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Rates of defecation of black-tailed deer in the Tillamook Burn of western Oregon were estimated using counts of groups of fecal pellets in 1959 and 1960. A 340-acre enclosure was divided into eight range types on the basis of depth of soil, aspect, and elevation. The estimated rates of defecation were used to calculate the density of deer for each range type. A total of 285 plots, each 100 square feet in area, were cleared and checked in March-April 1959, May-August 1959, and February-March 1960. Calculated rates of defecation varied from 22.0 to 23.9 groups of pellets per day which were substantially higher than rates previously reported. Accuracy of finding groups of fecal pellets varied with seasonal changes in vegetative cover with the most accurate counts occurring during the winter and early spring. The density calculations indicated the deer preferred southeast facing slopes and areas of deep soil.

Pellet Counts as a Census and Range-Use Technique for Columbia Black-Tailed Deer

by

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PELLET COUNTS AS A CENSUS AND RANGE-USE TECHNIQUE FOR COLUMBIA BLACK-TAILED DEER

INTRODUCTION

This is a report of an investigation to determine the feasibility of using counts of groups of fecal pellets to estimate number of black-tailed deer, Odocoileus hemionus columbianus (Richardson), in western Oregon. The use of counts of groups of fecal pellets of deer to obtain indices to range use was also studied. The study was part of an Oregon State Game Commission program to determine which method of enumerating black-tailed deer was most appropriate for use in Oregon.

The technique of using counts of groups of fecal pellets as indices to numbers of deer was first described by Bennett et al. (1940). Rasmussen and Doman (1943) reported that counts of groups of fecal pellets could be used to estimate number of mule deer, O. h. hemionus (Rafinesque), in Utah. Dasmann and Tabor (1955) compared counts of groups of fecal pellets with other methods of censusing black-tailed deer in chaparral communities in California and concluded that the technique would have wide application if a reliable average daily rate of pellet deposition could be obtained.

Observations on both northern white-tailed, O. virginianus borealis Miller, and mule deer indicated that these deer defecate

about 13 groups of fecal pellets daily (Rasmussen and Doman, 1943; McCain, 1948; Eberhardt and Van Etten, 1956). Rogers et al. (1958), however, obtained an average defecation rate of 15 groups per day in a study of fenced mule deer. Dasmann and Taber (1955) found that the defecation rate of black-tailed deer varied from 10 to 17 groups per day depending on their diet.

METHODS

My study area was a 340-acre plot enclosed by an 8-foot deer-proof fence. The enclosure was located in the Cedar Creek drainage on a tributary of the Wilson River about 18 miles inland from Tillamook and 60 miles west of Portland. The general area is known as the Tillamook Burn. There have been three major fires in the area. The first fire, in 1933, burned 244, 700 acres (Morris, 1936). The second fire, in 1939, and the third fire, in 1945, destroyed most of the same area. The later fires increased the total acreage to 360, 000 acres by extending the boundaries in several places (Neiland, 1958). The Tillamook Burn study area was originally constructed to enclose an area where the relationship of density of deer to conifer survival could be examined under controlled conditions (Hines, 1964).

Field studies were conducted from July 1958 to April 1960. The enclosure contained a population of 43 deer from January to May of 1959. Fawns dropped in May and June of 1959 were not used in the May - August calculations. It was felt that the fawns would not contribute to the counts of pellet groups because they are not weaned until 3 to 5 months of age (Taylor, 1956). During the first two months of the lactiferous period, fawns do not excrete characteristic pellets. During the latter part of this period, small pellets are excreted. We had observed pellet groups of fawns in pens and felt we could identify

these groups of small pellets in the field. One adult mortality occurred during the last week of June 1959 reducing the number of deer used in the calculation to 42. During the fall of 1959, the population was reduced to 15 deer by removing 32 of the original residents and introducing 5 deer from the area outside the enclosure. These 15 deer remained in the enclosure during the remainder of my study.

Counts of Fecal Pellets

The sample plots for this study were in the form of strips 2-feet wide by 50-feet long. All of the strip plots ran perpendicular to the contour of the terrain to increase altitudinal dispersion.

Placement of Plots

The enclosure was divided into eight range types on the basis of factors of depth of soil, aspect, and elevation. Each of these factors was divided into two categories: depth of soil (a) shallow, $<$18 inches, (b) deep, $>$18 inches; aspect (a) SE, 45 - 225°, (b) NW, 225 - 45°; and, elevation (a) low, 800 - 1, 400 feet, (b) high, 1, 400 - 2, 000 feet. This division resulted in four range types below 1, 400 feet: southeast deep and shallow; northwest deep and shallow. These were complemented by four range types above 1, 400 feet (Figure 1).

Locations for 300 strip plots were selected randomly. The per-

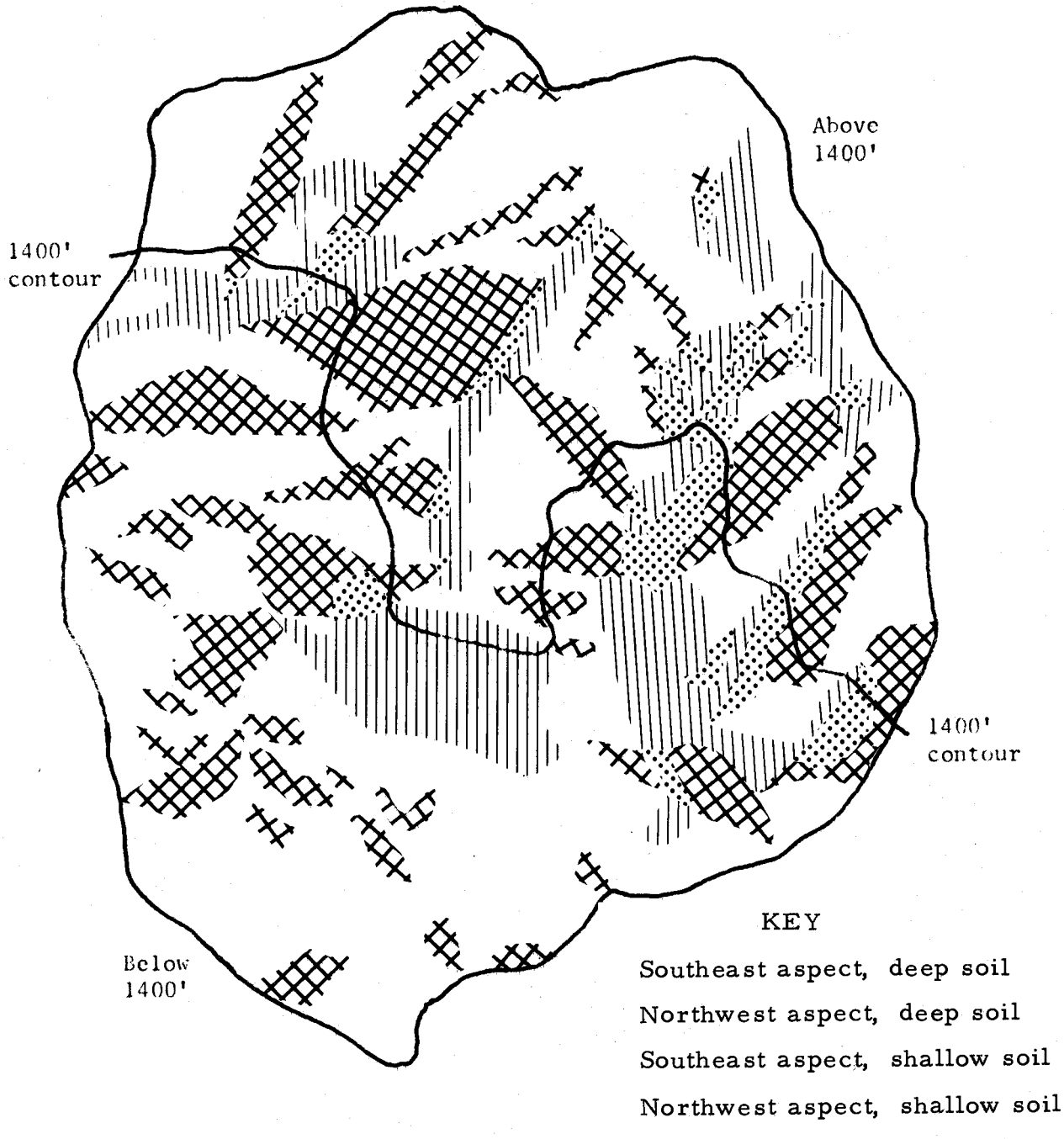

Figure 1. Map of the Tillamook Burn enclosure showing division into eight range types on the basis of depth of soil, aspect, and elevation.

centage of area covered by each type of range determined the number of plots that were established in that range. The locations were plotted on aerial photographs and the plots were established in January and February 1959. The plots were permanently located by marking each end with a cedar post. Each plot was cleared of all fecal pellets. Due to the ruggedness of the terrain, 15 plots could not be established.

Methods of Counting Pellets

Based on experience gained during the establishment of the plots, I decided that one investigator could survey a minimum of 20 plots in one day, even under conditions of heavy rain or snow.

The 285 plots were divided into 14 subgroups of approximately 20 plots each. The borders of the subgroups were described with both cross-sectioning of the types of range and ease of checking in mind. One unit of seven subgroups was assigned to the resident research biologist and I checked the remaining subgroups. The order in which the seven subgroups were checked was taken from a table of random numbers. Examination of the entire area required 4 to 6 days depending on weather and season.

Upon reaching the sample plot, a plastic clothesline was attached to the posts to provide a guideline down the center of the plot (Figure 2). The investigator would then proceed along the line from the lower

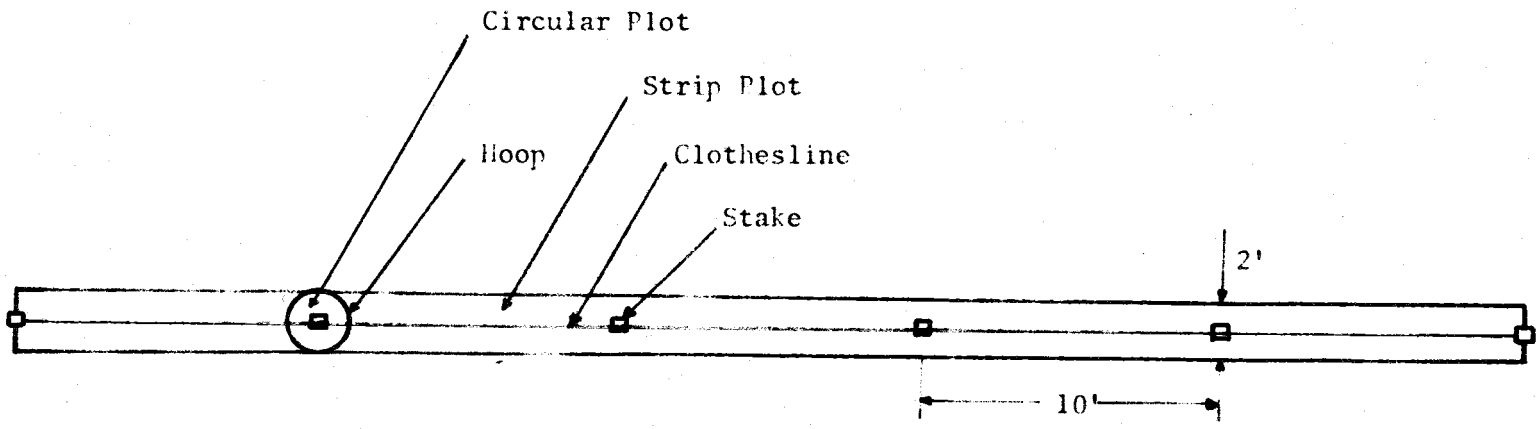

Figure 2. Diagram of the layout of the strip plots used in determining black-tailed deer defecation rates and of the circular plots used in determining the percentage of vegetation covering the area.

end to the upper end of the plot. The following data were recorded for each plot: plot number; time at start and finish of count; number of groups of fecal pellets; type of group (a full group had more than half the group in the plot, a partial group had less than half the group in the plot). Only full groups were utilized in the determination of defecation rates. The use of partial groups would have, in effect, widened the sample plot. During the establishment of the plots, it was noted that groups of fecal pellets numbered 20 or more individual pellets. As a result of this, an arbitrary level of five pellets was chosen as the minimum level to be counted as a group. All fecal pellets were cleared from the plot during each count.

Seasonal Accuracy Counts

Counts were made to ascertain the accuracy of the investigator and consequently the method. Accuracy was defined as the level of success the investigator had in finding all groups of pellets the first time through the plot. These counts involved 10 to 30 plots. They were made during all four seasons of the year to see if there were temporal changes in the level of accuracy. Each plot was checked in the usual manner removing pellets as groups were counted. The plot was then rechecked by the complete removal of all vegetation more than 1 inch above ground level. Large pieces of material, such as leaves and bark, were also removed even if they were below the

1-inch level. The number of groups of pellets found and the time spent making the check count were recorded.

Changes in Density of Cover

During the course of the study, seasonal changes in the amount of vegetation interfered with the sighting of pellet groups and influenced the accuracy of the counts. To determine the change in the density of vegetation and litter by season, six circular plots, 2 feet in diameter, were superimposed on each of the 285 strip plots (Figure 2). This gave a total of 1, 710 density plots. The center of each circular plot was marked with a small cedar stake. A plastic hoop of proper diameter was used to delineate the border of the plot. This provided a rapid and portable method of denoting the circular plots.

The following three classes were recorded for the circular plots: bare (without vegetation); obstructed (vegetation and litter that interfered with the sighting of pellets); clear (vegetation and litter that did not interfere with the sighting of pellets). The percent of each class that covered a circular plot was estimated and recorded. The mean percentage of each class was then computed for the six circular plots on each strip plot.

Methods of Data Analysis

The mean defecation rate per deer per day was calculated from

the pellet survey using the formula given by Ryel (1959) in the follow-in manner:

$$\text{Defecation rate} = \frac{\text{Area of enclosure in acres} \times \text{total new pellet groups}}{\text{total plots searched} \times \text{days of exposure} \times \text{number of deer in enclosure} \times 0.0023 \text{ acres}}$$

Reduced to variables this becomes:

$$\frac{340 \text{ acres} \times \text{total new pellet groups}}{\text{total plots searched} \times \text{days of exposure} \times \text{number of deer in enclosure} \times 0.0023 \text{ acres}}$$

Since the surveys were based on stratified random sampling, a weighted mean pellet group per plot and a weighted number of days of exposure were used. The equation then becomes:

$$\text{Defecation rate} = \frac{340 \text{ acres} \times \text{weighted mean pellet groups per plot}}{\text{weighted days of exposure} \times \text{number of deer in enclosure} \times 0.0023 \text{ acres}}$$

The results of the accuracy counts were compared with the density of cover information by computing the coefficients of correlation and determination. Range-use was determined by calculating the density of deer for the eight range types.

RESULTS

Rates of Defecation

Mean daily rates of defectation and the standard error were determined for three periods of deposition (Table 1). For the March - April 1959 period, the mean rate of defecation was 23.8 groups of pellets daily with a standard error of $\pm$2.9. During the May - August 1959 period, the rate dropped to 22.0 groups per day but standard error increased to $\pm$5.0. In the last period studied, February - March 1960, the defecation rate dropped to 19.1 groups per day with a standard error of $\pm$4.3. The significance of the differences in mean defecation rates between 1959 and 1960, disclosed by t-tests (Table 2), are open to question because the data were not normally distributed.

Accuracy of Method

The accuracy of finding groups of fecal pellets changed by month from a low of 33 percent in summer to a high of 89 percent in the winter (Table 3). Density of cover recorded for circular plots changed substantially with the season reaching a maximum in September (Table 4). A significant ($P<0.05$), positive correlation, $r = 0.852$, existed between the accuracy of finding pellet groups and the percent of clear area.

Range-Use Index

The calculated density of deer per square mile for the eight range types varied from 0. 0 to 111. 9 in 1959 and from 0. 0 to 57. 5 in 1960 (Table 5). The difference between the calculated density of deer per square mile for the entire area and the actual density was due to rounding errors.

Table 1. Daily rates of defecation for black-tailed deer in the Tillamook Burn enclosure in western Oregon, 1959-1960.

Period of Deposition	Mean Daily Rate of Defecation ± Standard Error	Number of Sample Plots Examined	Mean Number of Deer Present
March - April 1959	23. 8 ± 2. 9	275	43. 0
May - August 1959	22. 0 ± 5. 0	28	42. 4
Feb. - March 1960	19. 1 ± 4. 3	279	15. 0

Table 2. Results of t tests on the difference between mean daily rates of defecation for black-tailed deer in the Tillamook Burn enclosure in western Oregon, 1959-1960.

Rates of Defecation Tested	Difference	t	P	Degree of Freedom
23. 8 - 22. 0	1. 8	1. 62	0. 30 - 0. 40	301
23. 8 - 19. 1	4. 7	8. 97	≤0. 001	552
22. 0 - 19. 1	2. 9	2. 90	0. 01 - 0. 001	305

Table 3. Accuracy of finding groups of fecal pellets of black-tailed deer in various months of the year in the Tillamook Burn enclosure in western Oregon, 1959-1960.

Date	Number of Sample Plots Checked	Total Pellet Groups Originally Located	Total Pellet Groups After Accuracy Count	Accuracy of Original Search (Percent)	Correction Factor
Aug. 1959	13	3	9	33	3.000
Sept. 1959	10	5	8	63	1.600
Dec. 1959	10	8	9	89	1.125
Feb. 1960	30	16	18	89	1.125
April 1960	27	4	5	80	1.250

Table 4. Seasonal changes in the density of ground cover for circular plots in the Tillamook Burn enclosure in western Oregon, 1959-1960.

Date	Percent of Plots			Number of Sample Plots
	Obstructed a/	Clear b/	Bare c/	
June 1959	42.7	25.6	31.7	240
Aug. 1959	50.7	27.7	21.6	13
Sept. 1959	59.0	27.7	13.3	10
Dec. 1959	37.1	54.4	8.5	10
Jan. 1960	11.2	81.7	7.1	24
Feb. 1960	5.4	61.0	33.6	30
April 1960	4.9	62.0	33.1	27

a/ Vegetation and litter interfered with sighting of fecal pellets.

b/ Vegetation and litter did not interfere with sighting of fecal pellets.

c/ No vegetation or litter.

Table 5. Calculated deer per square mile in each range type and in the entire area within the Tillamook Burn enclosure in western Oregon, 1959-1960.

Type of Range			Calculated Deer per Square Mile		Number of Groups of Fecal Pellets	
Soil Depth	Elevation	Direction of Slope	May 1959	April 1960	May 1959	April 1960
Deep	Low	Southeast	108.6	33.8	76	11
Deep	Low	Northwest	78.6	9.4	18	1
Deep	High	Southeast	92.6	40.7	35	16
Deep	High	Northwest	58.9	0.0	12	0
Shallow	Low	Southeast	75.2	41.4	15	4
Shallow	Low	Northwest	22.6	0.0	1	0
Shallow	High	Southeast	11.0	17.8	1	1
Shallow	High	Northwest	0.0	55.8	0	1
Entire Enclosure (Calculated)			81.6	28.5	158	34
Entire Enclosure (Actual)			81.0	28.2	---	---

DISCUSSION

Rates of Defecation

The three estimated rates of defecation for black-tailed deer (Table 1) were substantially higher than the rate used by most workers for mule deer, white-tailed deer, and black-tailed deer (Table 6). This increase in the mean rate of defecation could be due to two causes: (1) Failure to remove all groups of fecal pellets when the strip plots were established would have affected the calculations for the first counting period, March-April 1959. The use of accuracy counts provided a correction factor for this type of error during subsequent counts; or (2) a higher rate of defecation for black-tailed deer in the Tillamook Burn enclosure. I do not believe it was the first reason because plots were established during January and February, a time of year when the ground was sparsely covered by interfering vegetation and litter (Table 4). In addition, the resident biologist and I double-checked the clearing of every plot during the original establishment of the plots. Therefore, it appears that black-tailed deer in the Tillamook Burn enclosure have a higher rate of defecation than reported for deer in other areas.

Several changes in sampling should be stressed if direct comparisons are made between the 1959 defecation rates and the 1960

Table 6. A summary of defecation rates for deer reported in the literature.

Reference	Species and Area	Daily Defecation Rate
McCain (1948)	Mule deer Utah	12. 7
Eberhart & Van Etten (1956)	White-tailed deer Michigan	12. 7
Van Etten (1959)	White-tailed deer Michigan	13. 2
Rogers et al. (1958)	Mule deer Colorado	14. 9 - 15. 2
Julander et al. (1963)	Mule deer Utah	12. 6
Dasmann and Tabor (1955)	Black-tailed deer California	10 - 17

rate (Table 1). There were 42-43 deer in the enclosure in 1959 and only 15 deer in the enclosure in 1960. This caused a reduction in the number of deer days from 3, 530 for the March-April 1959 estimate and 4, 983 for the May-August 1959 estimate, to only 789 deer-days for the February-March 1960 estimate. The reduction in deer-days resulted in an increased standard error for the 1960 rate. The primary reason for the large standard error in the May-August 1959 estimate is the small number of plots examined (Table 1).

The May 1959 count (March-April deposition period) was the first full-scale check of the area which could provide a reliable

estimate for comparison with subsequent counts. Several cross-checks were made to determine if any groups of fecal pellets were missed during counting. No missed groups were found on these cross-checks and I assumed that nearly 100 percent of the groups present was found. Therefore, the rate of 23.8 was used as a base for comparison with later counts. The second 1959 rate of 22.0 was calculated from data collected while making efficiency counts and recounts, and agreed closely with the first rate of 23.8 (Table 2). The methods used during the recounts assured a complete count on the 28 plots involved. The accuracy data (Table 3) for April 1960 shows a level of efficiency of 80 percent. If the February-March 1960 rate of defecation (calculated from the April 1960 check of strip plots) of 19.1 is multiplied by the April correction factor of 1.250, a corrected mean rate of defecation of 23.9 is obtained. This is only 0.1 groups different from the first 1959 rate and is not significant ($P>0.90$).

Accuracy of the Method

Accuracy data (Table 3) indicated counts of fecal pellets were most useful during the winter months when the accuracy of finding groups was high (89 percent). The subject of improving accuracy was covered in detail by Van Etten and Bennett (1965) in their investigation of the technique used in Michigan. They felt the level of accuracy could be increased to nearly 100 percent with proper train-

ing of field personnel.

Index to Range-Use

The 1959 range-use data (Table 5) illustrate a definite preference by deer for areas of deep soil. These areas exhibited a more luxuriant growth of the major winter browse species: trailing blackberry, Rubus vitifolius; salal, Gaultheria shallon; and red huckleberry, Vaccinium parvifolium (Crouch 1966). A southeast exposure was preferred over a northwest exposure within areas of both deep and shallow soils. Several factors may be responsible for this division. The areas with a southeast exposure contained more of the preferred forage species. Southeast exposures also exhibited a higher mean daytime temperature, less snow, and fewer areas of shade (Nieland 1958). The data indicate a preference for low altitude. This was probably due to the weather at the time. Deep snow covered the higher altitudes during most of the time between clearing and counting. Deer were observed descending to lower altitudes during the first heavy snowfall in January. They remained at the lower altitude until the snow disappeared in the first week of March. The number of deer frequenting the higher altitude increased in April.

Data from 1960 (Table 5) indicated a southeast exposure was the primary factor determining the distribution of deer. Areas of deep soil received more use than areas of shallow soil. Distribution of

deer was not related to altitude. This was expected since no snow occurred between clearing and counting the plots. There were not many groups of fecal pellets in the area at the time and a variation of one group would drastically change the results for six of the eight types of range. We know from the accuracy data (Table 3) that about eight groups of pellets were missed on the April 1960 count making it difficult to draw any firm conclusions. The small number of groups of pellets in the area resulted because the population of deer in the enclosure was low (15). This indicates that using groups of fecal pellets as an index to range-use in areas of low deer population requires that care be taken to find all groups.

Data from both years (Table 5) indicated that black-tailed deer migrated to a lower altitude during the winter only when a heavy snowfall occurred. The data also showed that black-tailed deer preferred southeast facing slopes and areas of deep soil. Recent studies by Hines (personal communication) indicated that south facing slopes, either southeast or southwest, are preferred by black-tailed deer in the Tillamook Burn.

Feasibility of the Method

The use of any method of estimating deer numbers as a management tool is largely dependent upon the man-hours needed to obtain a desired accuracy. The average time needed to check the 285 plots

in the 340-acre enclosure was 57 man-hours. Such a time-consuming method is impractical for anything other than a research tool. Using Cochran's (1953) formula for estimating sample size and accepting a coefficient of variation of 10 percent, the optimum number of strip plots for March-April 1959 would have been 23. The February-March 1960 data gave an optimum sample size of 70 plots. This is a reduction of 91.6 percent and 74.9 percent respectively when compared to the 275 and 279 plots actually sampled. The difference in the optimum number of plots is due to the large difference in deer-days (3, 530 in March-April 1959 and 789 in February-March 1960) between these two counts.

Sampling intensity is dependent upon the area of the range unit to be sampled and the density of the groups of fecal pellets per acre (Robinette et al. 1958). The area of the range unit would normally be a predetermined figure. The density of groups per acre, however, is dependent upon the number of deer per acre and the number of days of plot exposure. The number of deer per acre can be determined with the lowest sampling intensity by increasing the number of days of exposure.

The rate of disintegration of groups of fecal pellets would be the determining factor in arriving at the maximum number of days of exposure. If groups of pellets remained for more than 365 days, an annual count could be made each winter. If groups did not retain their

identity for a full year, it would be necessary to clear the plots of groups and then count the number of new groups a few months later.

Despite some minor areas requiring further research, I would recommend the pellet group count technique for censusing deer in western Oregon. It provides a high level of reliability and repeatability not found in other methods.

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