Hunting pressure, deer populations, and vegetation impacts in the Kaimanawa Recreational Hunting Area

K. W. Fraser and C. J. Speedy

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CONTENTS

Abstract

The relationships between recreational hunting pressure, indices of deer density and “condition” (= skeletal size), and two measures of deer impacts on vegetation (browse indices and seedling densities) were investigated in the Kaimanawa Recreational Hunting Area (RHA). There were distinct gradients in hunting pressure, deer density, and deer condition within the RHA. Hunting pressure was highest in the north and decreased towards the south, and was related to the ease of access and the presence of back-country huts. Deer density was inversely related to hunting pressure, being lowest in the northern hunting blocks and highest in the southern hunting blocks. Mean deer condition indices decreased from north to south, associated with the increase in deer density, a general increase in altitude, and a decrease in forest species diversity and the quantity of palatable forage present. Indices of browsing pressure were typically higher in the southern hunting blocks than in those in the north, although the overall gradient in browsing pressure throughout the RHA was not as clear as those for deer density and condition. While overall seedling densities were generally similar in each of the hunting blocks sampled, most moderately to highly palatable fern and woody species tended to have lower seedling densities in the southern hunting blocks. Seedlings of species of low palatability were generally more abundant in the south. The impact of deer was also apparent in the differing height-class distributions for a number of species common to all the areas sampled. The ecological costs of the presence of deer are summarised and a range of management options presented which could offer some scope for enhancement or manipulation of hunting pressure to achieve improved conservation outcomes.

1. Introduction

Spatial, seasonal, and year-to-year variation in recreational hunting pressure, hunting success, and deer densities in the Kaimanawa Recreational Hunting Area (RHA) were assessed by Manaaki Whenua – Landcare Research, Christchurch, for the Department of Conservation (DoC). This information was related to patterns and variation in vegetation condition in order to assess the potential conservation benefits of recreational hunting. The work was done between July 1994 and March 1996.

2. Background

Recreational hunting on land administered by DoC is a legitimate recreational activity in its own right and a potential tool for controlling introduced big game species which impact on conservation values. Although DoC's primary obligation for indigenous forest ecosystems is the protection of indigenous natural resources, it also aims to foster recreational activity where this does not conflict with the former. However, the protection of conservation values typically requires low animal densities, whereas hunters generally prefer higher animal densities (Nugent & Fraser 1993; Fraser 1996a).

In order to evaluate possible options for hunting management in the Kaimanawa RHA and similar areas, the Department needs information on usage patterns and the requirements of hunters, improved information on their impact on deer populations, and an overall assessment of the conservation benefits of their recreational hunting. A review addressing the latter question in the national context is currently being prepared and will contribute to the development of a national deer management plan. Analysis of the extensive database from the Kaimanawa RHA on recreational usage complements the recreational hunting review by providing a case study of a high-use recreational hunting area. The Kaimanawa RHA was chosen because data on recreational hunting effort and success have been systematically collected since the mid 1980s. In addition, >900 deer jawbones submitted by recreational hunters during this period provide information on deer population age structure and condition. The vegetation has been previously surveyed qualitatively by Elder (1962) and quantitatively by Brabyn (1988).

The conservation benefits of recreational hunting in the Kaimanawa RHA have been assessed by comparing indices of deer density with patterns of (i) road and aerial access, (ii) track and hut facilities, (iii) forest type, (iv) browsing pressure, (v) seedling densities, and (vi) regeneration within different parts of the RHA.

3. Objectives

To assess the recreational benefits and the conservation costs/benefits provided by recreational hunting in the Kaimanawa RHA by:

- collating and reviewing all available information on recreational hunting in the RHA and examining the relationships between parameters such as seasonal and spatial hunting patterns, hunting effort and success, and deer population demography;
- re-examining the results of the 1987–88 vegetation survey in the RHA and collecting additional data on seedling densities and browsing impacts in order to relate any variation in species composition and regeneration patterns to spatial differences in hunting effort and deer densities; and
- evaluating options and strategies for the future management and enhancement of recreational hunting to provide improved conservation benefits in the RHA.

4. Methods

4.1 STUDY AREA

The 24 000-ha Kaimanawa RHA is situated c. 35 km southeast of Taupo and is one of 10 RHAs gazetted between 1980 and 1986. Topographically the RHA consists of a dissected greywacke ridge system lying between c. 500 m and c. 1400 m a.s.l. Slopes are generally relatively steep (25–35°) but there are extensive areas of relatively flat terrace country in the north. The RHA is almost completely forested, with red beech (*Nothofagus fusca*) and silver beech (*N. menziesii*) associations predominant. Some mountain beech (*N. solandri* var. *cliffortioides*) occurs in the southern part of the RHA. In the Jap Creek catchment, Fraser & Leathwick (1990, unpubl. FRI contract report) identified 8 distinct vegetation types, and our observations during this study indicated that these types can be found throughout most of the RHA.

4.2 HUNTING PATTERNS

Recreational deer hunting in the Kaimanawa RHA occurs year-round, with no restrictions on the number of permits issued or the number of hunters permitted in the RHA at any one time. The RHA is divided into 9 hunting blocks. Between 1983 and 1988 permits were issued for periods of up to 1 month and hunters were asked to report hunting effort (in days) and kills (by species). Since 1989, permits have been issued for 1 of 3 seasons (winter: June - September; summer: October - January; roar: February - May) and hunters have been asked to report hunting effort (days), sightings, and kills (by species and sex) on a standard hunting diary. Information is recorded separately for each block and for each hunting trip undertaken within the season.

The information for the period 1989–1995 (part-year only) was pooled to examine patterns and trends in hunting effort, hunting success, and harvests. The more limited information for the period 1983–1988 has also been included in some analyses. The data were used to calculate return rate (number of permits or diaries returned as a percentage of total issues), reported hunting effort, sighting rate (deer seen/day hunted), kill rate (deer killed/day hunted), and kill efficiency (kills/sighting). The indices of hunting effort used were total number of days hunted and average number of days hunted/km^2.

Total hunting effort and total number of deer killed each year were estimated by extrapolating from reported efforts and kills using the return rate. This extrapolation presupposes that hunting returns are filled in accurately and also assumes that hunting effort and success were similar for hunters who submitted hunting returns and those who did not. While hunters who do not submit returns without prompting undoubtedly kill many deer, there is some evidence of non-response bias (i.e., non-reporting hunters tend to have done less hunting: Nugent 1990a, unpubl. Landcare Research contract report; Henderson & Nugent 1989, unpubl. Forest Research Institute contract report; Fraser 1996a). The reported hunting effort and harvests therefore represent very conservative minimum estimates while the totals based on extrapolation represent maximum estimates.

4.3 DEER POPULATION DEMOGRAPHY AND CONDITION

The lower jawbones of deer have been collected since 1987 to assess deer demography and condition. Deer age was determined using the sequence of tooth eruption (for deer up to 3 years old) or by sectioning one or more mandibular molar teeth (for older deer) and counting the annual growth layers in the cementum pad (Fraser & Sweetapple 1993). Where the date of death was known, age was assessed to the nearest month using an assumed median birth date of 13 December for sika deer (Davidson 1976) and 9 December for red deer (Caughley 1971)).

The skeletal size of deer reflects the quality of their habitat (Challies 1978; Frampton & Nugent 1992). Therefore, a parameter of jawbone size, hinge length (see Fraser & Sweetapple 1993) was measured. Sex-specific growth curves based on jawbone hinge length were calculated for sika deer (n=889) using the Weibull equation which has been shown to produce a better fit for deer jawbone lengths (both hinge and heel) than several other commonly used growth curves such as the Richards, Gompertz, and von Bertalanffy curves (C. Frampton pers. comm.). Individual jawbone hinge lengths were then compared with the predicted population averages for deer of equivalent sex and age to provide an index of condition for each animal (Challies 1978; Frampton & Nugent 1992). The index was calculated as follows:

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

A condition index >1 indicates the individual is larger than the population average whereas an index <1 indicates smaller than the population average.

"Condition" is used here as a synonym for skeletal size, and the index essentially reflects environmental and habitat conditions over the period when most skeletal growth is occurring (i.e., up to c. 5 years in hinds and c. 6 years in stags). Too few red deer (n=56) were collected to determine growth curves and condition indices for that species.

Mean age and condition indices were compared between sexes, locations (hunting blocks), cohorts (year of birth), and year shot using analysis of variance (ANOVA) to test for statistical significance. Variation in the species composition between hunting blocks and the overall sex ratio of the harvest were compared using chi-square contingency tests. Variation in the harvest sex ratio between hunting blocks and between months was also tested against the overall harvest sex ratio using chi-square contingency tests.

4.4 VEGETATION SURVEYS

In 1978–79, a total of 40 permanent 20 x 20 m vegetation plots (as in Allen 1993) were established in the Kaimanawa RHA. The purpose of these plots, which were located on eight transects throughout the RHA, was to provide a baseline for comparisons of future changes in forest composition and structure over time. These plots were subsequently remeasured in 1987–88 (Brabyn 1988). We re-examined some of the results of Brabyn's (1988) survey, particularly those that related to seedling densities for plant species with different deer palatability ratings.

To assess deer impacts on regeneration patterns, the incidence of browsing on selected tree, shrub, and fern species within the browse tier (<2 m) was determined in 5 of the 9 hunting blocks. These 5 blocks were chosen to represent the range of hunting pressure (and access) and deer densities within the RHA. Within each of them, short transects following an altitude contour were established at 80–240 m altitude intervals (x = 135 m) on 2 or 3 valley-ridge lines (Fig. 1), with transects restricted to north-facing slopes to reduce potential aspect-related variation. Along each transect, 12–17 'browse plots', 2 m radius, were established at 20 m intervals. Each plot was subjectively classified into 1 of the 8 major forest types present in the Kaimanawa RHA (see Brabyn 1988; Fraser & Leathwick 1990). For each plot, a subjective cover-class score, using Bailey & Poulton's (1968) cover classes, for all woody and fern species within the browse tier (<2 m) was recorded together with an assessment of the amount of browsing (by species rather than by individual plant). Browsing impact was subjectively assessed within 2 separate tiers (<30 cm and 30–200 cm) according to the following scale:

0	none	no browsing damage visible
1	very light	browse on one or two shoots only (1%)
2	light–moderate	browse on >1% but <25% of shoots
3	moderate	browse on ≥ 25% but <50% of shoots
4	moderate–heavy	browse on ≥ 50% but <75% of shoots
5	heavy	browse on ≥ 75% of shoots

Four measures of browsing pressure ("browse indices") and a measure of deer impact on regeneration ("susceptibility rating") were calculated (Appendix 11.1) and used to compare deer impacts between plant species, vegetation types, altitude strata, and hunting blocks. The indices were calculated separately for both the browse tiers examined. Scoring browsing damage in 2 tiers enabled direct comparison of between browsing damage in the lower tier and seedling counts (see below). Furthermore, browsing damage on vegetation in the upper tier (30–200 cm) was more readily observed since small seedlings are often taken completely.

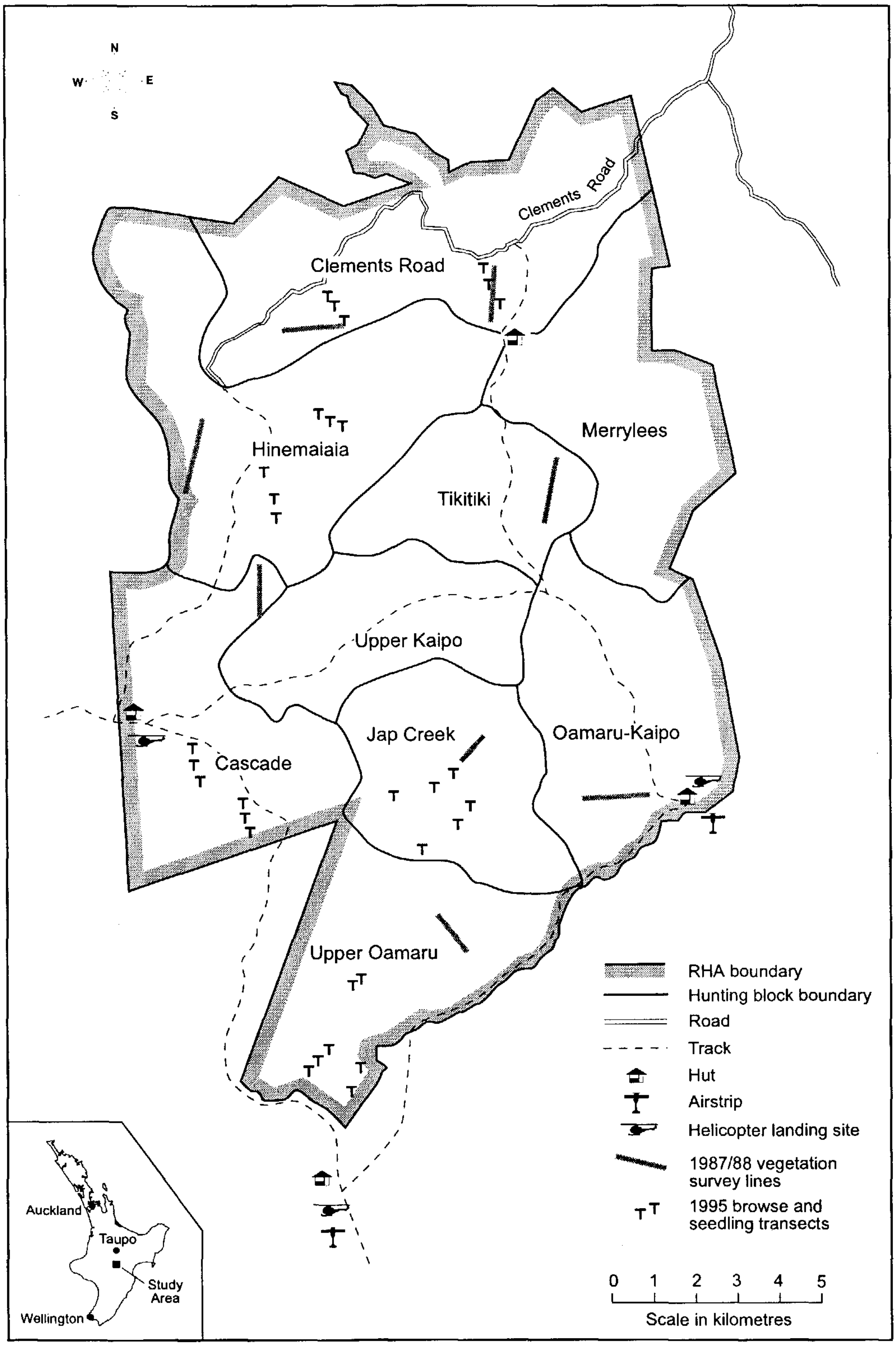

FIGURE 1: MAP OF THE KAIMANAWA RHA SHOWING THE NINE HUNTING BLOCKS, LOCATION OF THE 1987-88 VEGETATION SURVEY LINES, AND THE 1995 BROWSE AND SEEDLING TRANSECTS.

Seedling plots (0.49 m radius) were established using the same centres as for the browse plots. Counts of woody and fern species were made in the following height tiers: 0–5, 6–10, 11–20, 21–30 cm. Cover class scores by species for vegetation above the browse tier were assessed using the standard recce plot technique (Allen 1992). These assessments described the vegetation in the immediate vicinity (i.e., within c. 8 m) of each browse/seedling plot and enabled a check of the forest type classification for each plot. They also provided a semi-quantitative measure of forage availability from outside the browse tier (i.e., >2 m) and could be used as an approximate indicator of 'habitat quality'. Because deer in New Zealand forests obtain a significant part of their food as fallen leaves (e.g., Nugent & Challies 1988; Nugent 1990b; K.W. Fraser unpubl. data), the relative abundance of highly palatable species such as *Griselinia littoralis* provides only a semi-quantitative measure of food availability.

5. Results and discussion

5.1 HUNTING PATTERNS

Hunting effort

Since 1983 the total reported number of days hunted each year has varied between c. 1600 and c. 3100 (see Appendix 11.2). Over the same period the estimated total annual hunting effort has varied between c. 5200 and >10 000 days hunted. Both reported and estimated total hunting efforts were higher before 1987 than from 1987–1994. However, permit return rates were consistently lower before 1987 (19–26%, cf. 27–45% between 1987 and 1993). At very low return rates there may be some non-response bias (i.e., hunters who obtain permits but do not actually use them are less likely to return their hunter diaries than hunters who do use them). If this bias is occurring, the estimated total hunting effort (and other parameters extrapolated using return rates) before 1987 will be inflated compared with the estimates since 1987. The trend in return rates (see Appendix 11.3) suggests that from initially low levels, return rate increased considerably following the establishment of DoC but has subsequently declined. This could be a reaction by hunters to DoC policies or operations.

Since 1987 the Kaimanawa RHA has received an estimated total hunting effort of c. 6000–7000 days per year. Assuming that on average hunters spend c. 6 hours (h) hunting each day (Fraser & Sweetapple 1992), this equates to an overall hunting pressure of c. 300 h/km^2. This is much higher than the national average (c. 40 h/km^2; derived from Nugent 1992) but similar to the intensively hunted Blue Mountains RHA (c. 215 h/km^2; Nugent 1993, unpubl. Landcare Research contract report).

Seasonal variation

There is a marked peak of hunting effort in April (28% of the total annual hunting effort; Fig. 2) during the sika rutting period. Hunting effort is also slightly higher in January and May than at other times of the year, with the lowest level of hunting activity occurring over the winter period (June - August) and in February.

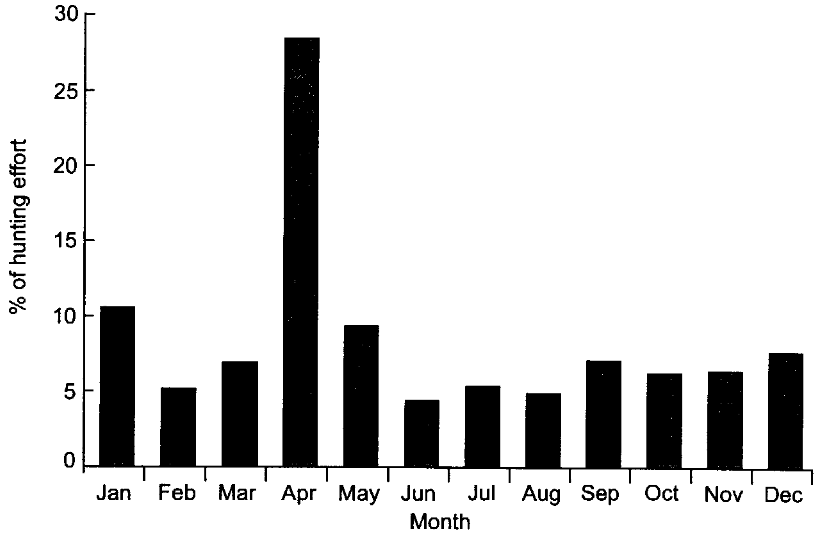

FIGURE 2: DISTRIBUTION OF HUNTING EFFORT BY MONTH IN THE KAIMANAWA RHA (1989-1995 DATA POOLED).

Geographic variation

Hunting effort varied widely between hunting blocks (Fig. 3). The Clements Road block received more than half the total reported hunting effort, whereas the Jap Creek, Upper Oamaru, and Tikitiki blocks each received ≤3% of the reported hunting effort.

Although the hunting blocks vary in size (from Tikitiki at c. 15 km ^{2} to Clements Road at c. 39 km ^{2}), this does not explain the large differences in hunting effort between blocks, as the hunting effort per unit area is still far higher for the Clements Road block than any other block (Table 1; see also Appendix 11.2). This difference mainly reflects relative ease of access, with the Clements Road block bisected by a well-maintained metal road (see Fig. 3) which provides ready access to a large amount of country and enables hunters to begin hunting immediately on leaving their vehicle. The relatively high hunting effort in the Oamaru-Kaipo and Cascade hunting blocks suggests that the presence of airstrips, helicopter landing sites, and huts is also important.

The presence of access tracks is important. However, the actual length of track within any given hunting block is probably less important in influencing the amount of hunting effort than its location in relation to preferred deer habitat. For example, on the basis of the length of track available in the Upper Oamaru block, hunting pressure might be expected to be higher (particularly when it is also considered that the Boyd but and airstrip is only c. 30 minutes walk from parts of this block). However, the track only traverses part of the eastern edge

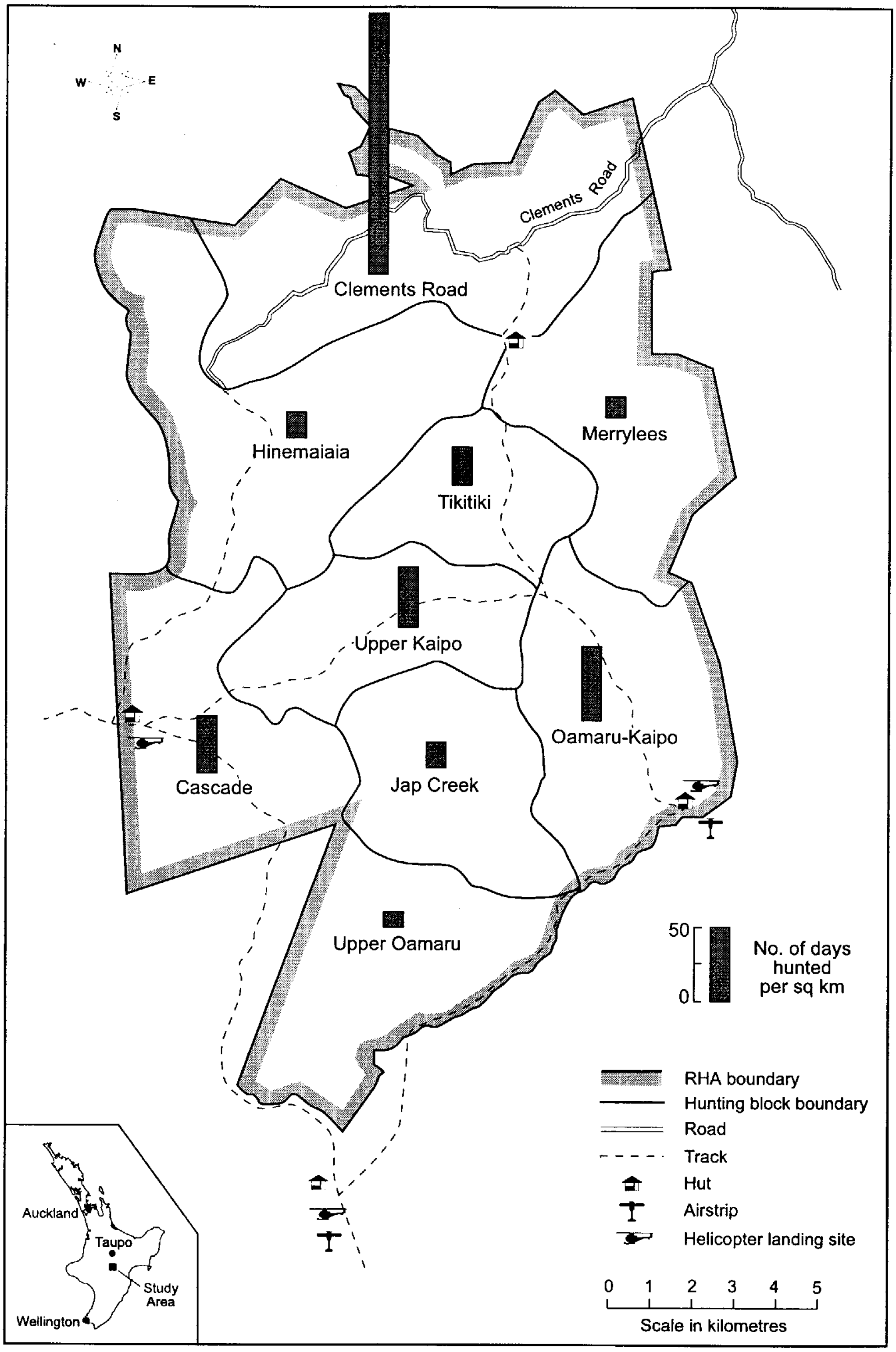

FIGURE 3: DISTRIBUTION OF HUNTING EFFORT BY HUNTING BLOCK IN THE KAIMANAWA RHA (1989-1995 DATA POOLED).

TABLE 1: COMPARISON OF THE SIZES OF HUNTING BLOCKS WITHIN THE KAIMANAWA RHA AND TOTAL REPORTED HUNTING EFFORT WITH ACCESS FEATURES AND TRACK AND HUT FACILITIES.

Hunting block	Area (km^2)	Hunting effort (hr/km^2)	Road access	Aerial access[a]	Approx. km of tracks	Hut present[b]
Clements Road	39.4	1061	Yes	-	3	Yes
Oamaru-Kaipo	27.3	301	No	H, F	7	Yes
Upper Kaipo	18.9	244	No	-	8	No
Cascade	27.5	231	No	H	12	Yes
Tikitiki	15.0	152	No	-	4	No
Merrylees	25.9	127	No	-	2	Yes
Hinemaiaia	38.9	104	No	-	6	Yes
Jap Creek	20.6	82	No	-	<1	No
Upper Oamaru	26.6	60	No	-	6	No

[a] H = helicopter landing site, F = fixed-wing airstrip

[b] within or immediately adjacent to the block

of this block and does not provide access to the preferred deer habitat at higher altitudes in the west of the Upper Oamaru block. In contrast, the upper Kaipo block, with its higher hunting effort, is bisected by a well maintained walking track that facilitates hunter access to a large area of relatively good deer habitat.

Hunting success

Geographic variation

Hunting success, as measured by sighting and kill rates, was highest in those blocks with the least hunting pressure and lowest in the blocks with the greatest hunting pressure, although the inverse relationships were not statistically significant (sighting rate vs hunting pressure: $r^2=-0.56$, $p>0.09$; kill rate vs hunting pressure: $r^2=-0.52$, $p>0.15$). By far the greatest number of deer were seen and killed in the Clements Road block, where most hunting was concentrated. However, the kill rate was highest in the Jap Creek and Upper Oamaru blocks which had the lowest hunting pressure.

Trend over time

Deer sighting rates appear to have declined slightly since 1989 when sighting data were first collected (Fig. 4). However, prior to 1989 the parameter recorded was “encounters” which do not rely on actually sighting the animal. Therefore, the apparent decline in this index may be a result of hunters gradually adjusting to recording a different parameter. When the hunter diary form was changed to specify “sightings” rather than “encounters”, the appearance of the form was similar and no real effort was made to draw hunters’ attention to the change in parameter. Alternatively, other factors such as an actual decrease in deer density, increased wariness and elusiveness of the animals due to high hunting pressure, or an overall decline in hunter skills could have contributed to the change in deer sighting rate. However, since deer kill

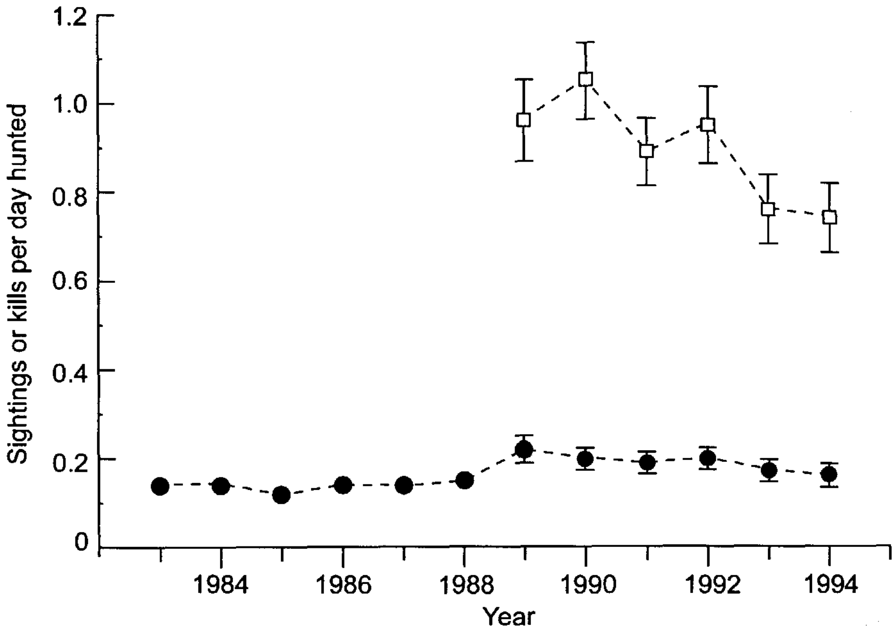

FIGURE 4: DEER SIGHTING (0) AND KILL (•) RATES (t95% CONFIDENCE LIMITS) IN THE KAIMANAWA RHA (1983-1994); PRIOR TO 1989 DEER SIGHTINGS WERE NOT RECORDED AND DATA ON THE NUMBER OF DAYS HUNTED AND DEER KILLED WERE RECORDED IN A WAY THAT DID NOT ALLOW THE CALCULATION OF CONFIDENCE LIMITS.

rates have changed little over the same period it appears unlikely that these could have contributed.

Between 1983 and 1988, reported deer kill rates were generally stable and slightly lower (0.14 deer/day; i.e., 1 deer killed for every 7.3 days hunted) than in the 1989-1994 period (0.18 deer/day; i.e., 1 deer killed for every 5.5 days hunted). However, it is unclear whether this apparent increase in hunting success is associated with a corresponding increase in deer density. Because the way hunting information was gathered was changed in 1989 (from permit returns to diaries) and because even small changes can affect the way hunters report hunting success (Nugent 1990a, unpubl. Landcare Research contract report), the data for the 2 periods are not directly comparable. Therefore, the lower kill rate before 1989 may be an artifact of sampling method. Sighting and kill rate data for the 1995 part-year were not included, as these parameters vary seasonally (Nugent 1990a, unpubl. Landcare Research contract report).

Kill efficiency

Overall, 21% of the deer seen were killed (i.e., 1 deer killed for every 4.8 deer seen), which is lower than for red deer in Pureora Conservation Park (32%; Fraser 1996a) but higher than for red deer in the Oxford RHA (16%; Henderson & Nugent 1989, unpubl. Forest Research Institute contract report). These differences in kill efficiency could be due to a number of factors, including deer species (in general sika are more elusive and difficult to hunt than red deer), hunting effort (lower in Pureora Conservation Park and markedly lower in the Oxford RHA), and deer density (markedly lower in the Oxford RHA). The differences may also reflect differences in the reporting systems (i.e., season diaries with data for each hunting trip pooled vs 1-5 day permit returns with actual hours hunted and sightings for each day reported separately).

Kill efficiency varied from 15% in June to 26% in December and, in general, was highest in the early autumn and spring periods and lowest in the winter period. Kill efficiency also varied between hunting blocks, with the Tikitiki block having the lowest (18%) and the Oamaru-Kaipo block having the highest values (30%; Fig. 5). Habitat factors, such as density of cover at ground level affect visibility and almost certainly influence hunting efficiency. For example, the high kill efficiency in the Oamaru-Kaipo block probably ref-lects the extensive areas of open grassland present in this block (but not elsewhere in the RHA).

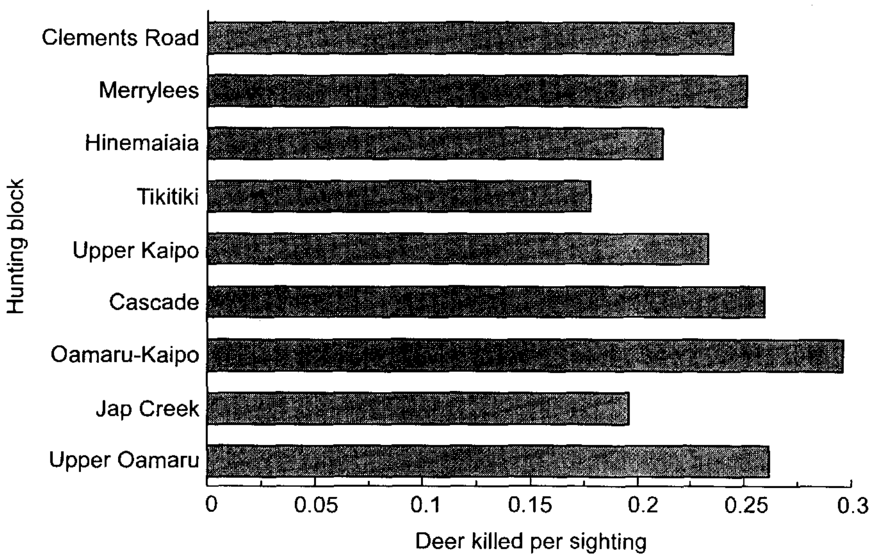

FIGURE 5: VARIATION IN KILL EFFICIENCY (RATIO OF DEER KILLED PER DEER SEEN) BETWEEN HUNTING BLOCKS IN THE KAIMANAWA RHA (1989-1995).

5.2 DEER POPULATION DEMOGRAPHY AND CONDITION

Species mix

The species mix of the recreational hunting harvest is assumed to reflect the actual species mix within the deer population in the Kaimanawa RHA, although this may slightly overestimate the proportion of red deer since they are less elusive and easier to hunt than sika deer. Since 1987, red deer have constituted c. 6% of the total harvest, with general agreement between data from hunter diaries and from jawbone collections (Table 2). Kills recorded as hybrids on hunter diaries constitute <1% of the total reported harvest and <2% of jawbones collected, and these have been excluded from Table 2.

The sika:red deer kill ratio in the Kaimanawa RHA appears to be relatively stable. In the adjacent Kaweka Conservation Park, sika deer have been steadily replacing red deer, although red deer still constituted approximately 30% of the total harvest in 1987-88 (Davidson & Fraser 1991). Sika deer are better adapted to digest poorer quality forage than red deer because of their different rumen morphology (Hofmann 1982; Fraser 1996b) and this may provide them with a

TABLE 2: THE NUMBERS OF SIKA DEER AND RED DEER SHOT, AND PERCENTAGE OF THE TOTAL HARVEST THAT WERE RED DEER, FROM RECREATIONAL HUNTER DIARIES AND DEER JAWBONE COLLECTIONS, 1987-1995.

Year	Hunter diaries			Jawbone collections		
	Sika deer	Red deer	% red deer	Sika deer	Red deer	% red deer
1987	401	33	7.6	37	3	7.5
1988	340	12	3.4	111	8	6.7
1989	385	34	8.1	151	11	6.8
1990	370	20	5.1	179	6	3.2
1991	398	25	5.9	147	7	4.5
1992	318	27	7.8	132	14	10.3
1993	308	8	2.5	67	1	1.5
1994	223	20	8.2	52	3	5.5
1995[a]	90	1	1.1	21	1	4.6
Total	2833	180	6.4	897	54	6.0

[a] part-year only

competitive advantage, particularly in the forage-limited habitats of the central North Island mountain ranges.

Geographic variation

There is a marked spatial variation in the species mix, with the proportion of red deer killed in the Cascade hunting block significantly greater than for all other hunting blocks in the Kaimanawa RHA (x`=34.3, p<0.001; Fig. 6). Both the Cascade and the Upper Oamaru (with the next highest proportion of red deer) hunting blocks are adjacent to extensive areas of open grassland habitat which appears to be favoured more by red deer.

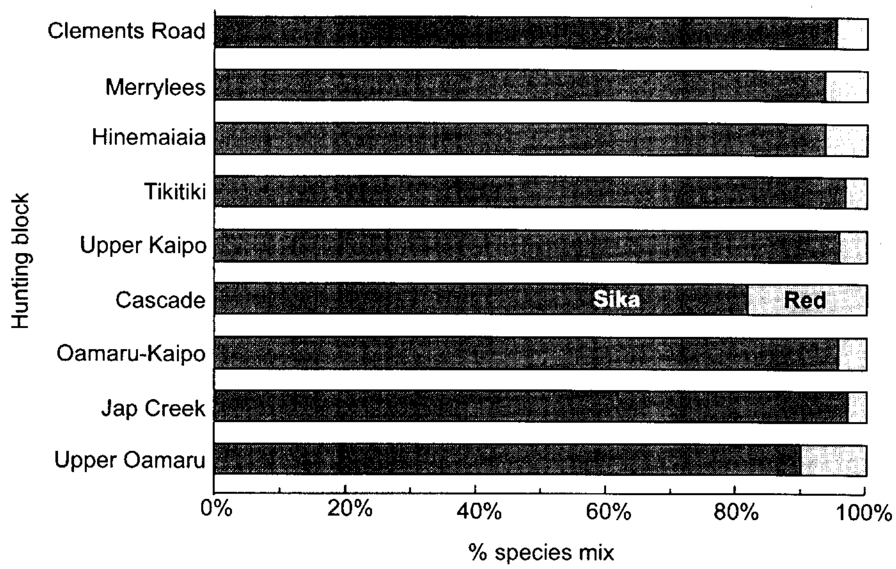

FIGURE 6: VARIATION IN SPECIES MIX BETWEEN THE NINE HUNTING BLOCKS IN THE KAIMANAWA RHA (ALL DATA FROM 1989-1995 POOLED; PUTATIVE HYBRIDS HAVE BEEN OMITTED FROM THIS ANALYSIS).

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