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EFFECTS OF COMMERCIAL HUNTING ON RED DEER DENSITIES IN THE ARAWATA VALLEY, SOUTH WESTLAND, 1972-76

C. N. CHALLIES

Protection Forestry Division, Forest Research Institute,
New Zealand Forest Service, Christchurch

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ABSTRACT

This paper describes the recent changes in density and local distribution of the commercially hunted red deer population in the lower Arawata Valley, South Westland. It is based on five annual (1972 to 1976) remeasurements of 986 permanently marked pellet sample points representing all of the forested and subalpine parts of the deer range. The study area was divided into five altitude-vegetation strata in the analysis.

There was an average reduction in pellet group density of 11.2% of the surviving population per annum, and a total reduction of 38% for the four years. Densities were reduced at different rates in the five strata. The largest changes occurred in the sub-alpine scrub and grassland (by 28.3% per annum), where deer are most vulnerable to helicopter hunting, and on the adjacent forested upper valley slopes (by 13.8% per annum). Reductions on the forested valley flats and slopes below 600 m were much smaller (averaged 4.9% per annum), and together contributed only 37% of the total. In 1976, pellet densities ranged from 40 groups/ha in the subalpine scrub and grassland to 302 groups/ha in the forested lower valley slopes.

The overall reduction in deer numbers attributable to commercial hunting in the Arawata Valley was around 72% since 1969, and in the order of 80 to 95% since the start of helicopter hunting in the mid-1960s.

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INTRODUCTION

In March 1969 a group of pellet-sampling lines was established in the lower Arawata Valley, South Westland, to monitor the long-term impact of commercial hunting on the density and local distribution of the red deer (*Cervus elaphus* L.) population. The lines have been remeasured in the same month each year since 1969 and results of the first four measurements (i.e., 1969 to 1972) were summarised by Challies (1973). This report describes the changes in pellet group densities that have occurred in this area during the 4 years 1972 to 1976.

The Arawata Valley is a forested mountainous area typical of much of the Westland and Fiordland high country. It is characterised by deep, steep-sided valleys ranging in altitude from 50 m on the valley floor up to 1500 to 2000 m on the major ridges. The valley slopes are forested from the river flats up to the subalpine scrub zone at around 1000 m. Silver beech (*Nothofagus menziesii* (Hook f.) Oerst.) is the main canopy species often mixed with rimu (*Dacrydium cupressinum* Lamb.) or red beech (*Nothofagus fusca* (Hook f.) Oerst.) on the lower slopes (Wardle *et al.* 1973). The subalpine scrub belt is generally narrow and rarely exceeds 50 m in depth. Above this are areas of tussock grassland composed mainly of *Chionochloa pallens* Zot. at lower levels and *C. crassiuscula* (T. Kirk) Zot. on the higher slopes up to 1500 m.

The commercial hunting of red deer in the Arawata Valley has been amongst the most sustained and intensive (on a "hunting-effort-per-unit-area basis") of any in the South Island. This has been particularly so for the helicopter operations, which have accounted for around 76% of the deer killed commercially in this district (Challies, unpubl.). Helicopter crews have worked the open subalpine vegetation, and the larger hillside clearings and swamps, continuously since the summer 1964-65 (Challies, 1974). During the last 4 years, between two and six crews have operated in South Westland, several of them on a semi-permanent basis. Their combined hunting efforts have equalled the equivalent of the year-round operation of one general-purpose light helicopter (e.g., Hiller 12E) per 50 000 ha of forest.

All of the suitable grassed valley flats have been hunted by shooters on foot each summer from the early 1960s until 1974-75. Many of these operations have since been phased out because of a combination of reduced tallies, increased costs of transport, and the restrictions imposed by The Game Regulations 1975/174. During the last 3 years helicopter crews have extended their hunting areas to include the valley flats. Ground hunters on the lower Arawata Valley flats now have to compete directly with these operations for their animals.

METHODS AND MATERIALS

This study is based on observations from 986 permanently marked pellet-sample points. These plots are distributed at 25-m intervals along nine lines sited on the east side of the lower Arawata Valley on either side of the Waipara River confluence. Each line follows a compass bearing from the lower forest edge directly up the forested valley slope; the altitude of the lines vary, some reaching as high as 1300 m a.s.l. in the subalpine grassland (Fig. 1).

The point-distance nearest-neighbour distances method (Batcheler, 1973; 1975) was used to estimate the densities of deer pellet groups comprising six or more complete

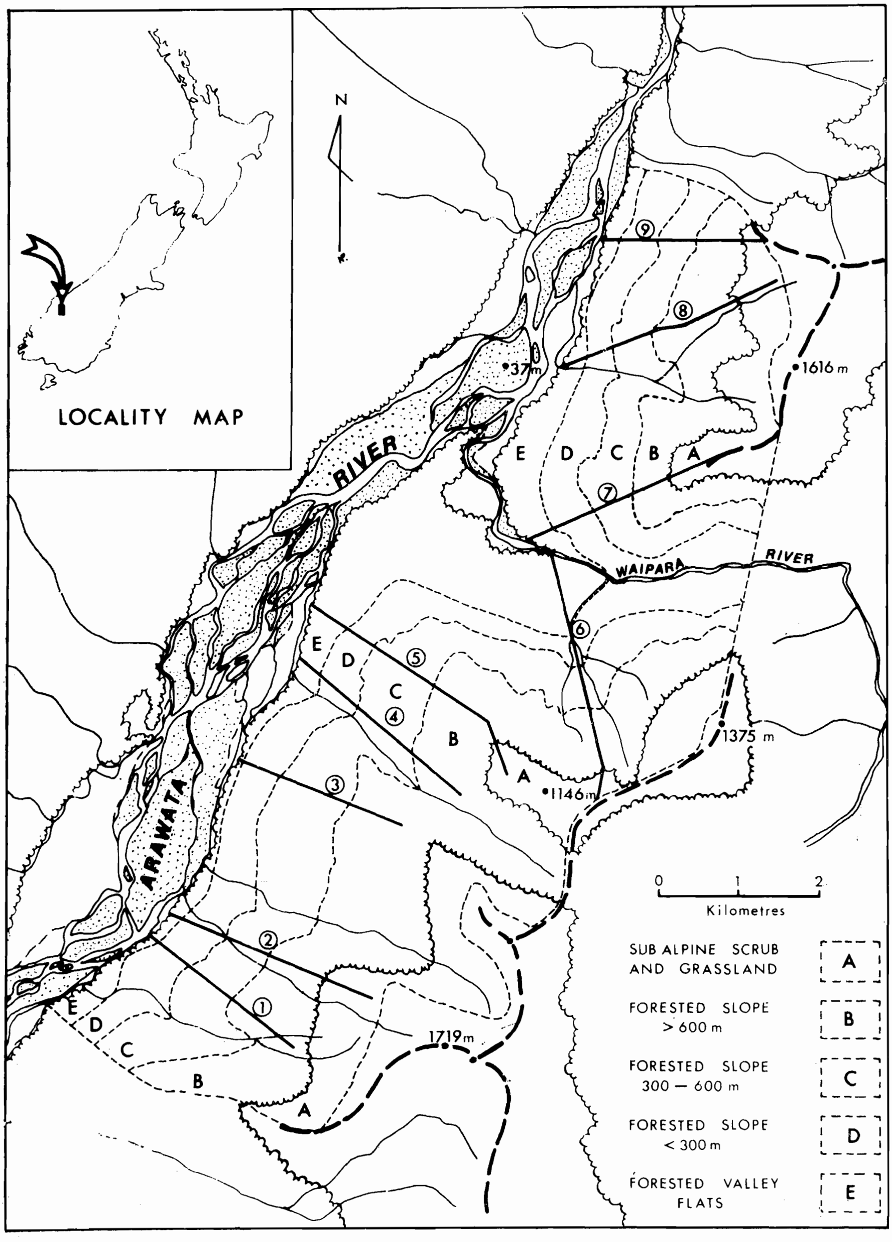

FIG. 1—Map of the study area showing the location of the nine pellet lines and the areas comprising each of the five strata.

pellets. Each plot was searched in each survey, and the point-distance and first neighbour measurements within a radius of 3 m were recorded. These data were analysed with the aid of the computer program written by Spurr *et al.* (1976); the N/P = 0.5 values were accepted as the best estimates.

On preselected lines, all of the pellet groups found in each survey were marked with wooden pegs and examined during the following survey to estimate the disappearance rate over the interval. The results are presented as groups/group/day in Table 1A.

TABLE 1—Mean pellet group disappearance rates for years and strata

A. Rates for years-strata combined

Years of measurement	No. groups marked (k1)	No. groups surviving (k2)	Time interval in days (t2-t1)	Disappearance rate in groups/group/ day (C)*
1971-72	209	32	374	0.00502
1972-73	644	109	361	0.00492
1973-74	623	89	369	0.00527
1974-75	421	46	365	0.00607
1975-76	373	56	364	0.00521

B. Rates for strata-years combined

Strata	No. groups marked (k1)	No. groups surviving (k2)	Time interval in days (t2-t1)	Disappearance rate in groups/group/ day (C)*
A	176	47	366	0.00361
B	416	56	366	0.00548
C	728	103	366	0.00534
D	607	91	366	0.00519
E	343	35	366	0.00624

* Calculated from the formula $C = \frac{\text{Log}_e\ (k1/k2)}{t2\text{-}t1}$

The estimates of pellet group density have been corrected for these differences by multiplying them by the disappearance rate for the preceding year, then dividing them by the mean of the rates for the 5 years.

The study area is divided into five strata: subalpine scrub and grassland combined; the forested valley slope over 600 m; 300 to 600 m; under 300 m; and the forested valley flats. Table 2 gives the number and the percentage of the pellet sample points in each stratum, and the proportional plan area of each stratum calculated from Fig. 1. The pellet group densities estimated for each stratum have been corrected for between-strata differences in group disappearance rate (Table 1B) by the same method used to correct for between-years differences.

These corrected density-estimates are directly comparable one with another, and are proportional to the number of deer units using an area during the few months prior to the survey concerned.

TABLE 2—Numbers of pellet count plots sited in each stratum, and the proportional area of the strata

Strata		Pellet count plots Number	Percentage	Percentage of "study area"*
A	Subalpine scrub and grass	92	9	15
B	Forested upper slopes	248	25	32
C	Forested mid slopes	301	31	24
D	Forested lower slopes	207	21	14
E	Forested valley flats	138	14	15
		986	100	100

* Plan area between the lower forest edge and 1300 m a.s.l.

RESULTS

The calculated and corrected pellet-group density and probable limits of error estimated for each stratum from the results of each survey are presented in Table 3. Data for the nine pellet lines are pooled. The calculated limits of error (%) are assumed to apply equally to the corrected values.

A mean pellet-group density for the whole study area was calculated for each survey by weighting the corrected density for each stratum by the relative area of that stratum (from Table 2). These estimates are presented in Fig. 2 fitted with a linear regression on a semilog transformation (reduction of residual sum-of-squares cf. the comparable arithmetic fit is 484 to 303). This curve shows that the change in density approximates a constant proportion of the population present. The limits shown are the probable limits of error for the combined data for each survey (from Table 3). These are probably wider than the true P = 0.05 limits because the variance of a population mean is usually reduced by stratification.

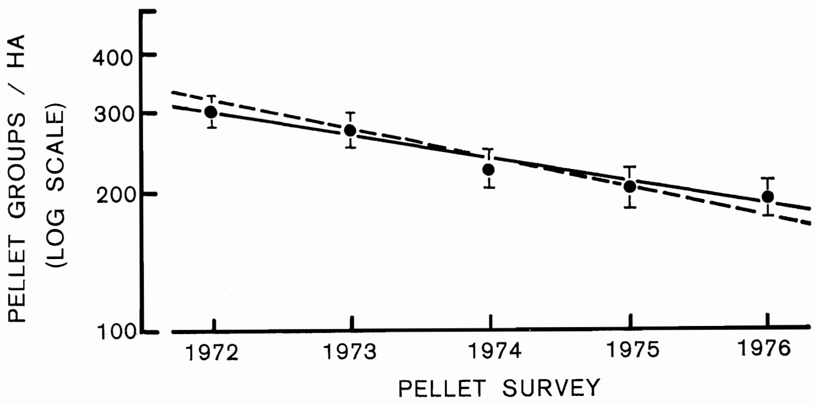

FIG. 2—Mean pellet group densities for the five surveys, regressed on a logarithmic scale. These estimates were calculated by weighting the "corrected" densities for each stratum by the relative area of that stratum.

TABLE 3—Calculated and corrected pellet group densities and limits of error for each stratum in each survey

Year of survey	Strata	Calculated* Density in groups/ha	Calculated* Limits of error (%)	Corrected† Density in groups/ha	Corrected† Limits of error in groups/ha
1972	A	285	± 25.0	189	± 47
	B	285	± 19.5	286	± 56
	C	272	± 13.1	266	± 35
	D	381	± 15.5	362	± 56
	E	399	± 23.2	456	± 106
	Combined	308	± 8.0	292	± 23
1973	A	208	± 35.5	135	± 48
	B	222	± 14.5	218	± 32
	C	324	± 15.0	311	± 47
	D	430	± 21.4	401	± 86
	E	315	± 22.1	352	± 78
	Combined	292	± 8.5	271	± 23
1974	A	108	± 32.9	75	± 25
	B	243	± 21.3	257	± 55
	C	231	± 16.5	238	± 39
	D	276	± 21.4	275	± 59
	E	198	± 20.1	238	± 48
	Combined	222	± 9.7	221	± 21
1975	A	50	± 71.7	40	± 29
	B	106	± 17.9	128	± 23
	C	236	± 17.9	279	± 50
	D	313	± 22.4	359	± 80
	E	195	± 25.4	269	± 68
	Combined	188	± 10.5	215	± 23
1976	A	56	± 24.7	38	± 9
	B	137	± 26.3	143	± 38
	C	208	± 14.3	211	± 30
	D	287	± 17.0	283	± 48
	E	296	± 22.7	351	± 80
	Combined	197	± 9.0	194	± 18

* These figures are the N/P = 0.5 values calculated with the computer program of Spurr **et al.** (1976).

† These figures are the calculated values corrected for differences in pellet group disappearance rates between years and between strata (Table 1A and 1B)

The overall reduction in pellet group density calculated from Fig. 2 averaged 11.2% per annum and totalled 38% for the 4 years. This estimate should be more accurate than the reduction of 14.2% per annum obtained by weighting the decrements for the individual strata (see Fig. 3); the two estimates are unlikely to be significantly different. A geometric decrement of 14.2% per annum is shown as a broken line in Fig. 2.

The five estimates for each stratum are plotted separately in Fig. 3 fitted with linear

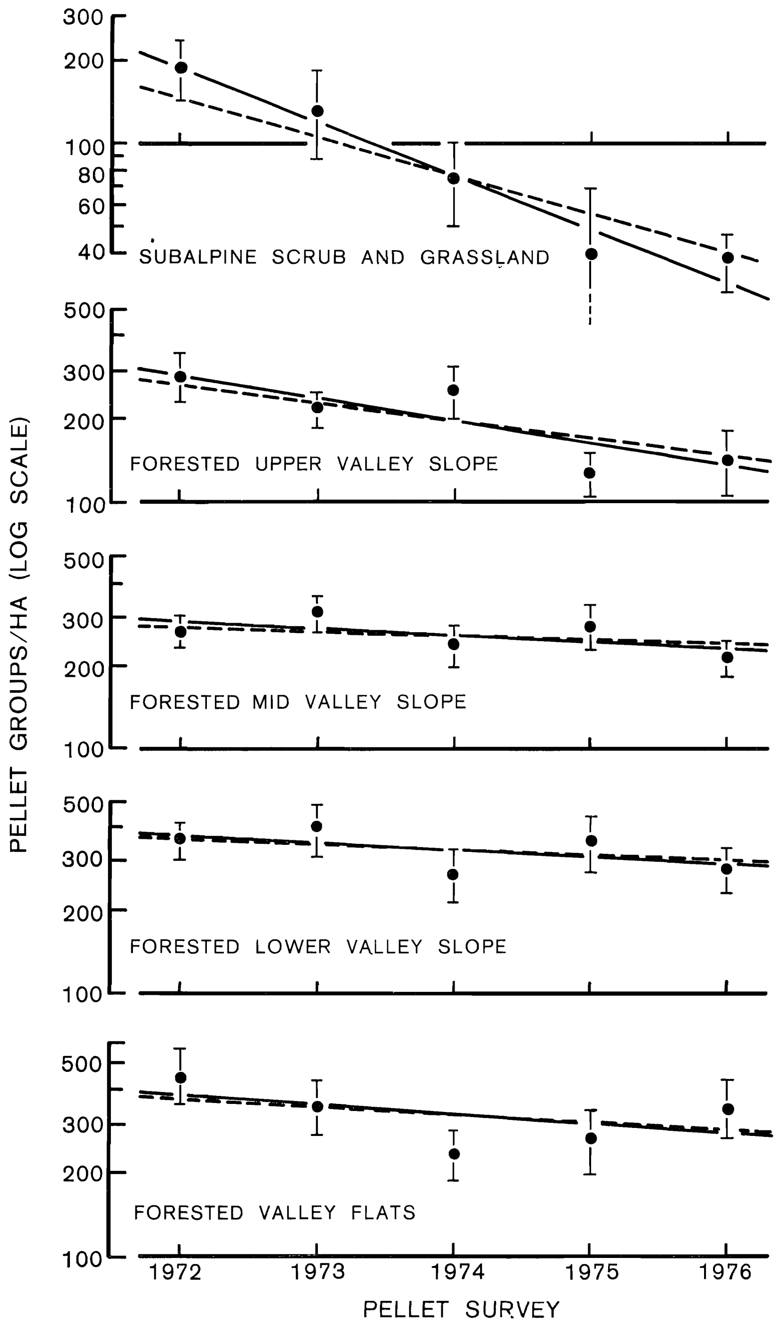

FIG. 3—The five corrected pellet-group-density estimates for each stratum regressed separately on logarithmic scales.

regressions on semilog transformations. This form of curve fits the data for most of the strata reasonably well, as would be expected from the combined-strata result (Fig. 2). The main exception is the forested valley flats where pellet group densities appear to have increased from 1974 to 1976. When the five strata are considered together, the goodness-of-fit of the geometric and comparable arithmetic curves are similar. The figures used subsequently have been calculated by multiplying the geometric decrements of the curves fitted in Fig. 3 by 0.78 (i.e., 11.2/14.2) to reduce them pro rata to the equivalent of an overall reduction of 11.2% per annum. Regression lines for the adjusted decrements are shown as broken lines in Fig. 3.

Table 4 gives a comparison of the recent changes in pellet group densities in the five strata. By far the largest reduction occurred in the areas of short subalpine vegetation where deer are most vulnerable to helicopter hunting. There was also a substantial reduction on the adjacent forested upper valley slopes whence the deer have easy access into the subalpine zone. Densities declined 74% in the subalpine zone and 36% on the forested upper slopes in the 4 years 1972 to 1976. By comparison, the three forested strata furthest from the timber line all sustained relatively small reductions, averaging only 4.9% per annum and totalling only 18% for the 4 years (calculated by weighting the decrements in Table 4 by the relative stratum areas from Table 2).

The percentage of the total reduction in pellet group density attributable to each stratum is given in Table 4. These figures are equivalent to the proportions of the total kill contributed either directly by hunting in that stratum, or indirectly by animals moving from the stratum and replacing losses in another. Nearly two-thirds of the total reduction was incurred in the subalpine zone and the forested upper valley slopes, as would have been expected from their high rates of reduction and their relatively large combined area. The low percentage reductions on the three lower-altitude strata have been partly off-set by their high initial densities, and together they contributed 37% of the total. As there was little hunting within these lower strata, most of the reduction must have resulted from animals moving either further up the valley slope, or out on to the grassed valley flats where they would have been killed.

The density of pellet groups in each stratum in March 1976 is given in Table 5.

TABLE 4—The reduction in pellet group density per year in each stratum, and the percentage of the total reduction contributed by each stratum

Strata	Mean annual reduction in density (%)	Distribution of total reduction per unit area (%)	Distribution of total reduction per stratum (%)
A Subalpine scrub and grass	28.3	27	19
B Forested upper slopes	13.8	28	44
C Forested mid slopes	4.4	11	13
D Forested lower slopes	4.6	15	10
E Forested valley flats	6.0	19	14
		100	100

TABLE 5—The density of pellet groups/ha in each stratum in 1976, and the percentage of the total contributed by each stratum

Strata	Pellet density groups/ha	Distribution of densities per unit area (%)	per stratum (%)
A Subalpine scrub and grass	40	4	3
B Forested upper slopes	146	15	24
C Forested mid slopes	236	23	28
D Forested lower slopes	302	30	22
E Forested valley flats	287	28	23
		100	100

These values were estimated from the adjusted curves in Fig. 3; all fall within the probable limits of error obtained from the 1976 survey data (Table 3). They show a pronounced decrease in density up the valley slope, as would be expected from the pattern of reductions shown in Table 4. Weighting these densities by their relative stratum areas shows, however, that the four forested strata are now each supporting a similar number of animals (on a per stratum basis). Deer are currently making very little use of the subalpine zone.

Histograms of the pellet group densities per stratum for 1972 and 1976 are presented in Fig. 4 along with a comparable diagram for 1969 (Challies, 1973. Note: the figures used have been adjusted for differences in "pellet-group-disappearance rates" between years). This figure shows diagramatically the reductions in densities detailed in Table 4 (cf. 1972 and 1976), and the residual densities detailed in Table 4 (i.e., 1976). The three histograms represent progressive stages in the evolution of the present altitudinal distribution of pellet groups.

The reduction in pellet group density during the 7 years 1969 to 1976 was of the order of 72%. All of the strata made significant contributions to this total.

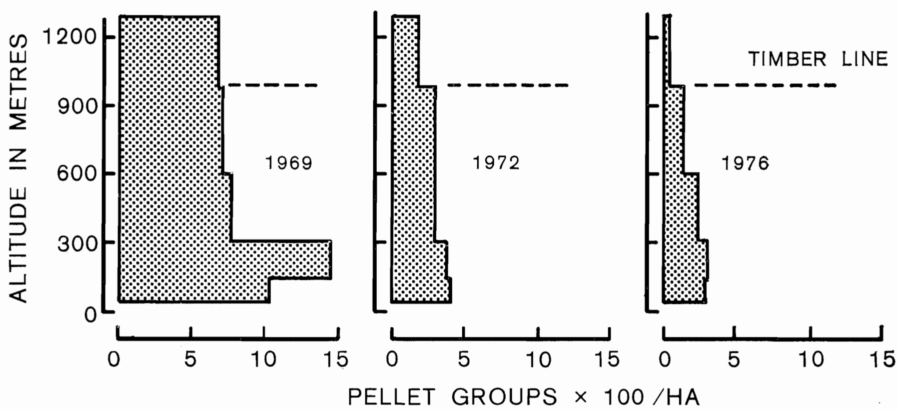

FIG. 4—Histograms of pellet group densities per stratum for 1969, 1972, and 1976. The densities for 1972 and 1976 were obtained from the curves fitted in Fig. 3.

DISCUSSION

The lower Arawata Valley was originally chosen for this study because it represented a potentially difficult type of situation in which to control deer numbers. The study area has extensive forested valley slopes 900 m in altitude with few mid-slope clearings and a relatively low ratio of open subalpine vegetation to forest (1.0 : 5.5 below 1300 m a.s.l.). Deer had been established in the area about 15 years when commercial hunting started, and they were still in good physical condition and had not modified their habitat much (Wardle *et al.,* 1973). The changes in density recorded in this study are likely, therefore, to be conservative compared with those that have resulted in other areas with similar hunting history. The Arawata Valley now provides some of the most productive helicopter-hunting in South Westland.

The overall reduction in deer numbers in the study area is not known, but appears to be in the order of 80 to 95% up to 1976. The large herds of deer seen in previous years had been virtually eliminated by commercial hunting before this study was initiated (M. T. Bennett, pers. comm.). From a visit to the adjacent Waiatoto and Turnbull Valleys in May 1968, C. L. Batcheler (pers. comm.) concluded that deer numbers in these areas may have already been reduced by as much as 80%. Red deer have been established in these valleys about 10 years longer on average than in the study area and were probably initially at higher densities. A further reduction of 72% between 1969 and 1976 (this study) on densities that had already been reduced by say 25, 50, or 75% from their pre-commercial-hunting levels, would give an overall reduction up to 1976 of 81, 86, or 93%, respectively.

Commercial hunting has not yet however established an equilibrium between the density and distribution of the surviving population of deer, and the economic level of carcass recovery. Deer numbers in the study area have continued to decline after 11 years of competitive helicopter hunting and 15 years of ground hunting. The rate of decrease in pellet group densities slowed between 1969 and 1972 (Challies, 1973), but appears to have remained nearly constant since then at around 11% annually of the surviving population. Now that deer have been almost eliminated from the subalpine scrub and grassland, and greatly reduced in numbers on the forested upper valley slopes, it seems unlikely that this pattern of decrease can continue for much longer. These two zones together contributed the majority of the deer killed between 1972 and 1976.

The changes in deer behaviour resulting from this sustained commercial hunting are little known. It is obvious to the hunters that at least some animals have become conditioned and now either move into cover at the sound of an aircraft or venture into the open only at night. The numbers of deer successfully avoiding the helicopter crews by these means were insufficient to stem the recent rapid decline in deer use around the timber line. There was however an apparent increase in pellet group density on the forested valley flats between 1974 and 1976, the period during which helicopter hunting on the adjacent grassed flats increased at the expense of the ground hunting. This part of the data should however be interpreted with caution until further measurements have been made.

Although these results auger well for the longer-term value of helicopter hunting as a means of deer control, they will not give the game meat industry much confidence if their intention is to continue hunting under the present highly competitive conditions. Since 1974 even the most experienced helicopter crews in South Westland have been barely able to maintain an average kill of 2½ deer per machine hour, or 200 deer per month, for the whole of the summer. This level of production is around half that obtained in 1970, and less than one-quarter that obtained during 1966-67 when helicopter hunting was in its heyday (Challies, unpubl. data).

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