operated a restricted block hunting system and typically had high hunting permit return rates. This study attempts to confirm these previous findings in a high-use area with an unrestricted open block hunting system and only a moderate hunter diary return rate (much more typical of elsewhere in New Zealand).

If the use of recreational hunter information proves valid for this more typical scenario, managers should be able to reduce the need for extensive faecal pellet surveys for long-term monitoring of deer population densities in areas where recreational hunting effort is high. The cost of such surveys is invariably high, which means that they have been conducted only at intervals of several years. In contrast, the now-routine collection of recreational hunting data in many DoC conservancies provides managers with information that could be used on a seasonal or annual basis.

Since part of Pureora CP is also used for helicopter-based commercial hunting, the sex ratios, and age structures of the commercial and recreational harvests

were compared to assess the relative impact of the two harvest methods on deer populations.

3. Objectives

- To develop a PC-based database system for the storage, collation, and preliminary analysis of information from standard recreational hunter diaries.
- To demonstrate the use of recreational hunting data for the routine monitoring of hunting effort, deer density, and deer condition.
- To compare the cost-effectiveness of deer density indices based on standard recreational hunter diaries with those based on traditional faecal pellet surveys.
- To identify hunting patterns and preferences of recreational hunters in Pureora Conservation Park, and determine the impact of recreational hunting on the deer population.

4. Methods

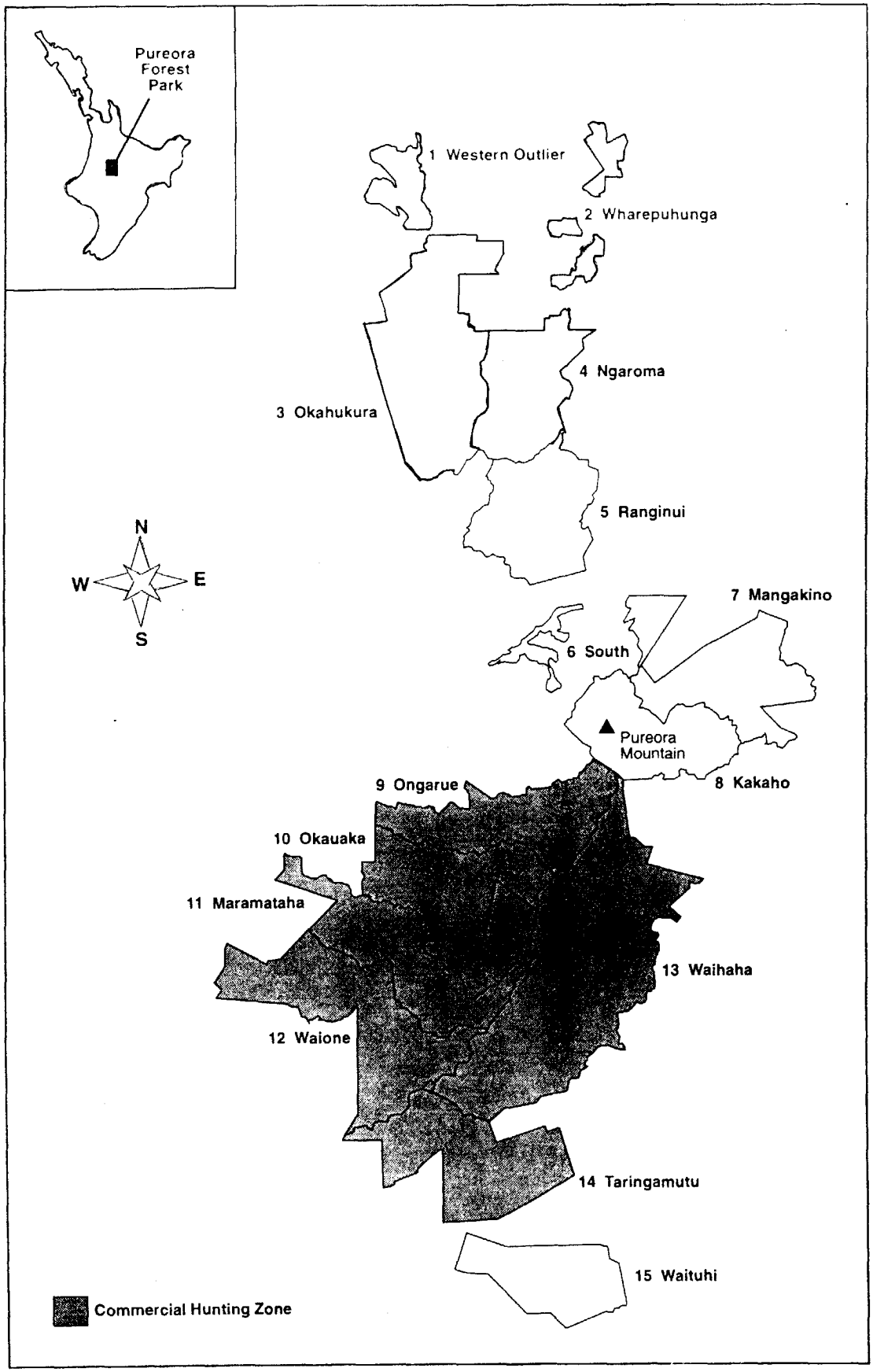
4.1 RECREATIONAL HUNTING INFORMATION

Pureora CP (c. 75,000 ha) is divided into 15 hunting blocks (Fig. 1) which are essentially only administrative units since an unrestricted open block hunting system operates in the Park. Hunting permits are issued for 4-month periods designated as: summer (1 October - 31 January), roar (1 February - 31 May), and winter (1 June - 30 September). Attached to each permit is a hunter diary on which hunters are asked to record the following for each hunting trip in the period:

- start date of hunting trip
- number of days hunted
- average number of hours hunted per day
- area hunted
- number of deer, pigs, and goats seen
- number of deer (stags and hinds recorded separately), pigs, and goats killed

Although deer sightings were recorded only from summer 1989/90 onwards, data on deer kills are available for the complete 5-year period studied. Data from hunter diaries between winter 1989 and winter 1993 were analysed to determine hunting effort and indices of hunting success (e.g., sightings/day, kills/day, kills/sighting) by hunting block and hunting period. For part of the study, hunters were sent a single reminder letter if they had not returned their hunter diary within 6 weeks of the end of the hunting period.

FIGURE 1 LOCATION OF THE 15 HUNTING BLOCKS WITHIN PUREORA CONSERVATION PARK AND THE ZONE WHERE HELICOPTER-BASED COMMERCIAL HUNTING IS PERMITTED.



A PC-based database software package (Reflex, ver. 2.0, Borland International Inc.) was used for the storage and preliminary analysis of recreational hunting information. A manual prepared specifically for dealing with hunter diary data from Pureora CP (Fraser 1991, unpubl. FRI contract report) allows the system to be used by people with minimal computing experience. Standard procedures and conventions were established for entering hunting permit details, hunter diary information, printing reminder letters for non-returns, printing address labels for mailing, and the production of simple tables (reports) or graphs summarising the information for specific hunting periods.

4.2 DEER POPULATION STRUCTURE AND CONDITION

Deer jawbones collected by recreational and commercial hunters were aged, and heel-to-tip (heel) and hinge-to-tip (hinge) length were measured (Fraser & Sweetapple 1993), to assess age structure and condition of deer populations in Pureora CP. The jawbone size data were combined with the age information to calculate sex-specific growth curves using the Weibull equation. Although the heel measurement is the most commonly used parameter of jawbone size, Pureora CP staff initially recorded only the hinge measurement. A condition index was therefore based on the jawbone hinge length, and the sex-specific population average was calculated for each individual as follows:

$$\text{condition index} = \frac{\text{jawbone hinge length}}{\text{sex-specific population aversge for age}}$$

A condition index of >1 indicates that the deer is larger than the population average whereas an index of <1 indicates smaller than the population average. DoC (Pureora) staff routinely calculate these condition indices and ages for recreational kills and return this information to the hunters by letter.

4.3 FAECAL PELLET SURVEY INFORMATION

A faecal pellet survey for deer, goats, pigs, and possums was conducted over two consecutive years (February-March 1992 and February-March 1993). It is not possible to discriminate between the faecal pellets of deer and goats with complete certainty, so pellets from these two species were classed as "ungulate". A total of 110 pellet transects (7400 plots) were assessed in the 15 hunting blocks that comprise Pureora CP. Most of these pellet transects have been used during one or more previous partial surveys of the Park and have permanently marked origins (Dale 1975; Jane 1979; Deuss 1981; Krzystyniak 1984; Broome & Krzystyniak 1985; Broome & Clegg 1990; unpublished NZFS and DoC reports). Between 36 and 97 pellet plots (at either 10-m or 20-m intervals) were located along a compass bearing. Presence/absence data (Baddeley 1985) for ungulates, pigs, and possums were recorded on 1.14-m radius plots. Point-distance (Baddeley 1985) and total-count data for ungulates

were recorded on 2.5-m radius plots (same centre as the 1.14-m plot). Slope was recorded at every plot and aspect at every fifth plot. The two plots on each side of each aspect measurement were arbitrarily assigned the same aspect.

4.4 HUNTING PATTERNS AND PREFERENCES

A postal survey of 1828 recreational hunters who obtained a permit for the Maniapoto District (which includes Pureora CP) in 1992 was used to provide information on hunter demographics and hunting experience and patterns (both general and specific to Pureora CP). Tkie respondents also provided feedback on present management of recreational hunting in the area and commented on future management.

5. Results

5.1 RECREATIONAL HUNTING INFORMATION

The data for each hunting period between winter 1989 and winter 1993 were summarised using the sequence of standard procedures and conventions for the use of the Reflex database, either for Pureora CP as a whole or for specific areas. Local DoC staff reported these summaries of hunting effort and harvests to recreational hunters through the Maniapoto District Hunters' Newsletter. Limited hunter diary data were available for the summer 1988/89 and roar 1989 hunting periods (i.e., before this study), and these were included in some analyses.

Hunter diary return rates

The number of hunting permits issued for Pureora CP varied with hunting period (Table 1). Permit issues were consistently lowest for the winter period =1617), moderate for the summer period (=1885), and highest for the roar period (=2302). An average of 5823 hunting permits were issued annually.

There was no strong "seasonal" trend in hunter diary return rates, although the ¡nitial (i.e., unprompted) response tended to be higher for summer hunting periods and lower for roar hunting periods. The latter may be attributable to "once-a-year" hunters during the roar who are less used to the hunter diary system. The average unprompted return rate for hunter diaries was c. 40%. When a single reminder letter was sent to non-respondents, the final return rate ¡ncreased to c. 70% (Table 1). However, there was no apparent improvement in hunter diary return rates for subsequent hunting periods after either one or a series of reminder letter exercises (i.e., voluntary response rate remained at c. 40%). Similarly, in both the Oxford and Blue Mountains RHAs the voluntary return rate declined after reminder letters were no longer sent (Henderson & Nugent 1989, Nugent 1990, unpubl. FRI contract reports), although it still

TABLE 1 NUMBER OF HUNTING PERMITS ISSUED, HUNTER DIARIES RETURNED, AND RETURN RATE BY HUNTING PERIOD FOR PUREORA CONSERVATION PARK.

HUNTING PERIOD	NO. OF PERMITS ISSUED	NO. OF DIARIES RETURNED	RETURN RATE (%)	EXTRA RE'TURNS FOLLOWING REMINDER	FINAL RETURN RATE (%)
Winter 1989	1540	713	46.3	-	-
Summer 1989/90	1820	794	43.6	-	-
Roar 1990	2374	903	38.0	-	-
Winter 1990	1479	623	42.1	403	69.4
Summer 1990/91	1905	881	46.2	-	-
Roar 1991	2120	864	40.8	-	-
Winter 1991	1598	570	35.7	512	67.7
Summer 1991/92	1936	868	44.8	459	68.5
Roar 1992	2552	806	31.6	816	63.6
Winter 1992	1821	708	38.9	561	69.7
Summer 1992/93	1879	919	48.9	368	68.5
Roar 1993	2163	840	38.8	695	71.0
Winter1993	1647	695	42.2	-	-

1 Reminder letter sent to all non-respondents c. 6 weeks after the end of the hunting period.

remained significantly higher than for Pureora CP. However, both the Oxford and Blue Mountains RHAs operated under a restricted block system during those studies and the degree of compliance, albeit voluntary, may have been influenced by hunters' perceptions of how their "co-operation" influenced their chances of obtaining permits for subsequent hunting trips.

5.2 HUNTING EFFORT AND SUCCESS

Hunter diary data for the 5-year period from summer 1988/89 to winter 1993 (see Appendix 10.2) were pooled to examine the distribution of hunting effort in Pureora CP by hunting period and hunting block. The indices of hunting effort used were number of trips, number of days hunted, total number of hours hunted (average no. of hours/day x no. of days), and average number of hours hunted per km^2. The estimated total hunting effort and total number of deer killed for each hunting period were calculated by extrapolation based on the hunter diary return rate. This assumes that hunting effort and hunting success are similar for hunters who submit hunter diaries and those who do not.

Analyses of voluntary and prompted hunter diary returns provide some justification for this assumption. Although 44% of prompted returns reported "nil hunting done" compared to 31% of voluntary returns, this was balanced by higher sighting and kill rates (9% and 21% greater, respectively) for prompted returns.

Variation for hunting periods

The greatest number of hunting trips occurred during the roar period, and the fewest during the winter period (Table 2). Although most hunting trips were of 1-2 days duration (summer 77%, roar 69%, winter 80%), the greatest percentage of longer trips (>_3 days) occurred during the roar (Fig. 2a). Although only 9% of hunting trips during the roar were >_5 days duration, they comprised >30% of the total hunting effort in this period (cf. 14% in both the summer and winter periods, Fig. 2b).

TABLE 2 REPORTED HUNTING EFFORT IN PUREORA CONSERVATION PARK OVER THE 5-YEAR PERIOD SUMMER 1988/89 - WINTER 1993.

"SEASON"	NO. OF TRIPS	% OF TOTAL	NO. OF DAYS	% OF TOTAL	NO. OF HOURS'	% OF TOTAL
Summer	5889	34.0	11,805	32.0	53,323	32.0
Roar	6813	39.3	16,162	43.8	76,821	46.1
Winter	4630	26.7	8,928	24.2	36,615	21.9

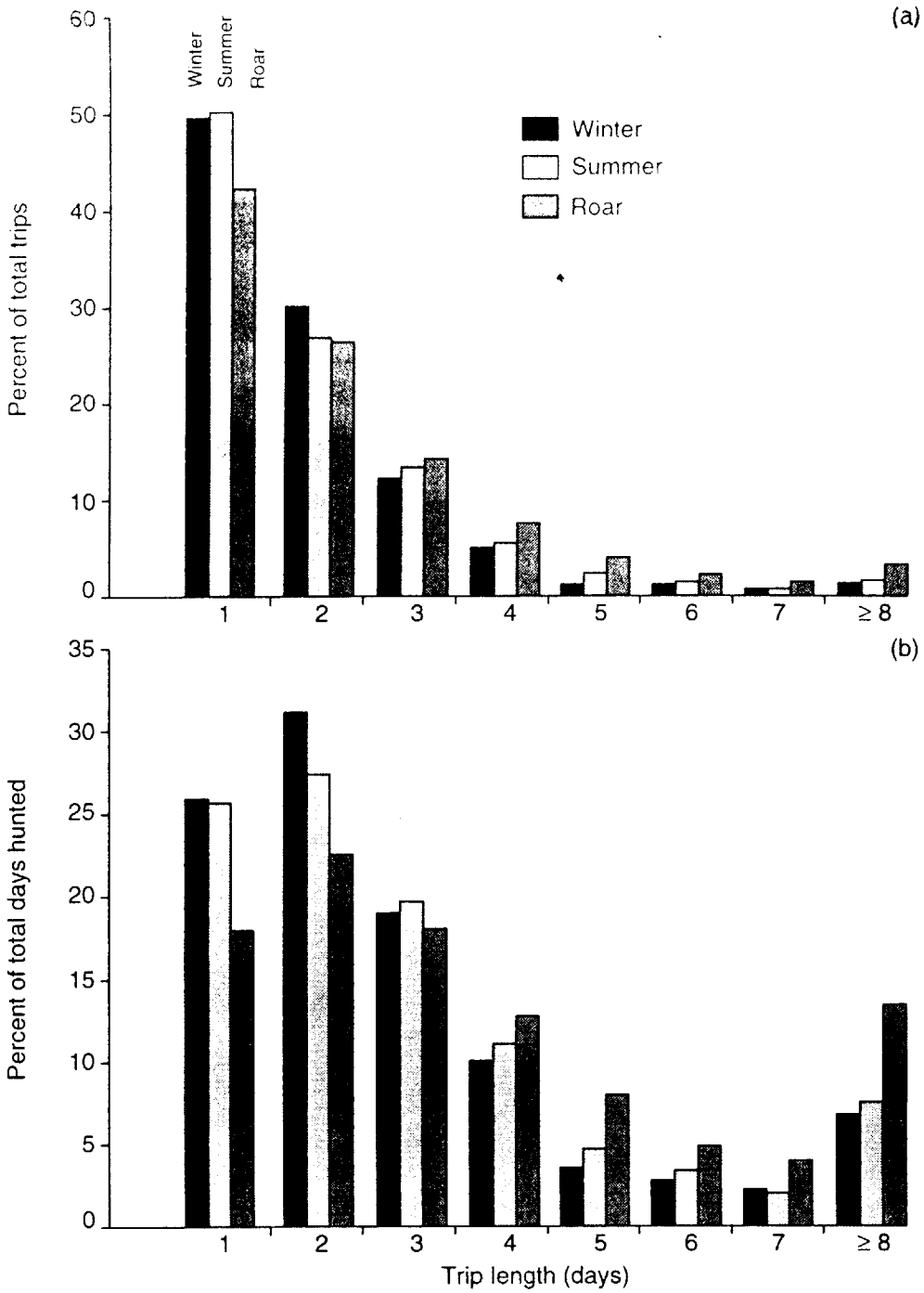
1 Based on the number of days hunted and the average number of hours hunted/day reported for each hunting trip.

There was a small but significant ($p<0.05$) variation in the average daily hunting effort (hours/day), which was highest during the roar (5.6 h/day), lower in winter (5.5), and lowest in summer (5.4). The combined effect of differences in length of hunting trip and average number of hours hunted per day was to further increase the effective seasonal variation in hunting effort. Almost half (46%) the reported recreational hunting effort occurred during the roar period and only 22% during the winter period (Table 2).

Variation between hunting blocks

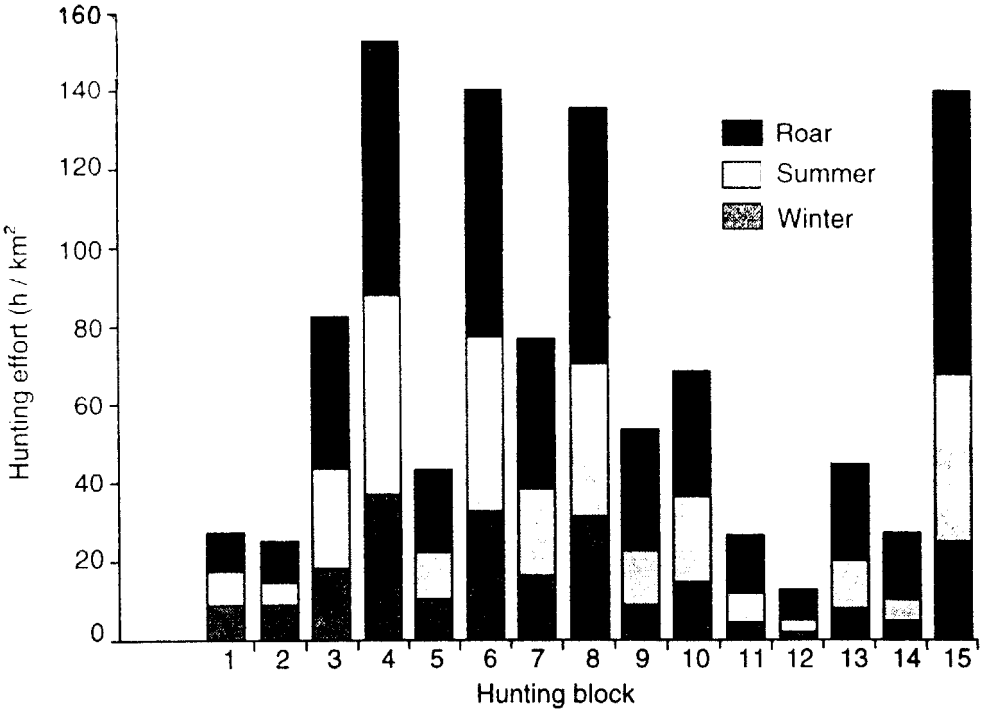
Indices of hunting effort varied considerably for different hunting blocks. Blocks 4 and 13 were hunted on c. 1000 days annually, blocks 3, 8, and 10 on c. 800 days annually, and the remaining blocks on <550 days annually. Hunting effort in blocks 1 and 2 was particularly low (<50 days annually), where c. 75% of trips were of 1 day duration. These blocks are small outliers of the Park and have relatively low deer densities. For the remaining hunting blocks north of Pureora Mountain (blocks 3-7; Fig. 1), the average trip length was <2 days. For all hunting blocks south of and including Pureora Mountain (blocks 8-15), the average trip length was >2 days.

FIGURE 2 DISTRIBUTION OF (A) HUNTING TRIPS (% OF TOTAL TRIPS) AND (B) HUNTING EFFORT (% OF TOTAL DAYS HUNTED) BY TRIP LENGTH AND HUNTING PERIOD.



The more northern hunting blocks (1-5) are close to the large population centres (i.e., Hamilton, Auckland) and have easy access, making them convenient locations for weekend hunting trips. The population centres closer to the more southern hunting blocks (9-15) are much smaller (e.g., Turangi, Taumarunui). Furthermore, these blocks have limited and more difficult access, so that hunters using these areas are more likely to make their efforts worthwhile by having longer hunting trips.

FIGURE 3 VARIATION IN ANNUAL HUNTING EFFORT (H/KM 2) BY "SEASON" FOR THE 15 HUNTING BLOCKS IN PUREORA CONSERVATION PARK (DATA AVERAGED OVER THE 2-YEAR PERIOD WINTER 1991 - ROAR 1993)



The average number of hours hunted/kilometre 2 in each block (Fig. 3) showed a similar pattern to the total number of days hunted. Blocks 4, 6, 8, and 15 received 136-153 h/km2 hunting effort annually. In contrast, blocks 1, 2, 11, 12, and 14 received only 14-28 h/km2 annually. The seven remaining blocks received 44-84 h/km2 annually. Typically, blocks with the greatest hunting effort are well-roaded and tracked, providing easy access. Blocks with the least hunting effort have more limited or difficult access. The variation in hunting effort between blocks followed a similar pattern for each hunting period ($r^2>0.86$ for each paired comparison).

The average annual hunting effort in Pureora CP (c. 63 h/km 2 is higher than the national average (c. 40 h/km2; derived from Nugent 1992) but considerably lower than the intensively hunted Blue Mountains RHA (>215 h/km2; Nugent 1993, unpubl. Landcare Research contract report). Variation in annual hunting effort (h/km2) by "season" for the 15 hunting blocks in Pureora Conservation Park (data averaged over the 2-year period winter 1991 - roar 1993).

Deer kills and hunting success rates

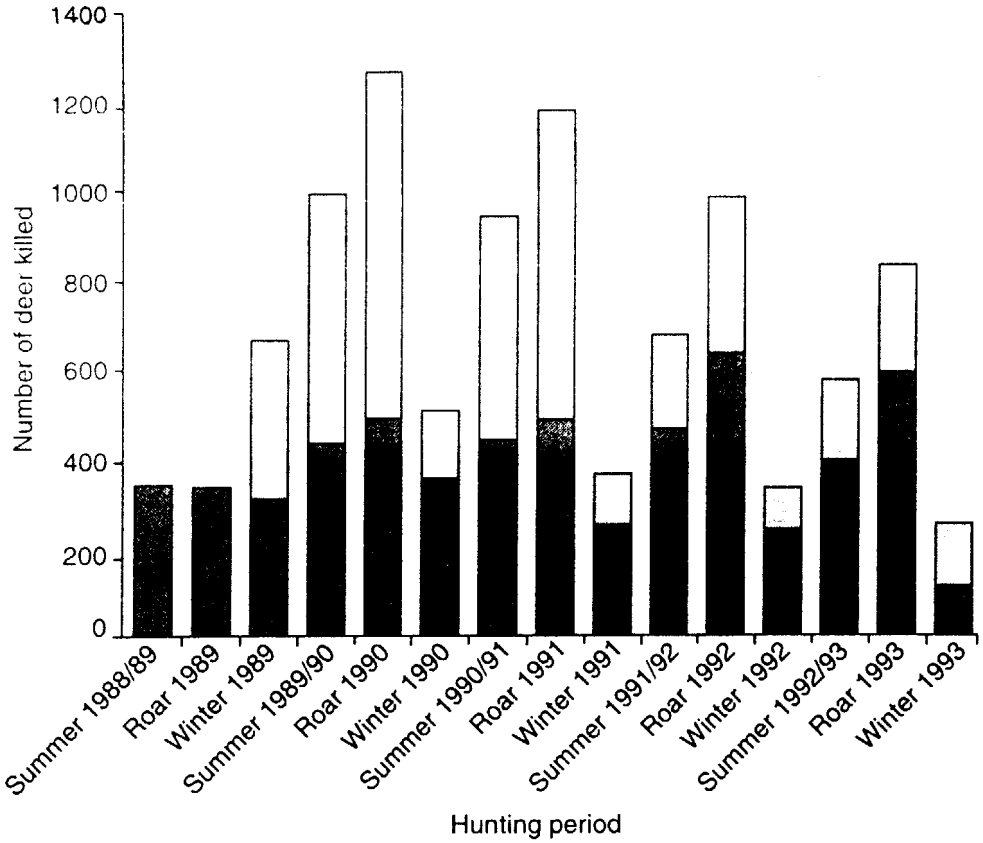
The reported number of deer killed annually is c. 1200-1300 (Table 3) and follows a distinct "seasonal" pattern (Fig. 4). The number of deer killed was lowest in the winter periods and highest in the roar periods. The reported harvest was relatively constant between years despite considerable variation in hunter diary return rate during the study.

TABLE 3 ANNUAL REPORTED AND ESTIMATED DEER KILLS IN PUREORA CONSERVATION PARK, WINTER 1989 - ROAR 1993.

PERIOD				HUNTER DIARY RETURN RATE (%)	REPORTED DEER KILLS	ESTIMATED TOTAL DEER KILLS'
Winter	1989	- Roar	1990	42.0	1223	2911
Winter	1990	- Roar	1991	50.4	1275	2530
Winter	1991	- Roar	1992	66.2	1340	2024
Winter	1992	- Roar	1993	69.8	1,220	1748

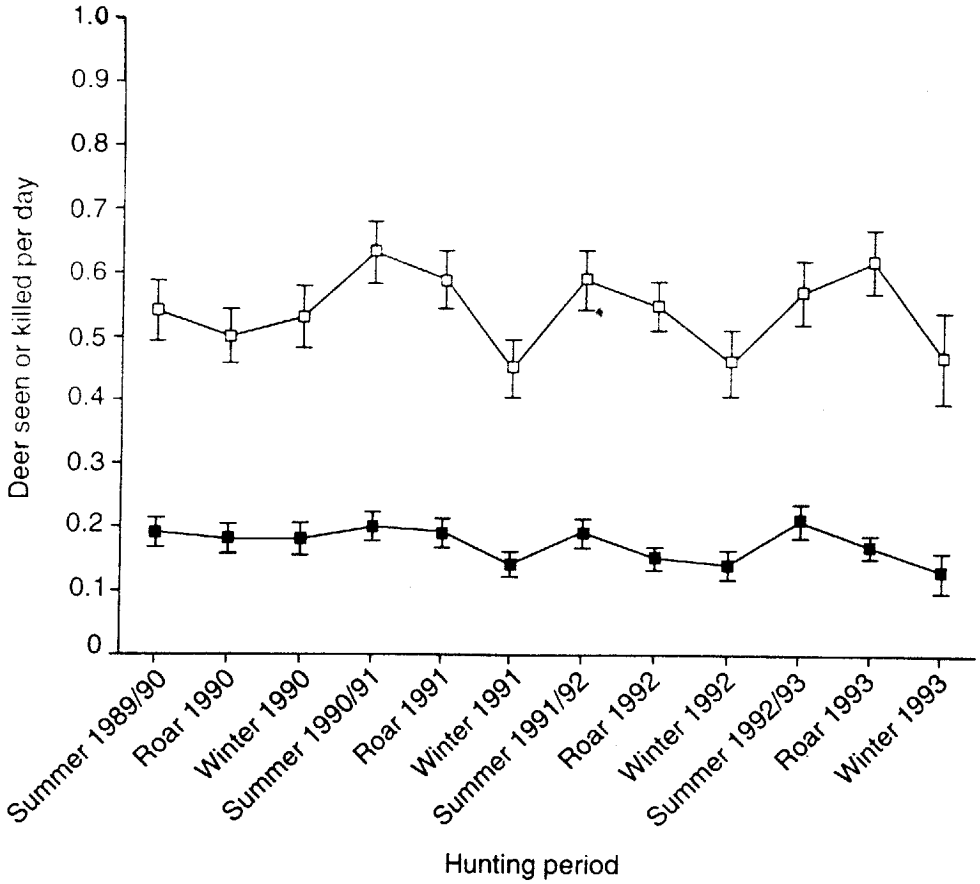
' Calculated by dividing the reported number of deer killed by the hunter diary return rate.

FIGURE 4 REPORTED (DARK BARS) AND ESTIMATED (LIGHT BARS) DEER KILLS IN PUREORA CONSERVATION PARK FOR EACH HUNTING PERIOD, SUMMER 1988/89 - WINTER 1993.



Comparison of the estimated total harvests from the first 2 years (with a lower hunter diary return rate) with those from the last 2 years (with a higher return rate) suggests that total harvests estimated by extrapolation should be viewed with caution, particularly when return rates are low. The estimated total deer harvest is likely to be most accurate when hunter diary return rates are highest (2024 in 1991/92 and 1748 in 1992/93). The decline in the estimates of total deer killed as hunter diary return rate increases is not because a larger

FIGURE 5 DEER SIGHTING (0) AND KILL (•) RATES ±95% CONFIDENCE LIMITS (CLS) IN PUREORA CONSERVATION PARK FOR EACH HUNTING PERIOD, SUMMER 1989/90 - WINTER 1993.



proportion of those hunters who failed to return their hunter diaries either did not hunt during the period or were unsuccessful. This decline probably reflects a decrease in hunting effort over the period studied (from an estimated 18700 days in 1989/90 to 11300 days in 1992/93). Since sighting and kill rates remained stable (see below), it is unlikely that the decline in the estimated total number of deer killed is associated with a population decrease.

Unpermitted and unreported hunting can lead to underestimates of the total harvest. Nugent (1989) estimated that about 20% of big-game hunting nationally was without a permit. While unpermitted hunting probably occurs in Pureora CP, there is no information on its likely scale (J. Mason, DoC Pureora, pers. comm.) and therefore its effect on harvest estimates. However, to some extent potential biases associated with non-return of hunter diaries and unpermitted hunting could be expected to cancel each other out. In addition, unrecovered kills (i.e., animals mortally wounded but not found by hunters) add to the total hunting-related mortality. It is likely that the total deer harvest from recreational hunting in Pureora CP is currently c. 2000 animals annually. Natural mortality is unlikely to be significant in such a heavily-hunted population, although the presence of Tb may contribute to greater natural mortality than in similar disease-free areas.

Variation for hunting periods: Between summer 1989/90 and winter 1993, the overall sighting rate in Pureora CP varied from 0.46 to 0.63 deer seen per

day hunted (i.e., one deer seen for each 1.6-2.2 days hunted; Fig. 5), but did not vary between years, indicating that deer populations in Pureora CP are stable. The overall kill rate for Pureora CP varied from 0.13 to 0.21 deer killed per day hunted (i.e., one deer killed for each 4.8-7.7 days hunted) and showed a similar "seasonal" trend to sighting rates.

When the data were pooled by "season", the sighting rate for winter hunting periods was significantly lower than for summer and roar hunting periods ($p<0.05$). Nugent (1990, unpubl. FRI contract report) reported similar seasonal variation in sighting rate for the Blue Mountains RHA before hunting restrictions were imposed. Pooling by "season" showed that the highest kill rate occurred in summer hunting periods (one deer killed per 5.0 days hunted) followed by the roar (6.7) and winter hunting periods (8.3; all differences significant, $p<0.05$). Despite similar sighting rates in the summer and roar hunting periods, the kill rate during the roar was lower, presumably because most hunters concentrate on mature stags at this time of year, passing up opportunities to shoot hinds or young deer of both sexes. Variation in the sex ratio of the harvest between hunting periods confirms this bias during the roar (see section 6.3). The low sighting and kill rates during winter hunting periods are associated with reduced activity by deer at this time of year (Putman 1988), which would influence hunters' chances of encountering deer.

Kill efficiency (ratio of deer killed per deer seen) was relatively stable (0.30-0.39, i.e., one deer killed for every 2.6-3.3 deer seen) and showed no apparent seasonal trend (Fig. 6). However, there appears to have been a small decline in this ratio over the course of the study, although the reason for this is unclear (particularly since sighting and kill rates have not declined). One possible explanation is that in recent years some recreational hunters may be practising their own form of herd management by refraining from shooting some animals (particularly hinds at certain times of the year), a pattern also noted in the Blue Mountains (Nugent 1990, unpubl. FRI contract report) and Kaimanawa RHAs (Fraser 1993, unpubl. Landcare Research contract report).

The average kill efficiency in Pureora CP during this study (0.32, i.e., one deer killed for every 3.1 deer seen) was higher than that for sika deer in the Kaimanawa RHA (one kill for every 4.6 sightings, C. Speedy pers. comm.), red deer in the Oxford RHA (one kill for every 6.3 sightings, Henderson & Nugent 1989), and fallow deer in the Blue Mountains RHA (one kill for every 7.8 sightings, Nugent 1990, unpubl. FRI contract report). This difference may be due to a combination of factors, including the deer species (in general sika and fallow deer are more difficult to hunt than red deer), variation in hunting effort (higher in the Kaimanawa and Blue Mountains RHAs), and the deer density (much lower in the Oxford RHA).

Variation between hunting blocks: There was little variation in daily sighting rates between hunting blocks (range: 0.37-0.59 deer seen/day), except for a low sighting rate (0.23) in block 1 (Fig. 7) which is a small outlier of the Park and has low numbers of deer. Typically, sighting rates tend to be lowest in the main northern hunting blocks (blocks 3, 4, and 5) and highest in the southern hunting blocks, particularly blocks 9-14. Kill rates show less variation but follow a generally similar pattern to sighting rates (Fig. 7).

FIGURE 6 KILL EFFICIENCY (RATIO OF DEER KILLED PER DEER SEEN, ±95% CLS) IN PUREORA CONSERVATION PARK FOR EACH HUNTING PERIOD, SUMMER 1989/90 - WINTER 1993.

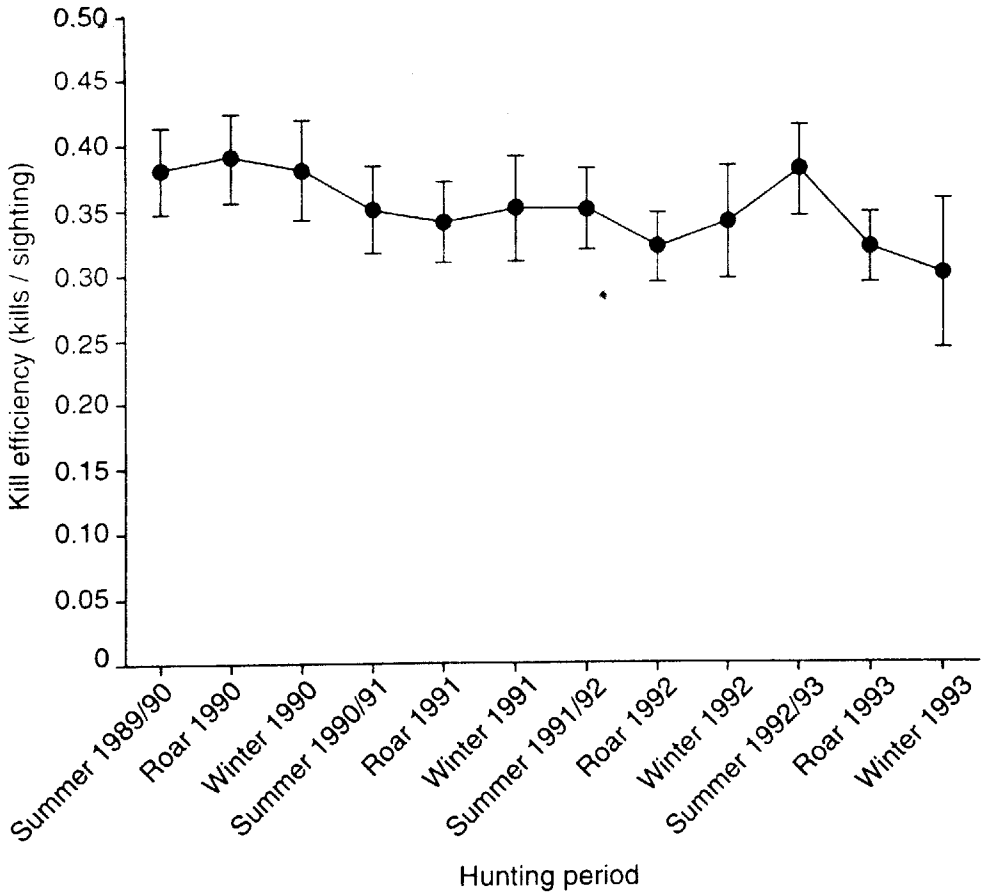


FIGURE 7 DEER SIGHTING (0) AND KILL (0) RATES (±95% CLS) IN PUREORA CONSERVATION PARK FOR EACH HUNTING BLOCK, ALL DATA FOR THE PERIOD SUMMER 1989/90 - WINTER 1993 POOLED.

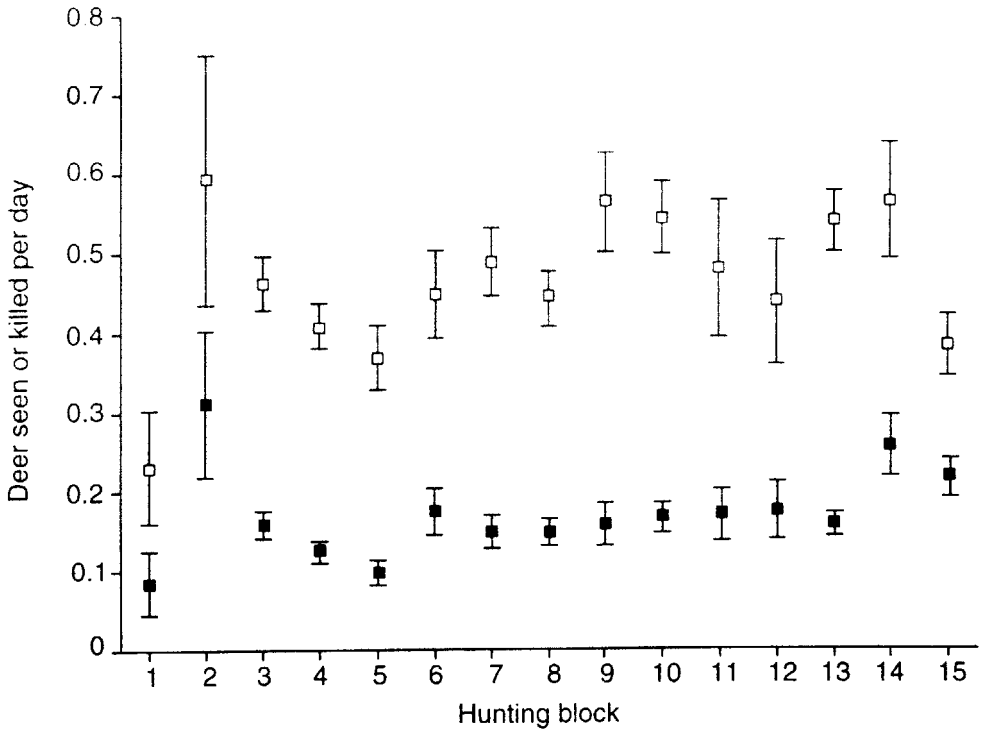
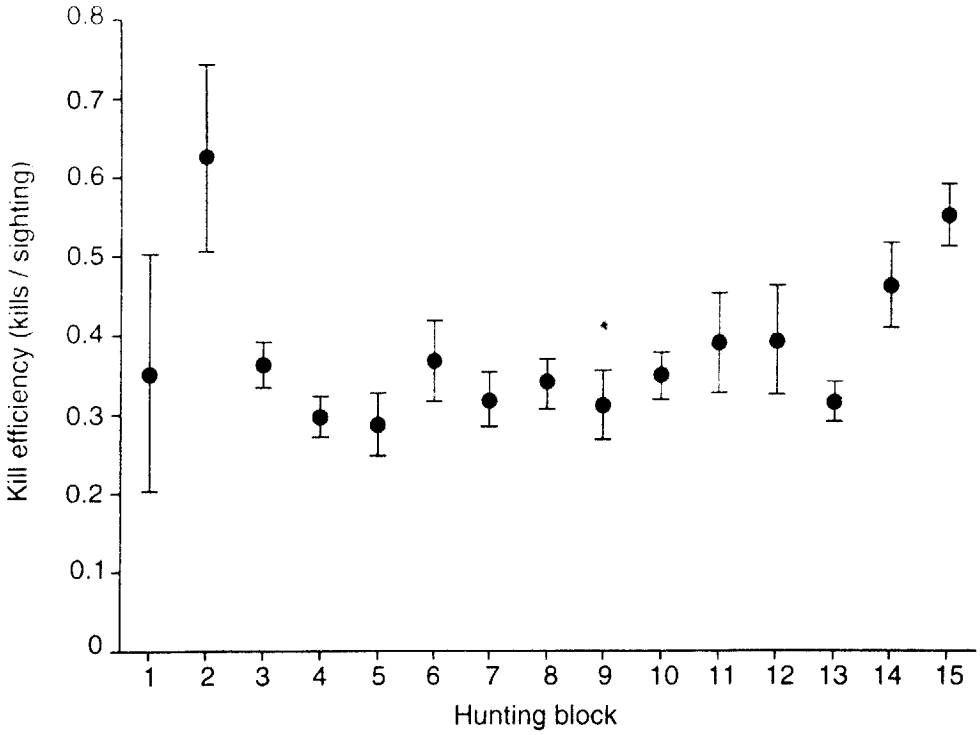


FIGURE 8 KILL EFFICENCY (RATIO OF DEER KILLED PER DEER SEEN, ±95% CLS) IN PUREORA CONSERVATION PARK FOR EACH HUNTING BLOCK, ALL DATA FOR THE PERIOD SUMMER 1989/90 - WINTER 1993 POOLED.



This pattern was also reflected in the kill efficiency ratio between hunting blocks (Fig. 8). Excluding blocks 1 and 2, this ratio tends to be higher in most southern hunting blocks where access is more limited, hunting effort is lower, and deer densities are higher. The markedly higher kill efficiency ratio in blocks 14 and 15 (0.46 and 0.55, respectively) compared with that in blocks 3-14 (0.28-0.39) may be partly due to the presence of relatively large open areas in these two blocks. These provide hunters with greater opportunities for careful stalking of any deer seen compared with typical bush-stalking where many encounters and sightings are brief.

5.3 DEER POPULATION STRUCTURE AND CONDITION

Variation in sex ratio

From summer 1989/90 onwards recreational hunters recorded the sex as well as the number of any deer killed on their hunter diaries (see Appendix 10.3). The sex ratio of the harvest varied according to hunting period (Table 4). During the roar periods the harvest was strongly biased in favour of stags. A similar but smaller bias was also evident for winter periods. Stags may be more vulnerable than hinds during winter months as they spend longer feeding at this time of year in an effort to regain condition lost during the roar (Clutton-Brock & Albon 1989). Recreational hunters killed similar numbers of stags and hinds during summer hunting periods. Overall, the sex ratio of the harvest for the 4-year period covered by these data was strongly biased in favour of stags. Similar stag-

TABLE 4 SEX RATIO OF THE RECREATIONAL HUNTER DEER HARVEST ACCORDING TO HUNTING PERIOD, SUMMER 1989/90 - WINTER 1993.

HUNTING PERIOD	STAGS	% OF TOTAL	HINDS	% OF TOTAL		P
Summer	863	49.8	870	50.2	0.03	NS
Roar	1341	61.3	846	38.7	112.04	<0.001
Winter	505	53.3	442	46.7	4.19	<0.05
Total	2709	55.7	2158	44.3	62.38	<0.001

biased harvests from recreational hunting have also been reported from other areas (Nugent 1990, unpubl. FRI contract report, Fraser 1993, unpubl. Landcare Research contract report).Eight of the 15 hunting blocks had stag-biased harvests over the period summer 1989/90 - winter 1993 (see Appendix 10.4). In the remaining blocks similar numbers of stags and hinds were harvested. The reason for these differences is unclear, particularly since some of these blocks receive considerable hunting effort during the roar (see Fig. 3) when much of the harvest occurs. Small sample sizes for blocks 1 and 2 may have contributed to the lack of a significant difference in these areas.

Age structure

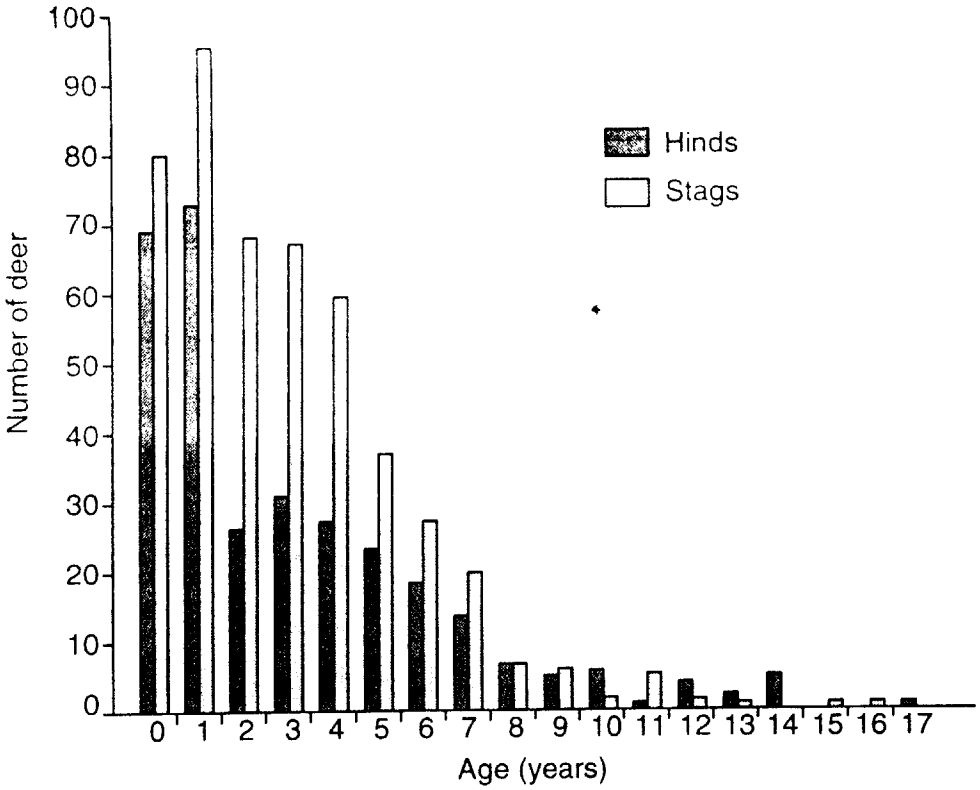
A total of 1347 red deer jawbones have been collected from Pureora CP since 1988, with 833 (62%) of these submitted by recreational hunters and 514 (38%) by commercial hunters (from the commercial hunting zone in the southern part of the Park). Age information is available for 789 of the recreational kills and 463 of the commercial kills.

The age structure of the recreational harvest is characteristic of a hunted population, with most deer in the younger age classes (>75% of these animals were <5 years old; Fig. 9). Although the average age of deer shot by recreational hunters was only about 3.6 years, some deer survive to considerable ages. Since 1988, 30 deer (11 stags and 19 hinds, c. 4% of the harvest) aged ?10 years have been shot. The oldest stag was 16 years and the oldest hind 17 years.

The age structure of the harvest also demonstrates the greater vulnerability of stags to recreational hunters. For the 2-7 year age classes the number of stags harvested (278, 67% of total) far exceeded the number of hinds harvested (138, 33%). Furthermore, male fawns and yearlings were also harvested in greater numbers than females in these age classes although the difference was not as marked. Sample sizes of older age classes were too small to effectively demonstrate such differences.

The average age of deer harvested in the northern part of Pureora CP (blocks 1-5) was 3.4 ± 0.4 (95% Us) years, compared with 3.8 ± 0.3 years in the southern part of the Park (blocks 6-15). This difference is a result of greater hunting effort in the more northern blocks and indicates its effect on deer survival.

FIGURE 9 AGE STRUCTURE OF THE DEER HARVEST BY RECREATIONAL HUNTERS IN PUREORA CONSERVATION PARK SINCE 1988 (NUMBER OF STAGS = 477, NUMBER OF HINDS = 311).



Growth curves and condition indices

The growth curve equations use age in months and are as follows:

Stags:	expected heel length (mm)	=	$295.710 * (1 - e^{-0.461*AGE^{0.480}})$
	expected hinge length (mm)	=	$307.233 * (1 - e^{-0.433*AGE^{0.494}})$
Hinds:	expected heel length (mm)	=	$269.814 * (1 - e^{-0.502*AGE^{0.499}})$
	expected hinge length (mm)	=	$277.338 * (1 - e^{-0.492*AGE^{0.509}})$

While both jawbone length parameters produced curves with good fit (all r2 values were >0.75), the sample sizes for hinge length (stags = 638, hinds = 483) were considerably greater than for heel length (stags = 264, hinds = 199) and the former have been used for all subsequent analyses. These growth curve equations can be used to calculate sex-specific population averages for hinge or heel lengths at any given age.

The condition indices estimated from actual and expected jawbone parameters were independent of both age and sex. Therefore, all the data can be pooled to test for differences in condition according to factors such as year shot, location, and cohort. Although there were no differences in mean condition indices according to year shot, condition indices varied significantly between hunting blocks ($p<0.001$, Fig. 10). With the exception of blocks 14 and 15, deer from the hunting blocks north of Pureora Mountain were typically larger (i.e., higher condition indices) than deer from south of Pureora Mountain. Variation in

FIGURE 10 MEAN CONDITION INDICES (t95% CLS) FOR RED DEER IN PUREORA CONSERVATION PARK ACCORDING TO LOCATION (CHZ = COMMERCIAL HUNTING ZONE); HUNTING BLOCKS WITH A SAMPLE SIZE <10 WERE EXCLUDED FROM THIS ANALYSIS.

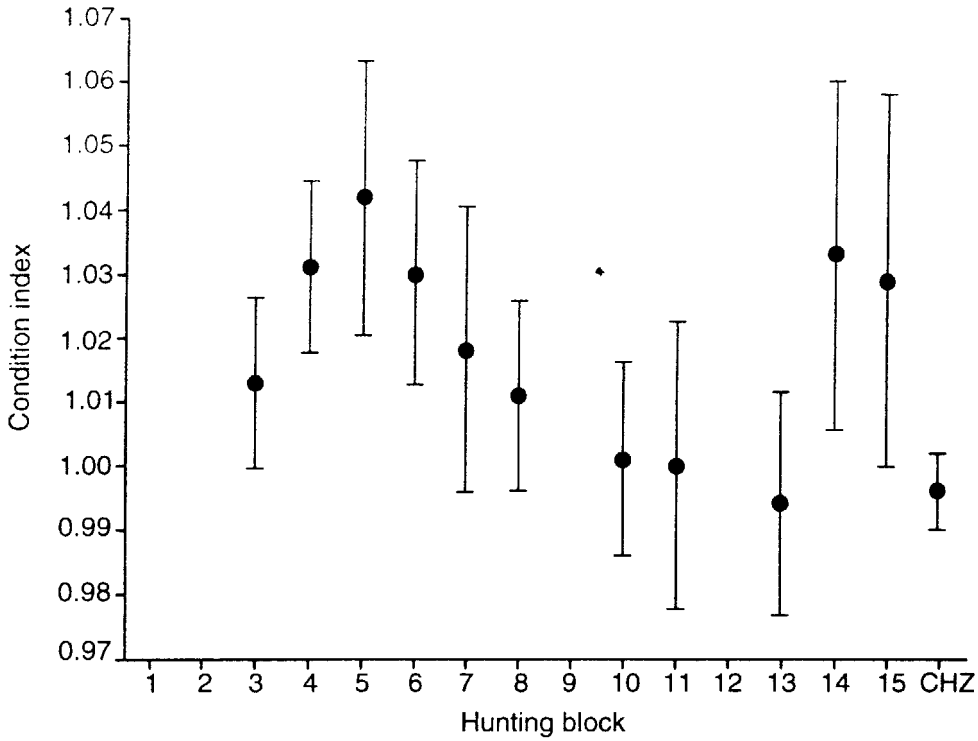
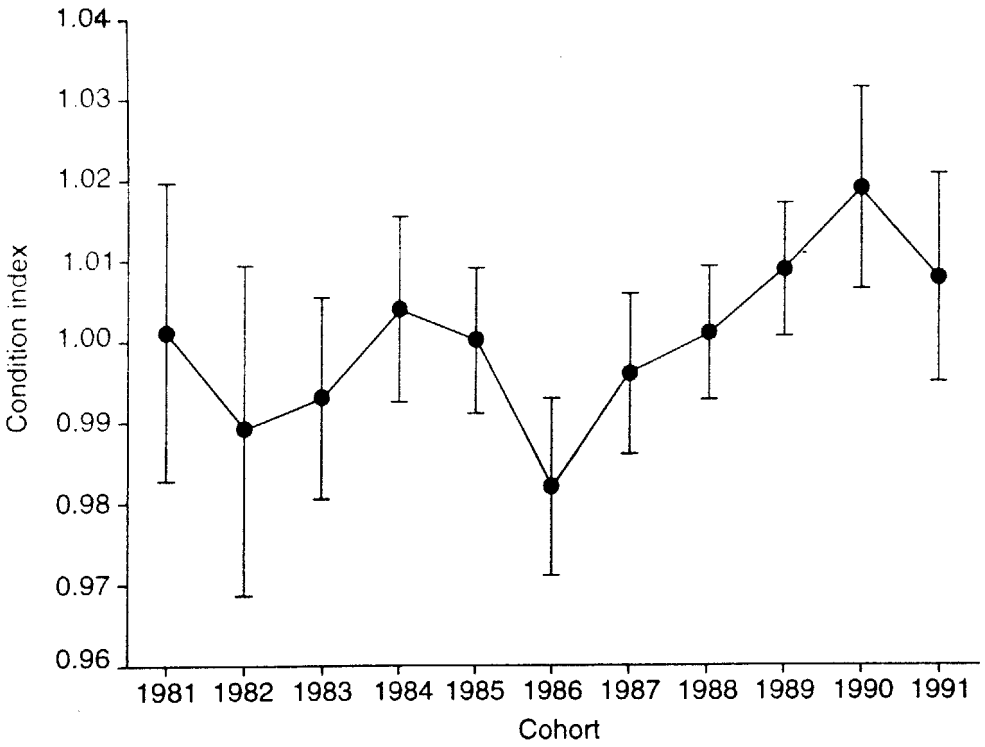


FIGURE 11 MEAN CONDITION INDICES (±95% CLS) FOR RED DEER IN PUREORA CONSERVATION PARK ACCORDING TO COHORT,



habitat quality, particularly the availability and abundance of highly palatable vegetation, and lower deer population density are likely to be the main determinants of these differences. More than half (54%) of the condition indices used in this analysis come from commercial kills in the southern part of Pureora CP which explains why most of the mean condition indices for hunting blocks are above 1.

There was also a significant difference in mean condition indices according to cohort (i.e., year of birth, $p<0.01$). The lowest condition indices were for deer born in 1982, 1983, and particularly 1986 (Fig. 11), suggesting that conditions for growth, principally food resources, were poorer over the period when these deer were growing (up to 4 years in hinds and 5 years in stags). There is a clear trend towards "better-conditioned" (i.e., larger) deer in recent years. This may be associated with milder winters and therefore better vegetation growth or a small decrease in deer densities contributing to greater availability of more palatable and higher quality forage.

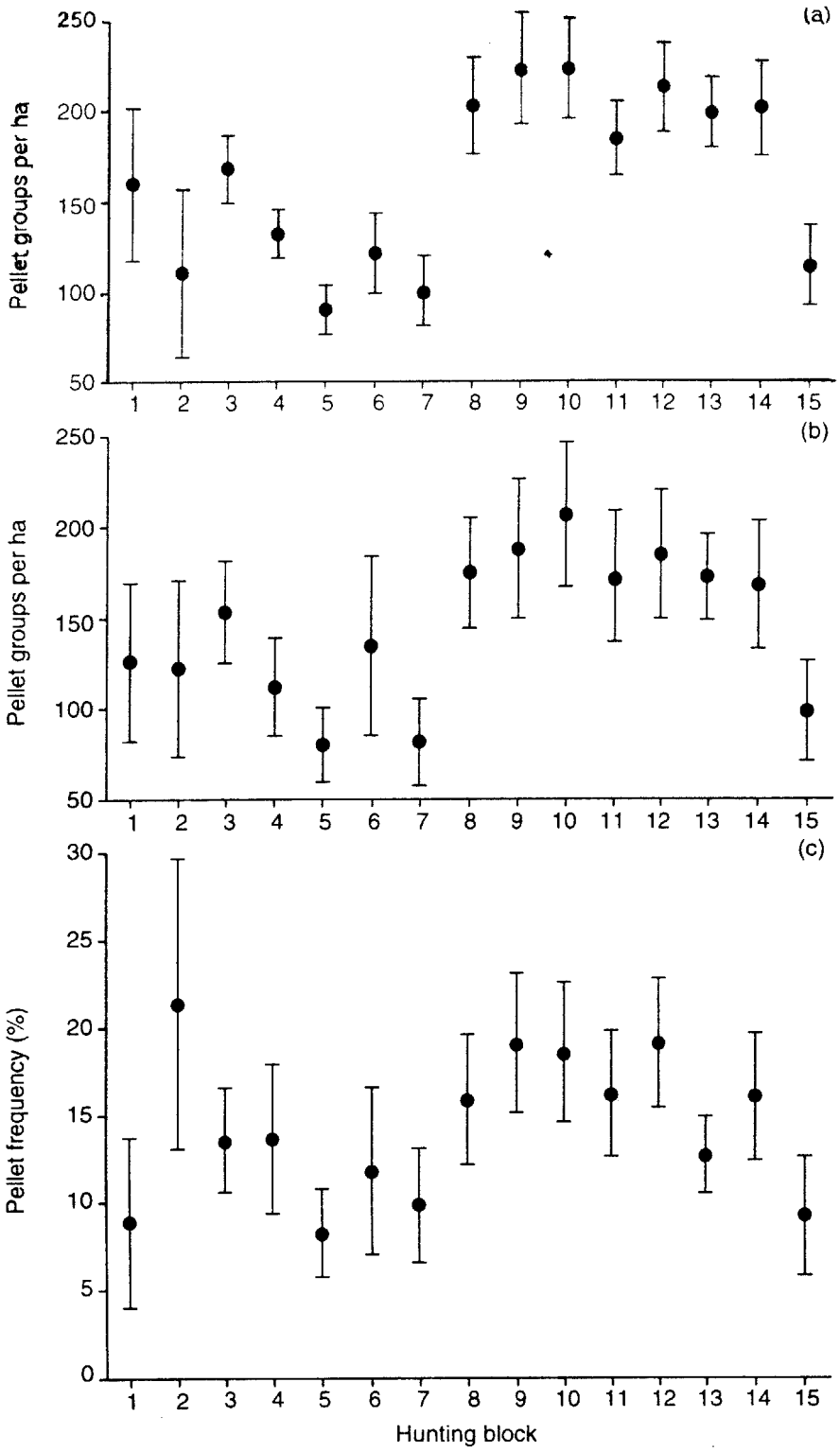
5.4 FAECAL PELLET SURVEY INFORMATION

Each hunting block had between three and 15 pellet lines depending upon the size of the block, with an overall sampling intensity of one plot per c. 10 ha. The overall pellet frequency for ungulates (deer and goats) in Pureora CP was 14.5% ± 4.0 (95% CLs). The point-distance and total-count indices produced estimates of 177.3 ± 6.5 and 154.8 ± 8.7 pellet groups/ha, respectively. The precision of the various indices varied considerably. For example, the average 95% confidence limits for the analysis by hunting block were ±16.4% of the mean for the point-distance index, ±24.5% for the total-count index, and ±29.2% for the presence/absence index.

All three indices of faecal pellet density showed similar patterns with aspect and slope. Faecal pellet indices were highest on west and south-west aspects and lowest on south and south-east aspects. This pattern was strongest in the southern part of the Park. Faecal pellet indices indicated that ungulate densities were highest on terrain with a slope of 31-45°, although results for the 0-15° and 16-30° slope classes were only slightly lower. To a large extent these results reflect that the more remote and less hunted areas generally have steeper terrain. All three faecal pellet indices indicated minimal use of terrain with a slope >45°.

All three indices of faecal pellet density produced similar patterns between the 15 hunting blocks (Fig. 12). With the exception of block 15, pellet group density estimates were generally about 40% higher in the hunting blocks south of and including Pureora Mountain (blocks 8-14) compared with the more northern hunting blocks, consistent with the higher deer sighting and kill rates in these southern blocks.

FIGURE 12 FAECAL PELLET INDICES OF UNGULATE (DEER AND GOATS) DENSITIES (95% CLS) IN THE 15 HUNTING BLOCKS IN PUREORA CONSERVATION PARK, (A) POINT-DISTANCE ESTIMATES, (B) TOTAL-COUNT ESTIMATES, (C) PRESENCE/ABSENCE ESTIMATES.



5.5 COMPARISON OF FAECAL PELLET SURVEYS AND HUNTING SUCCESS INFORMATION

For individual hunting blocks faecal pellet indices were correlated with daily sighting and kill rates for ungulates (Table 5). Accepting the fundamental assumption that faecal pellet indices are linearly related to actual deer (and goat) densities (Ratcliffe 1987), these correlations provide good evidence that sighting and kill rates also reflect animal densities.

TABLE 5 PEARSON CORRELATION COEFFICIENTS AND ASSOCIATED SIGNIFICANCE LEVELS BETWEEN FAECAL PELLET INDICES AND HUNTING SUCCESS INDICES (SIGHTINGS/DAY AND KILLS/DAYS), HUNTER DIARY INFORMATION FROM 1991 AND 1992 ONLY WERE USED FOR THIS ANALYSIS, SINCE THIS CORRESPONDS TO THE PERIOD OVER WHICH THE FAECAL PELLET SURVEY WAS CONDUCTED. HUNTING BLOCKS THAT ARE OUTLIERS FROM THE MAIN PART OF PUREORA CP AND THOSE WITH <2500 H HUNTING ANNUALLY WERE EXCLUDED FROM THIS ANALYSIS (I.E., BLOCKS 1, 2, 12, 14, AND 15).

INDEX	DEER SIGHTINGS	DEER KILLS	UNGULATE SIGHTINGS	UNGULATE KILLS
Point-distance	0.518 ns	0.464 ns	0.637 <0.05	0.663 <0.05
Total-count	0.491 ns	0.595 ns	0.681 <0.05	0.710 <0.05
Presence/absence	0.527 ns	0.492 ns	0.766 <0.05	0.792 <0.01

The better correlations produced using data for ungulates (both deer and goats) compared with deer only (Fig. 13) were not unexpected since the faecal pellet indices include both species. The five hunting blocks excluded from the correlation analyses contributed only <12% of the total hunting effort. Blocks 1 and 2 are small outliers from Pureora CP and receive only c. 500 h hunting annually. Furthermore, goats outnumber deer considerably in these blocks, as they do in blocks 12 and 14. Blocks 12 and 14 also have relatively difficult access and consequently receive relatively light hunting effort (<2500 h annually). The higher kill rate for deer in block 14 may be due to greater hunting success by hunters with local knowledge who gain access to this area through private land. While block 15 is also an outlier from Pureora CP, it is well roaded and tracked and close to Turangi and Taumarunui. Nevertheless, it receives less hunting effort (c. 4700 h annually) than most other parts of the Park, although the high kill rate for deer again suggests an element of local knowledge may be important in this area.

The estimated costs associated with the faecal pellet survey of Pureora CP (Table 6) were compared with the estimated annual costs of administering the recreational hunter permit and hunter diary system. The pellet survey costs are based on the actual expenses incurred by Landcare Research (without overheads) and approximate costs for DoC staff involved in the survey (although in reality this included personnel on a range of salaries). The latter component is based on a field worker rate of c. $123/day (K. Broome, DoC

FIGURE 13 RELATIONSHIP BETWEEN PELLET GROUP DENSITIES USING THE POINT DISTANCE METHOD AND (A) SIGHTING RATES FOR DEER, (B) KILL RATES FOR DEER, (C) SIGHTING RATES FOR UNGULATES, AND (D) KILL RATES FOR UNGULATES. THE NUMBERS BESIDE THE DATA POINTS DENOTE HUNTING BLOCK NUMBER; OPEN SYMBOLS HAVE BEEN USED FOR THOSE HUNTING BLOCKS EXCLUDED FROM THE CORRELATION ANALYSES.

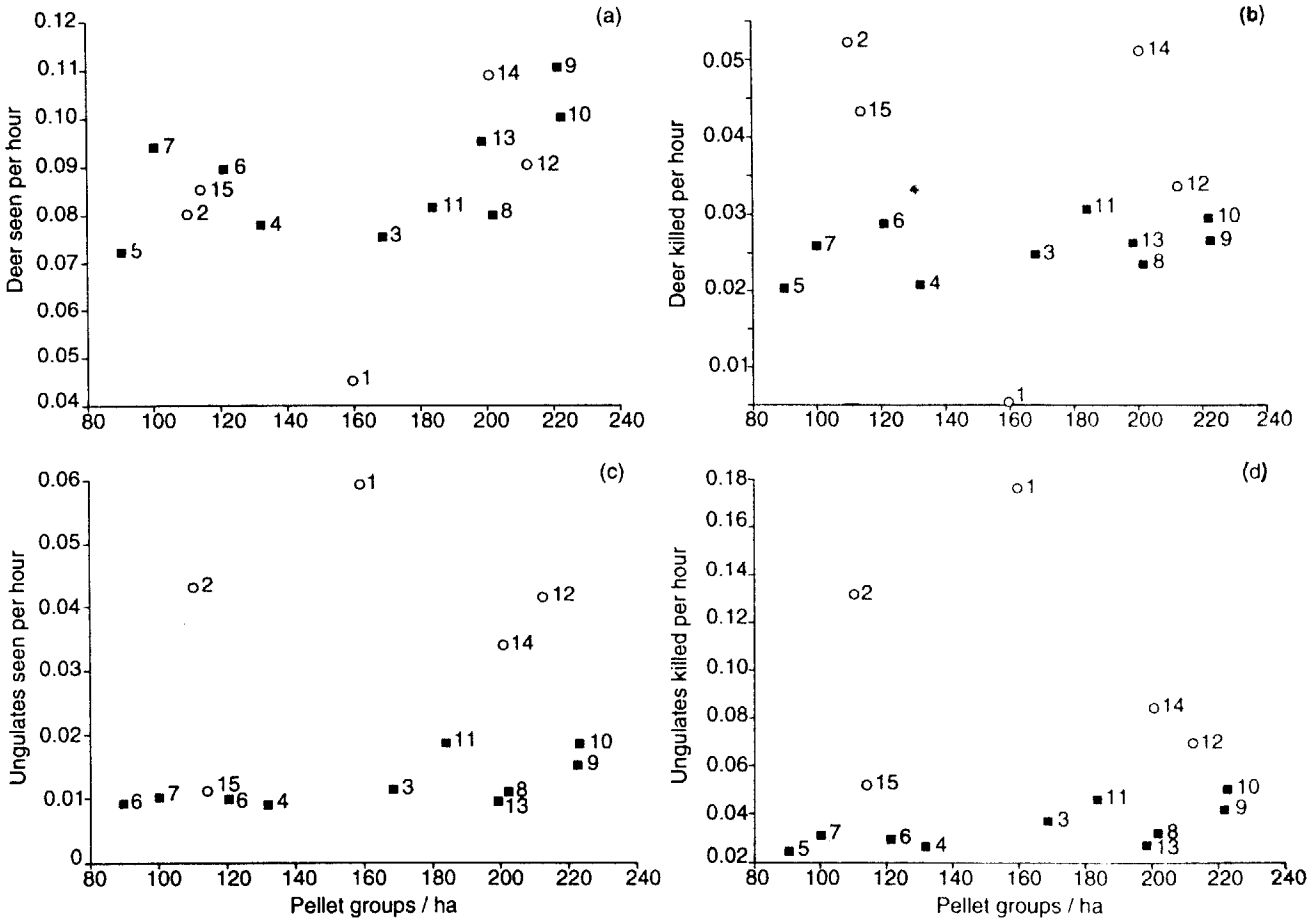


TABLE 6 ESTIMATED COSTS ASSOCIATED WITH THE FAECAL PELLET SURVEY CONDUCTED IN PUREORA CONSERVATION PARK IN 1992 AND 1993.

	COSTS ($)
Landcare staff	19,300
DoC staff	14,400
Field allowances	5,000
Vehicle expenses	4,000
Equipment	500
Total	43,200

Waikato, pers. comm.) and therefore provides a conservative estimate. The total cost of $43,200 includes the expenses associated with data entry, analysis, and report production, but the field work component accounted for over 80% of the total cost. Furthermore, faecal pellet indices provide only a "snapshot" of the population and must be repeated at regular intervals in order to monitor trends over time. They are also labour-intensive, require good weather conditions, and the quality of the results is dependent upon the patience and motivation of the survey personnel.

The costs associated with hunting permit and hunter diary system were estimated at $28,000 annually including overheads (S. Kelton, DoC Waikato, pers. comm.). This includes the issuing of permits, collection and collation of hunter diary information, and some reporting of the results. A considerable proportion of this total relates to the basic issuing of hunting permits (including $9000 for postage) and is unavoidable under the current legislation. The collation, analysis, and reporting of hunter diary information for monitoring and other purposes comprises less than half the total costs.

For extensive areas such as Pureora CP, recreational hunter diaries provide more detailed information than faecal pellet surveys on the deer populations in the area, except where hunting effort is low. Besides being based upon the actual animals being monitored (as opposed to animal sign for faecal pellet surveys), they provide continuous information on hunting effort (including spatial and temporal patterns) and the resulting harvests, and allow population trends to be closely monitored. For example, it will be useful to monitor any changes in hunting patterns and effort over the next few years as a result of the extensive possum and deer control operations in the southern part of the Park in winter 1994.

However, the accuracy of hunting success indices and other data provided through the hunter diary system is dependent upon hunters providing reliable information. While some individual hunters probably under- or over-estimate deer sightings and kills (unintentionally or otherwise), the thousands of hunter diaries collected each year should help to even out or minimise any such biases. Although hunting success indices have not been validated against known numbers of deer in New Zealand, the consistency of hunting success indices over time and the good correlations with faecal pellet indices suggest that both techniques can provide reasonably reliable information for the routine monitoring of deer populations. However, recreational hunter information is more precise and cost-effective than faecal pellet surveys.

Other Doc conservancies (e.g., Tongariro/Taupo, Hawke's Bay, Canterbury) have established similar database systems for recording and summarising recreational hunting effort and harvest information. These databases are seen by local managers as a useful way of maintaining an up-to-date appreciation of what is happening in their conservancies and collating information for feedback to recreational hunters. Nevertheless, there is still a need for deer density indices in current use to be validated against known numbers of deer.

Although hunting effort in Pureora CP is primarily related to deer, pigs and goats are also hunted. At present no attempt is made to partition hunting effort between these species. However, it would be relatively easy to incorporate such information into the existing hunter diary system and this would probably

increase the reliability and precision of indices based on recreational hunting parameters.

There are situations where faecal pellet surveys still provide a useful source of information. For example, detailed studies of habitat use within relatively small areas or where information on differential use between altitude or slope classes, or aspects is required. In addition, while hunter diaries do not provide any information on possum populations, these data are routinely collected as part of most faecal pellet surveys (at little or no additional cost). However, faecal pellet counts cannot reliably differentiate between ungulates or between deer species (there is some evidence that sika deer are spreading into Pureora CP naturally and there is always the threat of illegal liberations). This level of detail is relatively important for the long-term monitoring of animal populations in the Park since the impacts of various ungulate species can vary.

The complementary jawbone collections provide a wealth of information including the age structure of the population and condition indices. Such information can be used either independently or in conjunction with hunting success indices to ascertain population changes and confirm population trends over time. Combined with similar collections from commercial hunting, this information can also be used as a basis for comparisons of various aspects of the recreational and commercial harvests.

A conservation benefit resulting from the hunter diary system is the collection of wildlife sightings. Since hunters range into many relatively remote and inaccessible areas not normally visited by other people, they are often the only source of information which would otherwise cost a considerable amount to collect. For some of the rare and endangered bird species for which a national database is held, recreational hunters are the main source of records (E. Nicol, DoC Head Office, pers. comm.).

5.6 HUNTING PATTERNS AND PREFERENCES

Demographics of the recreational hunting population

A total of 1048 questionnaires were completed and returned, a response rate of 56%. Nearly 99% of the respondents were male. Most hunters were in the middle and older age groups (73% were ?30 years old), which conforms to other recent studies of recreational hunter age profiles (Fraser & Sweetapple 1992) and confirms concerns about an apparently low rate of recruitment of young hunters into the sport (Fraser & Batcheler 1989). Most respondents (64%) reported that they have hunted for >10 years.

Hunting patterns

Approximately half the respondents (55%) considered that Pureora CP was their main hunting area. "Close to home" and "familiar area" ranked highest among the primary reasons for hunting in Pureora CP (Table 7).

TABLE 7 PRIMARY REASONS ATTRACTING RECREATIONAL HUNTERS TO PUREORA CONSERVATION PARK BASED ON RESPONSES TO A POSTAL SURVEY (N=1019).

REASON	% OF RESPONSES
Close to home	28.4
Familiar area	19.7
Reasonable animal numbers	15.5
Good habitat to hunt	10.3
Good internal roading	10.3
Ease of terrain	5.8
Trophy potential	3.9
Annual hunting competition	2.7
Other	3.4

More than 80% of respondents indicated that their hunting trips were as part of a group. However, most respondents (68%) hunted alone. Just over 20% of respondents (mostly pighunters) reported using dogs. On trips of more than 1 day most respondents (77%) camped in the forest, 10% used DoC huts, 6% used DoC camping grounds, and 7% listed alternatives (e.g., shearers' quarters on nearby farms).

Most respondents (88%) indicated that they primarily hunted deer in Pureora CP. Pigs (8%) and goats (3%) rated much lower, although 50% of respondents reported that they did shoot species other than their intended game if they encountered them. However, although many hunters after deer would shoot pigs if they saw them and vice versa, most hunters were reluctant to shoot goats for fear of disturbing other game nearby.

The most popular hunting blocks in Pureora CP are 4 (Ngaroma, rated as one of the best three by 44% of respondents), 13 (Waihaha, 32%), 8 (Kakaho, 23%), 5 (Ranginui, 22%), and 3 (Okahukura, 21%). Familiarity with the area and ease of access were the most common reasons given for favouring these blocks, which helps to explain the popularity of the well-roaded northern blocks, despite lower deer numbers in these areas. The Western Outlier (4%), Wharepuhunga (5%), and Taringamutu (6%) were the least favoured hunting blocks.

Management of hunting in Pureora Conservation Park

Almost all respondents (97%) were satisfied with the 4-month hunting permit and hunter diary system that currently operates for the Maniapoto District (including Pureora CP). Although 40% of respondents indicated that they "always" and 30% of respondents indicated that they "mostly" returned their hunter diaries, this is not borne out by recent trends in hunter diary return

rates. However, this inconsistency probably reflects the likelihood that those hunters who regularly returned diaries were also more likely to respond to the survey.

Nearly all respondents (99%) enjoyed receiving the Maniapoto District Hunters' Newsletter and 88% of respondents wanted to see more of this sort of information made available to hunters. Although nearly 90% of respondents knew why jawbones are collected, only 17% indicated that they always submitted jawbones from deer killed and 45% have never submitted them. While lack of kills was often given as a reason for the latter, many respondents were unclear as to what was required and how to remove the jawbone from deer they shot. A subsequent article in the Maniapoto District Hunters' Newsletter (Fraser 1994) has addressed this problem.

Although only 15% of respondents took part in the 1992 hunting competition, 92% of respondents thought that the competition was a good idea and wanted to see it continue in future years. However, many respondents raised concerns about the heavy hunting effort during the roar period and associated safety issues.

Half the respondents considered that there could be improvements to the basic management of recreational hunting in Pureora CP. Most comments related to road and track conditions, improved access to some blocks (particularly in the southern part of the Park), and more information on animal densities and recreational harvest tallies. Respondents were divided on the question of restrictions on hunting in Pureora CP for reasons of safety or herd management; 43% wanted to see some form of restrictions, 40% did not want restrictions, and 17% were unsure. Most respondents were not satisfied with the present restriction of helicopter hunting to the southern part of Pureora CP; 12% wanted more restrictions and 69% wanted no helicopter hunting at all. Only 19% of respondents found the present situation acceptable.

Nearly all respondents (98%) indicated that they would continue to hunt in Pureora CP, suggesting a reasonable degree of satisfaction with either the area itself, recreational hunting management in Pureora CP, or both.

5.7 IMPACT OF RECREATIONAL HUNTING

Indices of hunting success suggest that deer numbers in Pureora CP are relatively stable. Furthermore, faecal pellet indices from surveys in 1992 and 1993 were similar those from previous surveys over the period 1974 to 1990 (Dale 1975; Jane 1979; Deuss 1981; Krzystyniak 1984; Broome & Krzystyniak 1985; Broome & Clegg 1990, unpublished NZFS and DoC reports). While the age structure of the jawbone sample is indicative of a reasonably heavily harvested deer population, the sex ratio of the harvest is strongly biased towards stags particularly during the roar hunting period. The effectiveness of recreational hunters as a management tool would be improved if hunters could be encouraged to shoot more hinds. Nevertheless, it is likely that recreational hunting will continue to be an important wild animal (deer, pigs, and to a lesser extent goats) management method in the long term in Pureora CP. However,

the recent availability of funds for Tb-related possum and deer control will present other options in the short to medium-term.

Comparison with the commercial harvest sex ratio and age structure

In comparison with the stag-biased sex ratio of the recreational harvest, the commercial harvest shows no such bias with equal numbers of stags and hinds being shot (Table 8).

TABLE 8 COMPARISON OF SEX RATIOS BETWEEN RECREATIONAL AND COMMERCIAL HUNTING.

HARVEST TYPE	STAGS	OF TOTAL	HINDS	% OF TOTAL	x^2	P
Recreational'	1122	56.0	882	44.0	28.7	<0.001
Commercial	256	49.8	258	50.2	0.0	NS

' Only the recreational hunting harvest from blocks 9-14 have been used for these comparisons as these blocks are where helicopter-based commercial hunting is permitted.

The average age of deer taken by recreational hunters was almost 4 years, whereas deer shot in the same area by commercial hunters were considerably younger (2.3 years for stags, 2.9 years for hinds; Table 9). Helicopter-based commercial hunting is concentrated at the time of year when young animals, particularly yearlings, are moving around more, but the recreational harvest results from year-round hunting.

TABLE 9 COMPARISON OF MEAN AGES (1N YEARS) BETWEEN RECREATIONAL AND COMMERCIAL HUNTING.

	STAGS		HINDS		TOTAL	
HARVEST TYPE	n	Age (years)	n	Age (years)	n	Age (years)
Recreational'	96	3.8	40	3.9	136	3.8
Commercial	226	2.3	237	2.9	463	2.6

' Only the recreational hunting harvest from blocks 9-14 have been used for these comparisons as these blocks are where helicopter-based commercial hunting is permitted.

Since 1988, recreational hunters have reported a total of 2463 deer kills from blocks 9-14 (i.e., c. 500 annually); over a similar period the commercial harvest is c. 1000 annually (K. Broome, DoC Waikato, pers. comm.). While the reported recreational harvest of c. 500 deer is a conservative estimate, the total estimated recreational harvest in these blocks is unlikely to exceed c. 1000 deer annually.

Therefore, although recreational hunters and commercial hunters probably take a similar number of deer from this area annually, the "conservation value" of an "average" recreational kill is somewhat less than for an "average" commercial kill because the recreational harvest is biased towards stags (the non-productive segment of the population). Consequently, the "average" commercial kill has a greater impact on the overall productivity of the deer population.

6. Conclusions

- The simple database system used in this study proved effective for the collation and preliminary analysis of hunter diary information. The concept has now been extended by using a relational database package to allow rapid retrieval of name and address information and to print hunting permits. Such databases provide managers with quick and easy access to a large amount of information on recreational hunting effort and harvests (not only in Pureora CP, but also in other DoC conservancies where similar systems have been established).
- While reminder letters are useful for improving hunter diary return rates for specific hunting periods, continued effort, perhaps coupled with other techniques (e.g., incentives, penalties), would be required to maintain hunter diary return rates for Pureora CP above 70%. Improved reporting of hunter diary information and deer jawbone analyses through the Maniapoto District Hunters' Newsletter or at strategically placed display boards at major access points to the Park may assist with this.
- Better access and proximity to population centres contribute to greater hunting effort most of the northern part of Pureora CP and, as a consequence, deer densities are lower than in the southern part of the Park, despite the additional commercial hunting effort in the south.
- In Pureora CP long-term monitoring of deer populations based on information from recreational hunter diaries is more cost-effective than faecal pellet surveys, which only provide a "snapshot" of the population and must be repeated at regular intervals in order to monitor trends. Hunter diaries also provide additional information on hunting patterns, sex ratio of the harvest, and wildlife sightings for rare and endangered species. However, both techniques have yet to be validated against known populations of deer in New Zealand.
- Since the hunter diary system used in Pureora CP has parallels in a number of other areas where recreational hunting effort is high and provides a low-cost control mechanism for deer populations, there is justification for continuing with this method of monitoring hunting effort and deer populations, and encouraging standardisation of the technique between DoC conservancies.
- The lack of any increase in the reported deer harvest despite a significant increase in hunter diary return rates suggests that deer numbers in Pureora CP have remained stable over the period of this study. The stability of sighting and kill rates over the same period tend to confirm this. In the

northern part of the Park this "control" is effected by recreational hunters alone, while in the southern part of the Park it is due to a combination of recreational and commercial hunting.

- Since nearly half (46%) of the total recreational hunting effort in Pureora CP occurs during the roar when the harvest is strongly biased towards stags, the "control value" of recreational hunting is less than it could be. From a conservation perspective, there is potential for improving the effectiveness of recreational hunting if recreational hunters can be encouraged to shoot more hinds, during the roar and early winter months in particular.
- While recreational and commercial hunters kill similar numbers of deer in the southern part of Pureora CP, the "conservation value" of commercial kills is greater because commercial hunters kill more young animals and a higher proportion of hinds (i.e., they have a greater impact on the productivity of the deer population).
- Hunter diary returns and the results of the postal survey of hunters suggest that the current level of interest by hunters in the area will be maintained, unless official control operations in the Park (for Tb and conservation) continue to target deer.

7. Recommendations

- DoC should use recreational hunter data to monitor hunting effort and deer densities in Pureora CP (and other similar areas).
- Efforts should be made to raise the hunter diary return rate to >70% to improve the accuracy of hunting success indices.
- In Pureora, CP jawbone collections from both recreational and commercial hunters should be continued to enable ongoing comparisons of the recreational and commercial harvests. More jawbone collection sites should be established, particularly in the southern part of the Park.
- Use of extensive faecal pellet surveys should be limited to the calibration of recreational hunting data where necessary, for surveying areas with low hunting effort, or for specific comparisons of habitat use.
- Indices of deer density in current use should be validated against known numbers of deer.
- Greater encouragement should be given for both recreational and commercial hunters to shoot goats in Pureora CP since this will benefit both hunters and conservation values, as well as improving the accuracy of deer density indices based on hunting success.

8. Acknowledgements

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9. References

Baddeley, C.J. 1985: Assessments of wild animal abundance. *Forest Research Institute bulletin no. 106.* 46 p.

Broome, K.; Clegg, S. 1990: Wild animals and their impact in the Rangitoto Range and the Waipapa ecological area. Department of Conservation unpubl. report. 48 p.

Broome, K.; Krzystyniak, S. 1985: The wild animal populations in the Hauhungaroa Range. New Zealand Forest Service unpubl. report. 40 p.

Clutton-Block, T.H.; Albon, S.D. 1989: Red deer in the highlands. BSP Professional Books, Oxford. 260 p.

Dale, R.W. 1975: An animal and vegetation assessment of the Rangitoto Range. New Zealand Forest Service unpubl. report.

Deuss, F.J. 1981: Animal survey 1980 - Pureora Forest Park. New Zealand Forest Service unpubl. report. 31 p.

Fraser, K.W. 1991: Instructions for using the Pureora Forest Park hunter diary database (version 1.1). Unpubl. Forest Research Institute report. 24 p.

Fraser, K.W. 1993: Age and condition of deer from the Kaimanawa Recreational Hunting Area. Landcare Research contract report LC9394/07 (unpublished). 26 p.

Fraser, K.W. 1994: Deer jawbone collections from Pureora Forest Park. Maniapoto District Hunters' Newsletter, Supplement to No. 3 (June-September 1994), 4 p.

Fraser, K.W.; Batcheler, C.L. 1989: Recreational hunting in future management of wild animals. In: Seminar 2000: The future of New Zealand's wild animals. Proceedings of a national seminar. Pp. 126-129.

Fraser, K.W.; Sweetapple, P.J. 1992: Hunters and hunting patterns in part of the Kaimanawa Recreational Hunting Area. *New Zealand journal of zoology* 19: 91-98.

Fraser, K.W.; Sweetapple, P.J. 1993: Assessing the age and condition of deer from jawbones. Manaaki Whenua - Landcare Research New Zealand Ltd, Christchurch. 32 p.

Henderson, R.J.; Nugent, G. 1989: Monitoring the hunting system for red deer in the Oxford RHA. Forest Research Institute Contract Report (unpublished). 18 p.

Jane, G. 1979: The wild animal populations and forest conditions in the Hauhungaroa Ranges. New Zealand Forest Service unpubl. report. 47 p.

Krzystyniak, S. 1984: Pureora North Block animal survey. New Zealand Forest Service unpubl. report. 24 p.

Nugent, G. 1989: An assessment of wild big-game harvests and their commercial utilisation. Forest Research Institute Contract Report (unpublished). 14 p.

Nugent, G. 1990: Monitoring the Blue Mountains Recreational Hunting Area. Forest Research Institute Contract Report FWE 90/24 (unpublished). 25 p.

Nugent, G. 1992: Big-game, small-game, and gamebird hunting in New Zealand: hunting effort, harvest, and expenditure in 1988. *New Zealand journal of zoology* 19: 75-90.

Nugent, G. 1993: Management issues for the Blue Mountains Recreational Hunting Area. Landcare Research Contract Report LC9394/30 (unpublished). 17 p.

Putman, R.J. 1988: The natural history of deer. Christopher Helm Ltd, London. 191 p.

Ratcliffe, P.R. 1987: The management of red deer in the commercial forests of Scotland related to population dynamics and habitat changes. Ph.D. thesis, University of London. 362 p.

10. Appendices

10.1 PUBLICATIONS OR OTHER SIGNIFICANT OUTPUTS RESULTING FROM THIS STUDY

Fraser, K.W. 1991: Instructions for using the Pureora Forest Park hunter diary database (version 1.1). Unpubl. Forest Research Institute report. 24 p.

Fraser, Wayne. 1991: What can jawbones tell us? Pureora Forest Park Hunters' Newsletter, Issue 10: 1-2.

Fraser, Wayne. 1991: Hunter diaries put to the test. Pureora Forest Park Hunters' Newsletter, Issue 11: 1-2.

Fraser, Wayne. 1992: 1992 pellet survey of Pureora Forest Park. Pureora Forest Park Hunters' Newsletter, Issue 12: 1-2.

Fraser, Wayne. 1992: Deer jawbone analyses from Pureora Forest Park. Pureora Forest Park Hunters' Newsletter, Issue 13: 1-3.

Fraser, Wayne. 1993: Postal survey of recreational hunters. Pureora Forest Park Hunters' Newsletter, Issue 14: 1.

Fraser, Wayne. 1993: Postal survey of recreational hunters. Pureora Forest Park Hunters' Newsletter, Issue 15: 1-3.

Fraser, K.W.; Sweetapple, P.J. 1993: Assessing the age and condition of deer from jawbones. Manaaki Whenua - Landcare Research New Zealand Ltd. Christchurch, New Zealand. 32 p.

Fraser, K.W. 1994: Postal survey of recreational hunters in Pureora Forest Park. Maniapoto District Hunters' Newsletter, Supplement to No. 1, 4 p.

Fraser, Wayne. 1994: Deer jawbone collections from Pureora Forest Park. Maniapoto District Hunters' Newsletter, Supplement to No. 3, 4 p.

Fraser, Wayne. 1995: Possum and deer control in the Hauhungaroa Range. Maniapoto District Hunters' Newsletter, No.5: 1-3.

10.2 BASIC INFORMATION ON HUNTING PATTERNS, HUNTING EFFORT, AND RESPONSE RATES OBTAINED FROM PUREORA CONSERVATION PARK HUNTER DIARIES OVER THE PERIOD SUMMER 1988/89 TO WINTER 1993.

				REPORTED				ESTIMATED'		
PERIOD HUNTED	NO. OF PERMITS ISSUED	NO. OF HUNTER DIARIES RETURNED	RETURN RATE (%)	NO. OF TRIPS	NO. OF DAYS HUNTED	AV NO. OF HOURS HUNTED PER DAY	TOTAL HOURS HUNTED2	NO. OF TRIPS	NO. OF DAYS HUNTED	TOTAL HOURS HUNTED
Summer 1988/89	-	-	-	-	1875	-	-	-	-	-
Roar 1989	-	-	-	-	2134	-	-	-	-	-
Winter 1989	1540	713	46.3	1060	2061	-	-	2289	4451	-
Summer 1989/90	1820	794	43.6	1388	2735	5.57	15234	3183	6273	34940
Roar 1990	2374	903	38.0	1271	3022	5.66	17105	3345	7953	45012
Winter 1990	1479	1026	69.4	1097	2251	5.65	12718	1581	3244	18326
Summer 1990/91	1905	881	46.2	1071	2060	5.29	10897	2318	4459	23587
Roar 1991	2120	864	40.8	1147	2678	5.49	14702	2811	6564	36035
Winter 1991	1598	1082	67.7	969	1736	5.53	9600	1431	2564	14180
Summer 1991/92	1936	1327	68.5	1399	2767	5.42	14997	2042	4039	21894
Roar 1992	2552	1622	63.6	1825	4308	5.60	24125	2869	6774	37932
Winter 1992	1821	1269	69.7	949	1793	5.16	9252	1362	2572	13274
Summer 1992/93	1879	1287	68.5	1193	2314	5.27	12195	1742	3378	17803
Roar 1993	2163	1535	71.0	1533	3812	5.48	20890	2159	5369	29422
Winter 1993	1647	695	42.2	554	950	5.31	5045	1313	2251	11954

' Calculated by dividing the reported values by the hunter diary return rate.

2 Calculated by multiplying the average number of hours hunted per day by the reported number of days hunted.

10.3 BASIC INFORMATION ON DEER SIGHTINGS AND KILLS OBTAINED FROM PUREORA CONSERVATION PARK HUNTER DIARIES OVER THE PERIOD SUMMER 1988/89 TO WINTER 1993.

PERIOD HUNTED	NO. OF DAYS HUNTED	NO. OF DEER SEEN	NO. OF STAGS KILLED	NO. OF HINDS KILLED	TOTAL NO. OF DEER KILLED	NO. OF DEER SEEN PER DAY	NO. OF DEER KILLED PER DAY	ESTIMATED TOTAL DEER KILLED[1]
Summer 1988/89	1875	-	-	-	347	-	0.19	-
Roar 1989	2134	-	-	-	337	-	0.16	-
Winter 1989	2061	-	-	-	307	-	0.15	663
Summer 1989/90	2735	1298	207	226	433	0.47	0.16	993
Roar 1990	3022	1368	301	182	483	0.45	0.16	1271
Winter 1990	2251	1040	194	160	354	0.46	0.16	510
Summer 1990/91	2060	1122	229	210	439	0.54	0.19	950
Roar 1991	2678	1388	294	188	482	0.52	0.17	1181
Winter 1991	1736	783	133	114	247	0.45	0.14	365
Summer 1991/92	2767	1489	212	251	463	0.54	0.17	676
Roar 1992	4308	2177	382	248	630	0.51	0.15	991
Winter 1992	1793	758	117	115	232	0.42	0.13	333
Summer 1992/93	2314	1107	215	181	396	0.48	0.17	578
Roar 1993	3812	2071	364	228	592	0.54	0.16	834
Winter 1993	950	405	58	49	107	0.43	0.11	254

[1] Calculated by dividing the reported number of deer killed by the hunter diary return rate.

10.4 SEX RATIO OF THE DEER HARVEST FROM RECREATIONAL HUNTING IN PUREORA CONSERVATION PARK OVER THE PERIOD SUMMER 1989/90 TO WINTER 1993.

HUNTING BLOCK NO.	HUNTING BLOCK NAME	STAGS	%	HINDS	%	TOTAL	x	P
1	Western Outlier	15	62.5	9	37.5	24	2.67	NS
2	Wharepuhunga	33	53.2	29	46.8	62	0.26	NS
3	Okahukura	301	59.3	207	40.7	508	17.39	<0.001
4	Ngaroma	298	57.2	223	42.8	521	10.80	<0.005
5	Ranginui	108	49.8	109	50.2	217	0.00	NS
6	South	109	57.7	80	42.3	189	4.45	<0.05
7	Mangakino	165	50.5	162	49.5	327	0.03	NS
8	Kakaho	244	51.5	230	48.5	474	0.41	NS
9	Ongarue	124	50.8	120	49.2	244	0.07	NS
10	Okauaka	280	53.4	244	46.6	524	2.47	NS
11	Maramataha	102	59.0	71	41.0	173	5.55	<0.05
12	Waione	84	69.4	37	30.6	121	18.26	<0.001
13	Waihaha	375	55.5	301	44.5	676	8.10	<0.01
14	Taringamutu	157	59.0	109	41.0	266	8.66	<0.01
15	Waituhi	263	57.7	193	42.3	456	10.75	<0.01