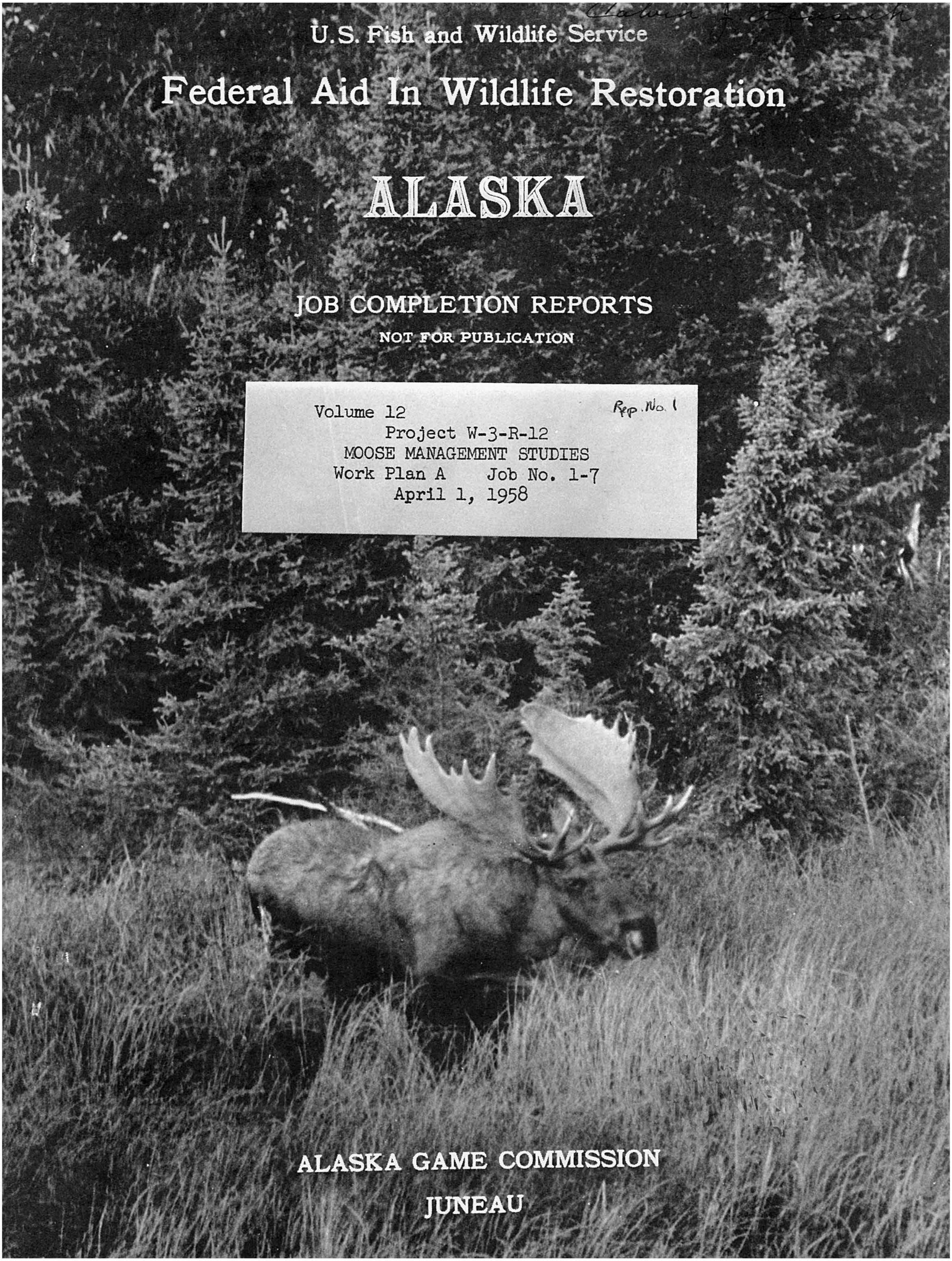

U.S. Fish and Wildlife Service

Federal Aid In Wildlife Restoration

ALASKA

JOB COMPLETION REPORTS

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Work Plan A   Job No. 1-7
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ALASKA GAME COMMISSION

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Project W-3-R-12 Alaska January 31, 1958

Wildlife Investigations

Work Plan A

MOOSE MANAGEMENT STUDIES

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(The results described in these reports are preliminary and often fragmentary in nature. Conclusions are subject to change with further investigation and interpretation.)

CONTENTS

SUMMARY

Job No. 1--Herd Composition Surveys--Susitna and Copper River Valleys

Sex and age composition counts of moose populations inhabiting the Lower Susitna-Matanuska Valley and the Upper Susitna-Copper River Valleys were conducted in October, November and December of 1957 with the following results:

1. Four thousand seven hundred sixty moose were tallied in 41.4 flying hours spent actually counting moose.

2. Productivity in both areas is good with an average of approximately 43 calves per 100 cows.

3. Young bull survival varies greatly from one local population to another. The factors affecting this survival are hunting and probably local environmental conditions.

4. The effects of hunting are reflected by the bull:cow ratios. These reveal that in areas accessible by road or to tracked vehicles the bull segment of the population is rapidly reduced. This reduction, however, has not been demonstrated to affect the pregnancy rate of the cows; thus, the hunting of bulls only does not control herd size.

5. Experimental counts made during the period of rut indicate a more homogeneous distribution of the various sex and age components of a moose population at that time. This is advantageous for sampling purposes.

Job No. 4--Distribution, Movements and Dynamics of the Railbelt Moose Populations.

A study of the railroad-moose conflict in the Lower Susitna Valley area was conducted from January 3, 1956, through May 15, 1956, and from November 1956 through June 15, 1957. A study of moose population dynamics was conducted in conjunction with the railroad-moose study.

The problem is created by the combination of the following factors: (1) an abundant moose population, (2) deep snow, and (3) large quantities of winter moose browse along and adjacent to the right-of-way.

The critical kill area is between Houston (Mile Post 172) and Talkeetna (Mile Post 226), a distance of 54 miles.

In December 1956 a system for reporting all railroad killed moose was devised.

Two hundred twenty-five moose were reported killed in 1955-56, and 93 in 1956-57. The reporting system is not accurate. The adjusted total kill was 366 and 179, respectively.

Several temporary moose saving technics, suggested in 1955-56, were evaluated in 1956-57. The following are worthy of implementation: (1) daylight train operation through critical areas, and (2) reduced train speed through critical areas.

Understanding the factors influencing seasonal moose movements is believed to be the key to formulating plans for keeping moose away from the right-of-way.

Some moose populations inhabiting the Lower Susitna Valley exhibit seasonal altitudinal migrations. The magnitude and extent of these migrations are not fully understood and warrant further investigation.

Bulldozed trails and feed yards, as a means of keeping moose off the right-of-way, were experimented with and found partially successful. Moose guards were tested, but no definite conclusions are drawn.

Approximately 40-45,000 pounds of moose meat were salvaged and distributed to charitable institutions in 1956-57. This represents 80-90 percent of all salvable meat and an increased salvage efficiency of 100 percent over 1955-56.

The direct cost of the moose problem to the railroad over the past ten years is not known, but has amounted to thousands of dollars annually.

The moose populations of the Lower Susitna Valley are probably the most valuable herds in Alaska. Future research must be directed towards goals which will benefit both the railroad and the moose.

The study of moose population dynamics revealed the following information:

1. Yearling bulls (16-18 months) are sexually mature.

2. Spermatozoa, presumably viable, are present in the epididymis from August to December.

3. Most cows breed first at 28-30 months of age, although a few yearling cows do breed.

4. Eighty percent of the cows in this population breed during a 15-day period in late September and early October.

5. Fifty percent of the cows have calves by late May.

6. One hundred twenty-four sets of lungs were examined for the presence of hydatid cysts, Echinococcus granulosus; 25, or 20 percent, were infected.

7. Ninety-eight cows were examined for pregnancy data; 87 of 93, or 94 percent, Age Class II or above were pregnant.

8. Weights and measurements of 69 fetuses and 83 calves and adults are presented.

9. Age determinations made on the mandibular teeth of 240 railroad killed moose revealed that there is a predominance of "middle" and old age females and that sex selective mortality factors probably affect males excessively.

Job No. 5--(W-3-R-11) Food Habits of Railbelt Moose

Rumen content samples from 122 moose killed by trains between Mile Posts 172 and 231 on the Alaska Railroad during the winters of 1955-56 and 1956-57 were analyzed. Only the gross particles, an average of 5 percent of each sample, were considered. This analysis revealed the following: (1) seventeen food items were identified; (2) willow, birch and aspen comprised 97 percent of the identifiable food material; (3) moose ate more willow during 1956-57, possibly due to lesser snow accumulations; and (4) until some technique for identifying the small food particles, which comprise about 95 percent of an average rumen content sample, is devised the validity of the present technique is questionable.

Job No. 5--(W-3-R-12) Sampling of Kill by Hunters

The 1957 moose hunting season can be summarized as follows:

1. Twelve percent of 2,075 hunters checked were successful.

2. Two hundred ninety-five moose were checked; interviews with guides and outfitters revealed 300 additional hunter kills for a total known kill of approximately 600.

3. Fifty-five percent of the moose checked were yearlings.

4. Ninety percent of the moose checked in the Matanuska Valley were yearlings.

5. Yearlings, due to habitat preference, may be more susceptible to hunters.

Job No. 6--Herd Composition in Interior Alaska

Aerial composition counts were made in three specific areas subject to hunting: the Tanana Valley, Fortymile, and the lower Koyukuk Valley. Six hundred nine moose were counted in 19.8 hours for an average of 30.7 moose sighted per hour. The sex and age data are summarized as follows:

Tanana Valley: The calf:cow ratio decreased from 47:100 in 1956 to 42:100 in 1957. Survival of bull calves to yearlings indicated 35 percent mortality. The bull:cow ratio of 68:100 indicated light hunting pressure.

Fortymile: The calf:cow ratio decreased from 53:100 in 1956 to 46:100 in 1957. Survival of bull calves to yearlings indicated 20 percent mortality. The bull:cow ratio of 91:100 indicates light hunting pressure; however, it is believed that a disproportionate sampling of bulls may have occurred.

Koyukuk: The calf:cow ratio was 67:100 indicating a high level of productivity. Data from 1956 were not available to determine calf survival. The young bull:bull calf ratio of 48:100, however, suggested higher mortality than in other areas; perhaps due to heavy wolf predation the previous winter. The bull:cow ratio of 80:100 indicated light hunting pressure.

The calf percentage of the total herd continues at 20 and 19 percent for the Tanana Valley and Fortymile respectively. These ratios have not changed since 1954. In the Koyukuk, there were 28 percent calves in 1957 as compared to 36 percent in 1954.

It is apparent that the moose populations in the Tanana and Fortymile are relatively stable and are not being affected adversely by the present hunting pressure. The Koyukuk moose herd also appears to be in healthy condition despite unusually heavy wolf predation during the winter of 1957.

Job No. 7--Stikine River Valley Aerial Surveys

Sex and age composition counts were made from the air in the Stikine River Valley in the fall of 1957. The population continues to show good productivity and a youthful age structure. Data summarizing the harvest of moose by hunters are given.

JOB NO. 1--Herd Composition Surveys--Susitna and Copper River Valleys

PERIOD COVERED: September 1, 1957, to December 15, 1957

ABSTRACT

Sex and age composition counts of moose populations inhabiting the Lower Susitna-Matanuska Valley and the Upper Susitna-Copper River Valleys were conducted in October, November and December of 1957 with the following results:

1. Four thousand seven hundred sixty moose were tallied in 41.4 flying hours spent actually counting moose.

2. Productivity in both areas is good with an average of approximately 43 calves per 100 cows.

3. Young bull survival varies greatly from one local population to another. The factors affecting this survival are hunting and probably local environmental conditions.

4. The effects of hunting are reflected by the bull:cow ratios. These reveal that in areas accessible by road or to tracked vehicles the bull segment of the population is rapidly reduced. This reduction, however, has not been demonstrated to affect the pregnancy rate of the cows; thus, the hunting of bulls only does not control herd size.

5. Experimental counts made during the period of rut indicate a more homogeneous distribution of the various sex and age components of a moose population at that time. This is advantageous for sampling purposes.

OBJECTIVES

To determine age and sex composition of identifiable local moose populations as an indication of relative productivity, survival, and effects of hunting.

TECHNIQUES USED

Coverage

Aerial surveys to determine sex and age composition of local identifiable moose populations were conducted principally during the months of November and December. The lack of adequate snow cover earlier altered the original plans, which were to make the counts during the period of rut in early October. Experimental flights to test the feasibility of sex and age composition counts during the period of rut were made on October 8, 9, and 10 in the Maclaren River, Clear Creek, and Upper Susitna River areas. Snow cover varied from traces at elevations below 2000 feet to complete above 3000 feet. The Upper Susitna and Copper River Valleys were surveyed between the 6th and 15th of November using Supercub aircraft. The pilots were Burkholder, Predator Control, and Thayer, Game Management. Flying time, actually spent counting moose, totaled 22.1 hours.

Snow cover in the Lower Susitna River Valley was not adequate for counting until late November. These areas were covered between November 15th and December 12th. Again Supercubs were used and the pilots were Switzer of Game Management and Wardleigh of the Aircraft Division. Flying time spent actually counting moose totaled 19.3 hours.

The counts were made within each predetermined local area from an altitude of 300 to 600 feet depending upon terrain, ground cover, and moose visibility factors, principally light and snow conditions. Each moose seen was inspected and assigned to a sex and age category. If doubt concerning its category existed, a low level inspection pass was made. Neither total counts nor systematic samples were practicable due to the great area involved; however, an attempt was made to spend a proportionate amount of time counting in each cover type and at the various altitudinal levels within the local area. Since the sex and age distribution patterns of the various moose populations were not known prior to counting, this technic unfortunately does not always produce a truly representative sample. As more knowledge of population characteristics accumulates, it is hoped that a solution to this problem will be found.

Data Recorded

Moose sex and age determination by aerial observers is limited to five categories:

1. Young bulls--bulls with spike or forked antlers, usually with little or no palm development. These animals are predominantly "yearlings", approximately eighteen months old, but there is some overlap in ages.

2. Medium bulls--bulls having some palm development, but not massive appearing. Probably two and three year olds. This category's most useful function is to create an awareness of the size differential between young and adult bulls. It does not provide clear-cut data useful in determining population trends. Animals in this category were considered as adult males in calculating sex and age ratios.

3. Adult bulls--all bulls having greater antler development than the preceding age category.

4. Cows--all cows, including yearlings.

5. Calves--young of the year, generally five to seven months old when the counts are made.

Methods of Analysis

The data from the 1957 sex and age composition counts were analyzed to determine current productivity, survival, and effects of hunting in each identifiable population and for the moose herds in general. These indicators of population status were first described in the 1956 P-R Quarterly Report, 10(3):7-11, and are defined below. Each of them is evaluated by examining one or more indices provided by the appropriate sex or age ratios.

Productivity--is defined to include both the initial incidence of live births to females in the population, and also the subsequent survival of these young to the date of the aerial count about six months later. The most significant index used is the ratio of calves per 100 cows.

Another indicator of productivity is the ratio of twins per 100 cows with calves. The significance of this index is not fully understood at present. In fact, the reliability of the ratio itself has been seriously questioned. Nevertheless, in certain areas the ratio of twins per 100 cows with calves approaches 25 per 100 and adds a significant number of individuals to the herd. In some areas, such as the Koyukuk, high incidence of twinning is concurrent with excellent productivity; in others, such as the Kahiltna Flats and Susitna-Beluga Mountains areas, productivity appears very good, but not any greater than in the Matanuska Valley area which has a low incidence of twinning as revealed by the 1957 fall counts.

The variance in observed twinning rates may reflect a number of survival factors rather than differences in initial rates of twinning. In the Matanuska Valley examination of nearly 100 cows during the months when cows are normally pregnant showed 27 sets of twins per 100 pregnancies, yet the 1957 fall aerial counts showed only nine sets of twins per 100 cows with calves. This suggests that in this area mortality rates for twins are greater than they are for singletons.

The reasons for certain other areas having higher ratios of twins are not known but these may reflect better survival of twins or a higher initial incidence of twinning due to environmental conditions or a different population age structure.

The principal index to productivity is the ratio of calves per 100 cows. In comparing productivity trends from year to year, and by areas, it is believed that descriptive terms indicating the general trends are more meaningful than the numerical ratios; for this reason the terms poor, fair, good, and excellent are used in the general discussion of productivity in this report. These terms correspond to the following numerical values:

Poor-------------below 20 calves per 100 cows
Fair------------- 20-35 calves per 100 cows
Good-------------36-50 calves per 100 cows
Excellent---------more than 50 calves per 100 cows

It should be remembered that these terms relate only to productivity at approximately six months as measured by the calf:cow ratio and they do not necessarily indicate the overall well-being of the herd. A population having poor productivity may have excellent survival and be increasing; conversely a population may have excellent productivity, poor survival, and be decreasing.

<u>Survival</u>--is defined as survival of the calves recorded on the annual sex and age counts to approximately the same date one year later--i.e., survival between approximately 6 and 18 months of age.

Two ratios may be used as indices, both measuring survival but using different segments of the population as comparison bases. In the first, the ratio of young (yearling) bulls per 100 bull calves indicates survival to 18 months. Here it is necessary to assume that calf production remains constant from year to year and that calves have a 1:1 sex ratio. Sex ratios of calf moose at or before birth indicate a slight preponderance of males, but the difference is not great enough to seriously affect the index. Calf production, however, may vary considerably from year to year in some areas, causing an error in the index.

The second index to survival is the ratio of young bulls per 100 cows as compared to the previous year's ratio of bull calves per 100 cows. Theoretically, the difference between these ratios represents mortality occurring during the period between approximately 6 and 18 months; however, exact percentages obtained from these methods should not be allowed to imply a degree of accuracy greater than one can obtain until more of the variables in aerial counting can be evaluated.

Cows are probably the most constant segment of moose populations in Alaska, because they are not hunted, and it is therefore advantageous to use them as a base for comparison. The use of the female population segment as a base for the two ratios used to obtain this index to survival assumes that natural mortality of adult females is approximately equal to the annual recruitment of yearling females which are counted as adult cows by aerial observers. In populations experiencing either a rapid increase or decrease the described index will be biased. However, the populations in south central Alaska appear to be either nearly stable or increasing slightly and the index is believed to portray a reliable trend providing that the various sex and age components of each population are sampled proportionately.

It is possible, but not considered necessary at present, to work with only those females two years and older. This is accomplished by subtracting a number equal to the total young bulls counted, from the total females counted. This method assumes a 1:1 sex ratio of yearling moose and provides an estimate of the number of cows two years or older. The previous year's mortality is offset by the addition of last year's yearlings to the base or comparison segment of the female population. This method provides an older and perhaps more stable age group for comparison purposes but does not provide for differential sex survival rates to two years, and in some areas hunting is a major decimating factor to yearling bulls. This would cause a significant error in this index in the areas experiencing intense hunting pressure.

Another indicator of survival, which must be carefully interpreted where hunting is a survival factor, is the young bull:adult bull ratio.

Effects of hunting--is defined as the extent to which hunting reduces the male segment of the population and is measured primarily by the ratio of bulls per 100 cows. Another index is the ratio of young bulls per 100 adult bulls. Hunting tends to lower both the number and average age of the bull segment of the population; thus the yearlings constitute a greater portion of the bull population as hunting pressure increases.

FINDINGS

Sex and Age Composition of the Lower Susitna Valley Moose Populations

The general area of the Lower Susitna Valley is illustrated in Figure No. 1. It includes the drainage of the Big and Little Susitna Rivers from the Talkeetna and Kahiltna Rivers to Cook Inlet. Several additional populations adjacent to Anchorage are also included in the area surveyed.

These areas support some of Alaska's most abundant, accessible and valuable moose populations, as well as some of the least accessible. Whenever possible the areas outlined in Figure No. 1 represent identifiable populations. Identifiable populations in most instances refer to specific geographic units which are believed to support a resident moose population. The Matanuska Valley and Willow areas represent local identifiable populations which have been studied for several years. The basis for classifying these as identifiable populations stems from these studies which are reported on in another section of this report, and also in the 1956 P-R Quarterly Report, 11.(2):19-22.

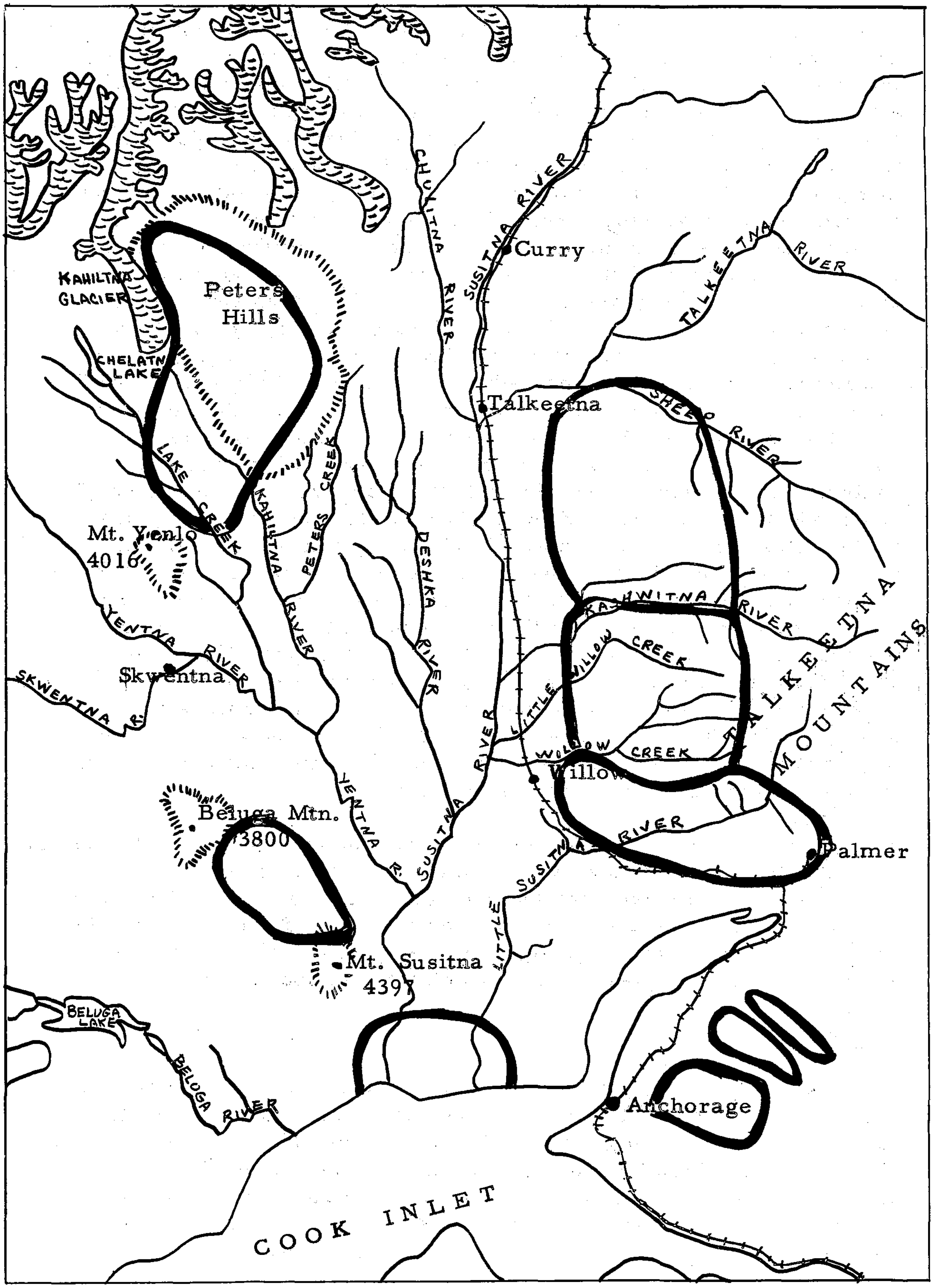
The areas covered are as follows: Matanuska Valley, above and below timberline, Willow, Susitna Flats, Kashwitna, Kahiltna Flats, Susitna and Beluga Mountains, Eagle River, Peters Creek, Ship Creek, and Fort Richardson.

Each population indicator is discussed separately below, as it applies to the general area and to certain local areas.

Productivity

Productivity throughout the Lower Susitna Valley and Anchorage areas is considered good. The combined and weighted average calf:cow ratio for the entire area is 44 calves per 100 cows (Table No. 3). This compares favorably with the 1956 average which

Figure No. 1. Moose populations in the Lower Susitna Valley and Anchorage areas.



was 40 calves per 100 cows (Table No. 8). The calf:cow ratios are remarkably similar in the various local populations comprising this general area, with the exception of the Willow and Kashwitna areas which have calf:cow ratios of 35 and 34 calves per 100 cows respectively. The Willow area has had relatively low productivity for the past three years, averaging about 30 calves per 100 cows for this period. The reasons for this seemingly lesser productivity are not completely understood, but it is believed to reflect survival rather than a lower initial production of calves. Previous work in this area has indicated that 90 percent of all cows two years old and older are successfully bred. This area lies in a deep snow belt and is also believed to have insufficient winter browse during winters having deep accumulations of snow. The combination of deep snow and limited winter browse may adversely affect calf vitality at birth or the ability of the females to care for their calves. Data obtained from the annual fall sex and age composition counts suggests a correlation between productivity and the severity of the previous winter. The winters of 1954-55 and 1955-56 were particularly severe and productivity as indicated by the fall aerial counts was only fair in the Willow area. The winter of 1956-57 was about normal and productivity in the Willow area increased from 27 calves per 100 cows in 1956 to 35 per 100 in 1957. This same correlation exists in the Matanuska Valley area where the winter of 1954-55 was severe and the 1955 fall counts show a calf:cow average of approximately 34 calves per 100 cows. The 1955-56 and 1956-57 winters were not particularly severe in the Matanuska Valley and the calf:cow ratios were 53 and 50 calves per 100 cows respectively. Quantitative data illustrating the mortality factors responsible for the differential calf survival in the Willow and Matanuska areas are needed.

The incidence of twinning in the Lower Susitna Valley and Anchorage areas, unlike the calf:cow ratio, is quite variable. The ratio of twins per 100 cows with calves varies from a low of 4 per 100 in the Willow and Kashwitna areas to a high of 23 per 100 in the Kahiltna area. The problems of interpreting the significance of twins are discussed in the section under techniques and are not elaborated upon here.

Survival

Survival of young bulls in the Lower Susitna Valley and Anchorage areas is poor. The 1956 bull calf:cow ratio was 20 per 100 and the comparable ratio, young bulls per 100 cows, in 1957 is 7 per 100 (Table No. 7). This indicates that more than 50 percent of last year's bull calves either failed to overwinter or were removed by hunting this past season. Examination of survival by area (Table No. 7) reveals that young bull survival varies greatly. The areas that are accessible and receive great hunting pressure, notably the Willow, Matanuska and Anchorage areas, have young bull:cow ratios of about 5 per 100. When this ratio is compared with the bull calf:cow ratio of the same areas in 1956 a mortality of 70 to 90 percent is indicated and hunting is probably the most important decimating factor. In areas where hunting is the most important survival factor, survival as measured by the present indices refers only to the male segment of the population. Survival of females may be excellent in the areas where the present data indicate a young bull mortality of 70-90 percent by 18 months. Unfortunately, at present there is no index for measuring female survival in heavily hunted populations.

In the more inaccessible areas such as the Kahiltna Flats and the Susitna and Beluga Mountains area, survival of young bulls appears reasonably good.

The Kashwitna area again is unique in that while hunting pressure is very light survival of young bulls is less than 50 percent. The reasons for this seemingly great mortality of young bulls from 6 to 18 months of age in the Kashwitna area are not known but the climatological and winter browse conditions which were discussed earlier may also apply to this age category.

The Effects of Hunting

In order to more effectively demonstrate the effects of hunting on the bull segment of the various populations and because hunting pressure varies in direct proportion to accessibility, certain of the areas experiencing different levels of hunting pressure are discussed separately.

Matanuska Valley. The Matanuska Valley represents an area subjected to nearly unlimited accessibility by car and foot in the lowlands and corresponding accessibility to swamp buggies and tracked vehicles in the timberline areas. This area has an overall bull:cow ratio of 8 per 100. The bull:cow ratio has declined steadily for a number of years. This ratio below timberline was 7, 5, and 3 per 100 in 1955, 1956, and 1957, respectively. The timberline counts for the same period were 25, 18, and 15 per 100, respectively. These figures indicate unusual hunter efficiency in harvesting bulls. This past fall 662 moose were included in the Matanuska area sample; only 32 were males, of which 20 were yearlings. There is no indication that this harvest of males has in any way lowered the annual calf crop. In all probability the hunter harvest will not significantly reduce the bull percentage below its present level because the principle of diminishing returns seems to apply to hunting as it does to other fields of endeavor.

Willow Area. The Willow area has been hunted intensively for a number of years and the bull:cow ratio of 28 per 100 reflects this utilization. The road system in this area is not as extensive as in the Matanuska Valley nor are the timberline areas as accessible to swamp buggies or tracked vehicles. Consequently, at present, bulls are more numerous in this area.

Susitna Flats. The bull:cow ratio is 43 per 100. The young bull:adult bull ratio is 69 per 100. This area is accessible by air only, but its close proximity to Anchorage makes it a favored hunting area for local plane owners. Although aerial hunting pressure is great, the bull:cow ratio has remained quite good from a hunter standpoint, even though trophy bulls are relatively few.

Kashwitna Area. The bull:cow ratio is 66 per 100. Hunting here is very limited as no roads other than the railroad traverse this area. Hunting by plane is also limited by the lack of lakes and landing strips, particularly at the higher elevations where most of the males are concentrated during the hunting seasons. Apparently hunting pressure is not greatly affecting the male portion of this population at present.

Susitna and Beluga Mountains and Kahiltna Flats. These areas are believed to be experiencing very light hunting pressure and are considered together. The bull:cow ratio is 86 per 100. The young bull:adult bull ratio is 15 per 100. Both ratios indicate very limited hunting. There are no roads in either of these areas and much of the region is inaccessible to airplanes.

Anchorage Area. The bull:cow ratio in the combined Anchorage areas is 20 per 100. The effects of hunting are difficult to assess in this area because much of it is military reservation close to big game hunting. Apparently hunting in the areas bordering the reservations in combination with previously mentioned mortality factors is sufficiently effective to reduce the bull:cow ratio significantly.

Sex and Age Composition in the Upper Susitna and Copper River Valleys

The local areas comprising this region are illustrated in Figure No. 2. In general the region includes most of the tributaries of the Susitna River above Deadman Creek, the Nelchina basin, and the Copper River and its tributaries from the Tazlina River to the Sanford River.

The populations identified in Table No. 3 represent primarily geographical divisions and when more detailed studies are possible segregation of some of these areas into more local identifiable populations seems possible.

The areas covered are as follows: Lake Louise, Maclaren River, Clear Creek, Alphabet Ridge, Oshetnas and Little Nelchina Rivers, Clarence and Black Lakes, Mt. Drum and Upper Gakona River.

In Table No. 2 several of the above areas have been subdivided. However, for purposes of analyzing the population trend indicators the combined totals for each geographic area are used. The indicators of population trends, productivity, survival and effects of hunting, are again discussed in order.

Productivity

Productivity in the Upper Susitna-Copper River basin is considered good. The 1957 fall counts indicate an overall average of 42 calves per 100 cows (Table No. 4); considerably better than the 1956 counts which indicated fair productivity with an average of 27 calves per 100 cows (Table No. 8).

This area's 1957 calf:cow ratio is nearly identical to that of the Lower Susitna Valley and Anchorage areas but productivity varies greatly from one local area to another in contrast to the relatively uniform productivity throughout the Lower Susitna Valley and Anchorage areas.

The calf:cow ratios range from a high of 66 per 100 in the Lake Louise flats to a low of 31 per 100 in the Maclaren River area. The Lake Louise data are based on a sample of 84 animals and may not be representative of the entire area. Despite the nonuniform rates of productivity the overall calf production appears good.

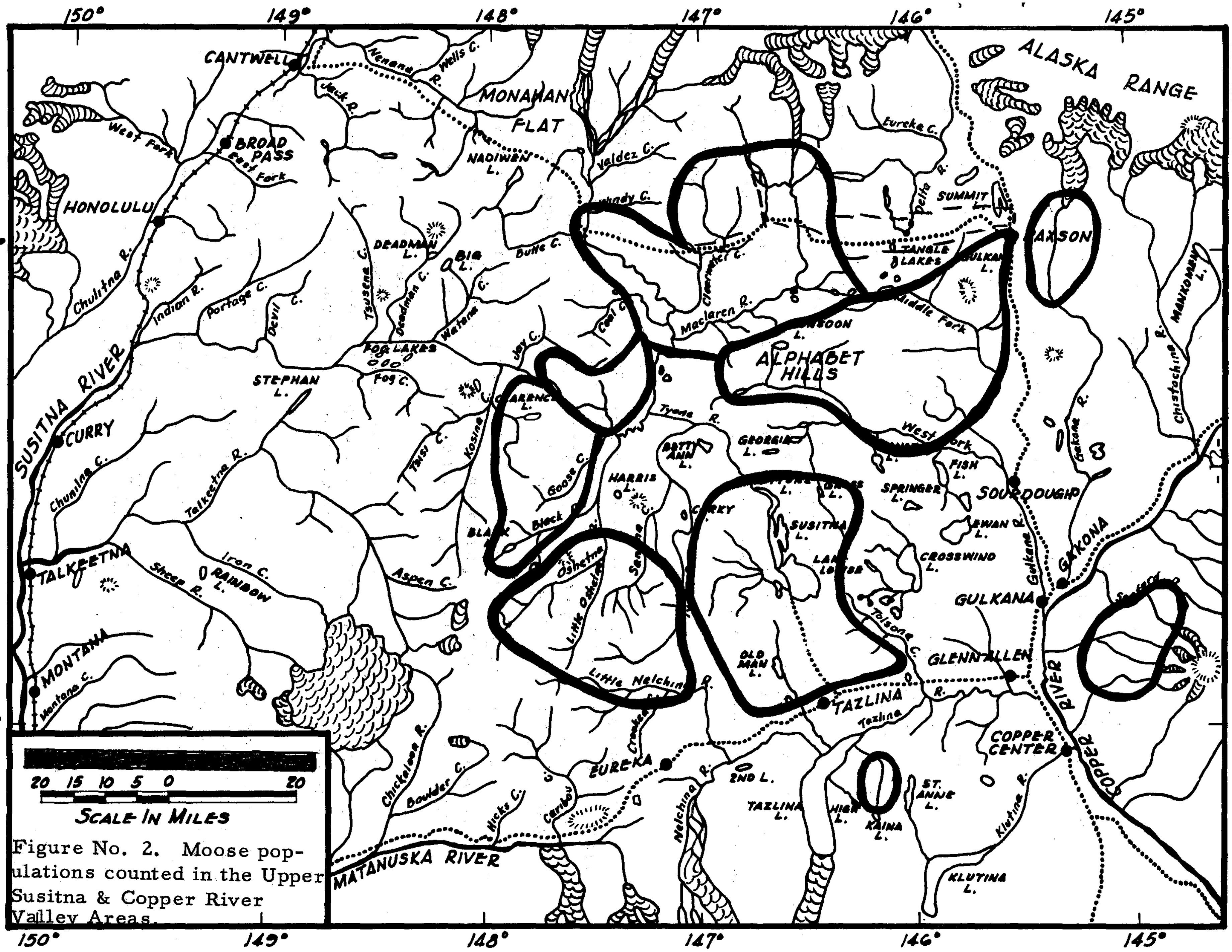


Figure No. 2. Moose populations counted in the Upper Susitna & Copper River Valley Areas.

Survival

Survival as measured by the previously described survival index is particularly variable in this area and the overall survival figure of 16 young bulls per 100 cows is excessive when compared to last year's bull calf:cow ratio of 14 per 100 (Table No. 7). In all probability the two figures are not comparable because the counts, due to climatic conditions and other factors, were conducted differently in 1957. A good example of this is the Alphabet Ridge area on which 843 moose were counted in 1957 and which was not counted in 1956.

Another possible factor accounting for the apparent high survival rates is disproportionate sampling of the bull population. This probably is the case in the Alphabet Ridge and Oshetna-Nelchina areas. The difficulties of sampling sex-segregated populations proportionately are discussed in another section of this report.

Survival in the areas accessible to hunting reflects hunting pressure, particularly the Maclaren and Clear Creek areas which are traversed by the new Denali Highway. On these areas the indicated mortality for young bulls was 21 and 57 percent, respectively. The factors causing poor survival of young bulls in the Mt. Drum area, where the indicated mortality was in excess of 50 percent, are not known.

Effects of Hunting

The bull:cow ratio for the entire Upper Susitna-Copper River area is 69 per 100. This is very similar to the 1956 bull:cow ratio of 67 per 100 for the same area. The effects of hunting are largely masked by combining the accessible areas with those subjected to a lesser hunting pressure and for this reason several of the areas representing varying degrees of hunting pressure are discussed separately below.

Lake Louise. Hunting has reduced the number of bulls in this population to 49 per 100 cows. This ratio is essentially the same as obtained from the 1956 counts. This area is subjected to rather intense aerial hunting and its many lakes make much of the area accessible. Nevertheless, aerial hunting apparently is not as efficient as foot and vehicle hunting and the bull proportions in the various accessible populations reflect this difference.

Maclaren River Area. Hunting is rapidly reducing the male segment of this population. The bull:cow and the young bull:adult bull ratios for this area are 42 and 33:100 respectively. In 1956 these ratios were 62 and 31, respectively. The newly constructed Denali Highway has opened this area to car and "swamp buggy" hunters. Another important factor is the terrain which is more gentle than much of Alaska, making swamp buggy operations for moose economically feasible from a commercial standpoint. These factors have combined to create hunter concentrations in this area. The bull:cow ratio reflects the additional pressure. The creation of the Denali Reserve apparently has not benefited bull moose as the sex ratio continues to decline within the Reserve as well as outside it. Possibly the bulls do not spend the entire year in the high country north of the highway. The reduction of bulls in this and the Clear Creek area is not considered undesirable from a management viewpoint, as the Matanuska Valley herds have already demonstrated the fact that a low bull:cow ratio does not affect the size of the annual calf crop. The rapid reduction of bulls does indicate that foot and swamp buggy hunters are more efficient in utilizing a game crop of this type than are airplane hunters. In all probability any area accessible by road will not produce trophy animals after the initial shoot.

Clear Creek. The bull removal here is similar to that in the Maclaren River area. The bull:cow and young bull:adult bull ratios for this area are 43 and 17:100 respectively. Here as in the Maclaren River area the bull portion of the population is being reduced by hunters.

Alphabet Ridge. Hunting, although intense in the accessible portions of this area, is not significantly reducing the overall bull:cow ratio. The bull:cow and young bull:adult bull ratios are 81 and 34:100 respectively. However, it is believed that bulls are over-represented in this sample, distorting the bull:cow ratio. The lakes and the area bordering the Richardson Highway are heavily hunted by airplane and car hunters respectively, but this has not significantly reduced the bull:cow ratios, probably because a major portion of the area remains inaccessible.

Oshetna and Little Nelchina Rivers. The bull:cow and young bull:adult bull ratios in these areas are 78 and 40 per 100 respectively. It is believed that bulls are over-represented in this sample, distorting the bull:cow ratio. Nevertheless, the young bull:adult bull ratio indicates effects of continued moderate hunting pressure. There are several airstrips in this area and swamp buggies, also, penetrate as far as the Big Oshetna River.

Clarence Lake-Black River Area. The bull population of this area is relatively untouched by hunting. The bull:cow and the young bull:adult bull ratios are 73 and 19 per 100 respectively. Hunting here is limited to airplane hunters and there are only a few lakes from which they can operate. Hunting does not appear to be influencing the number or age composition of the bull population.

Mt. Drum. The bull:cow and young bull:adult bull ratios are 73 and 11 per 100 respectively. The same ratios for 1956 are 152 and 12 per 100 respectively. In 1957 as in 1956 the lack of snow and weather conditions limited the number of observations made in this area. However, it is believed that this year's observations are more representative of the existing moose populations than those of 1956, as an attempt to sample both the timberline and forested areas was made. This moose population is not affected by hunting.

Upper Gakona River. This area has a bull:cow ratio of 88 per 100. Hunting, if any, is limited to airplane hunters landing on the sandbars along the river.

Evaluation of Aerial Sex and Age Counts

Since the inception of aerial sex and age counts of the various moose populations in 1950, efforts have been made to recognize and evaluate the effects of the variables seemingly inherent in aerial counts. Most of these variables have been discussed in previous P-R progress reports. Several experimental efforts to further test validity and to reduce certain variables in the counts were conducted this year.

Observers

Observers are a major variable in all aerial counts. No two individuals see and record the same animals exactly alike. In an effort to reduce this factor one observer did all the counting this year. The pilot also affects the total count and in some instances the classification of the animals seen. If possible, the same pilot should be used for all the counts. If the data are to be compared from year to year, then the same combination of pilot and observer should make the counts in order to maintain maximum continuity.

Timing of the Counts

Past experience has shown that moose exhibit seasonal sex and age habitat and altitudinal preferences. Frequently many large bulls and unknown-age cows will be at or above timberline during late October, November, and December. A large proportion of the cows with calves and many young bulls are found at lower elevations. In counting a population so distributed, it is impossible to know whether each stratum has been included in proportions that will make the total sample representative of the entire population. A total count of the area does not provide this information because the animals below timberline are difficult to see and a large percentage of them may be missed. The result is disproportionate sampling.

The "rut" or period of breeding activity extending from late September to mid-October is the one period when the various sex and age components of a moose population are distributed most homogeneously. In early October several populations in the Upper Susitna River drainage were counted in an attempt to establish sex and age data for comparison with November counts on the same area (Table Nos. 5 and 6). The Clear Creek drainage counts did not vary greatly from October 9th to November 11th. The Clear Creek drainage moose had not left the timberline river bottoms by November 11, although a downstream movement was in progress. However, the duplicate counts of the Maclaren River area are quite different.

Certain segments of the Maclaren River population had moved from the timberline areas of the Maclaren drainage to lower elevations south of the Denali Highway. The remaining animals were mostly bulls and cows without calves. Sex segregation was also evident in the Clear Creek areas but as this population had not crossed the highway it was identifiable. Also, most of this population were at or above timberline insuring a nearly complete count. Apparently most of the moose from these populations winter in the browse areas south of the Denali Highway and during the winter months the two populations are not distinguishable. The counts made in October show that most of the animals were in groups of 3 to 21 animals. The groups were composed of bulls (large and small), cows and calves. The peak of breeding had passed (see section on Reproduction) but the groups seemingly represented all sex and age components of the population. Cows with calves frequently were not closely associated with the larger groups, but were found 100 to 300 yards from them.

It is this writer's opinion that sex and age composition data obtained during the "rut" or period of breeding activity will yield more reliable data pertaining to population trends than will counts made at other periods of the year. Counts made during the rut will not always have the advantage of complete snow cover. This will result in a smaller sample, but as indicated earlier this sample is more representative of the true sex and age composition of the population.

Moose Population Densities

The number of moose tallied per hour of flying was computed for each area (Table Nos. 1 and 2).

These data could provide a valuable index to moose population densities providing that the counts are made under similar circumstances.

Analysis of this year's counts show a range of 40-145 moose per hour on the Lake Louise and Fort Richardson-Ship Creek areas respectively. The averages for the Lower Susitna River and Upper Susitna-Copper River Valley areas were 123 and 102 moose per hour. The average number of moose per hour on the various areas comprising the Lower Susitna Valley area are remarkably similar. The Willow, Kashwitna and Matanuska Valley areas averaged 140, 139, and 141 moose per hour respectively. These averages were computed from totals of 318, 352, and 662 moose respectively. The areas west of the Susitna River, Susitna and Beluga Mountains, and Kahiltna Flats, had moose-per-hour averages of 118 and 102. The Susitna Flats area had an average of 80 moose per hour. This area lies entirely below timberline and much of the vegetation is a mature white birch-spruce association. It is possible that the low moose-per-hour figure reflects the difficulty of observing moose in timbered areas rather than the moose population density of the area. The lowland portion of Fort Richardson with an average of 88 moose per hour may also illustrate this factor.

The Upper Susitna-Copper River Valleys exhibit greater variability in moose population densities. The range of moose-per-hour averages for these areas are from 40 per hour on the Lake Louise area to 130 per hour on the Alphabet Ridge area. The data indicate that the moose population densities in the Matanuska Valley and Lower Susitna are generally greater than those of the Upper Susitna-Copper River Valleys.

Table No. 1. Summary of moose population composition counts--Lower Susitna-Matanuska Valleys--November and December 1957.

Area	Young Males	Adult Males	Total Males	Females W/0	Females W/1	Females W/2	Total Females	Total Calves	Total Moose
Matanuska Below Timberline	5	2	7	109	130	12	251	154	412
Matanuska Timberline	15	10	25	118	46	5	169	56	250
Matanuska Combined	20	12	32	227	176	17	420	210	662
Willow	10	50	60	144	70	3	217	76	353
Kashwitna Area	12	93	105	107	50	2	159	54	318
Susitna Flats	18	26	44	54	44	5	103	54	201
Mt. Susitna-Beluga	7	34	41	27	19	4	50	27	118
Kahiltna Area	9	69	78	56	26	6	88	38	204
Eagle River	6	18	24	56	34	2	92	38	154
Peters Creek	2	2	4	27	20	1	48	22	74
Ft. Richardson	3	6	9	32	31	5	68	41	118
Ship Creek & Timberline	6	20	26	72	37	0	109	37	172
Anchorage Areas Combined	17	46	63	187	122	8	317	138	518
Totals	93	330	423	802	507	45	1,354	597	2,374

Table No. 2. Summary of moose population composition counts--Upper Susitna and Copper River Valleys --November 1957

Area	Young Males	Adult Males	Total Males	Females W/0	Females W/1	Females W/2	Total Females	Total Calves	Total Moose
Lake Louise	5	14	19	15	24	1	39	26	84
Maclaren River	13	39	52	86	36	1	123	38	213
Clear Cr. Above Road	7	47	54	68	29	4	101	37	192
Clear Cr. Below Road	2	5	7	24	15	1	40	17	64
Total Clear Creek	9	52	61	92	44	5	141	54	256
Alphabet Ridge	79	235	314	248	130	7	385	144	843
Oshetna Rivers and Tyone Creek	20	49	69	47	44	3	94	50	213
Little Nelchina	12	31	43	29	17	3	49	23	115
Oshetna & Nelchina Combined	32	80	112	76	61	6	143	73	328
Clarence L., Black R.	20	104	124	89	78	4	171	86	381
Mt. Drum	3	28	31	27	17	0	44	17	92
Upper Gakona River	16	36	52				59	26	137*
Kiana River	3	17	20	21	4	1	26	6	52
Totals	180	605	785	654	394	25	1,131	470	2,386

*Counts made by Burkholder and Richards.

Table No. 3. Sex and age ratios in Lower Susitna & Matanuska Valley moose populations--Nov. & Dec. 1957

Area	Total Bulls/ 100 Cows	Young Bulls/ 100 Adult Bulls	Calves/100 Cows	Twin Calves/100 Cows w/Calf	Calf Percent in Total Herd	Young Bulls Percent in Total Herd	Young Bulls/ 100 Bull Calves	Young Bulls/ 100 Cows	Moose Per Hour	Total Moose
Matanuska Below Timberline	3	250	61	7	37	1	6	2	141	412
Matanuska Above Timberline	15	150	33	10	20	6	59	9	142	250
Matanuska Comb.	8	166	50	9	31	3	19	5	141	662
Willow Area	28	20	35	4	21	3	30	5	140	352
Kashwitna Area	66	13	34	4	17	4	44	8	139	318
Susitna Flats	43	69	52	10	27	9	67	17	80	201
Mt. Susitna and Beluga	82	21	54	21	23	5	52	14	118	118
Kahiltna Area	89	13	43	23	19	4	47	9*	102	204
Eagle River	26	33	41	6	23	4	32	7	140	164
Peters Creek	8	100	46	5	30	3	18	4	127	74
Ft. Richardson	13	50	60	14	35	3	15	5	88	118
Ship Cr. & Timber.	24	30	34	0	22	3	32	6	258	172
All Anchorage Areas	20	36	44	6	26	3	25	5	--	528
Combined Totals	31	28	44	8	25	4	31	7	123	2,374

*13 unidentified animals--presumably cows without calves.

Table No. 4 . Sex and age ratios in Upper Susitna and Copper River Valleys--November 1957

Area	Total Bulls/ 100 Cows	Young Bulls/ 100 Adult Bulls	Calves/ 100 Cows	Twin Calves/100 Cows w/Calf	Calf Percent in Total Herd	Young Bulls Percent in Total Herd	Young Bulls/ 100 Bull Calves	Young Bulls/ 100 Cows	Moose Per Hr.	Total Moose
Lake Louise	49	26	66	4	31	6	38	13	40	84
Maclaren River Above & Below Road	42	33	31	1	18	6	68	11	106	213
Clear Creek Above Road	53	15	37	12	19	4	38	7	--	192
Clear Creek Below Road	17	40	42	6	27	3	23	5	--	64
Clear Cr. Total	43	17	38	10	21	4	33	6	128	256
Alphabet Ridge	81	34	37	5	17	9	97	20	130	843
Oshetna & Tyone Creek	73	41	53	6	23	9	80	21	73	213
L. Nelchina	88	39	47	15	20	10	104	24	77	115
Oshetna-Nelchina Combined	78	40	51	9	22	10	88	22	74	328
Clarence Lake Black River	73	19	50	4	23	5	47	12	127	381
Mt. Drum	70	11	39	0	18	3	35	7	92	92
Upper Gakona R.	88	44	44	--	19	12	123	27*	--	137
Kiana River	77	18	23	20	12	6	100	12		52
Totals Above	69	30	42	6	20	8	76	16		2,386

*Counts made by Burkholder and Richards.

Table No. 5. Comparison of Maclaren River-Clear Creek sex and age composition counts--October and November 1957.

Area	Young Males	Adult Males	Total Males	Females W/0	Females W/1	Females W/2	Total Females	Total Calves	Total Moose
10/8/57									
Clear Creek	9	33	42	63	26	4	93	34	169
Maclaren	8	33	41	20	29	1	50	31	122
Total	17	66	83	83	55	5	143	65	291
11/11/57									
Clear Creek	7	47	54	68	29	4	101	37	192
Maclaren	2	20	22	19	6	0	25	6	52
Total	9	67	76	87	35	4	126	43	244
10/9/57									
Susitna River Jay Creek Area	5	31	36	30	11	1	42	13	91

Table No. 6. Comparison of Maclaren River-Clear Creek sex and age composition count ratios--October and November 1957.

Area	Total Bulls/ 100 Cows	Young Bulls/ 100 Adult Bulls	Calves/ 100 Cows	Twin Calves/100 Cows w/Calf	Calf Percent in Total Herd	Young Bulls Percent in Total Herd	Young Bulls/ 100 Bull Calves	Young Bulls/ 100 Cows	Moose Per Hour	Total Moose
10/8/57										
Clear Creek	45	27	37	13	20	5	53	11	78	169
Maclaren	82	24	62	3	25	7	52	19	50	122
Total	58	26	45	8	22	6	52	13	63	291
11/11/57										
Clear Creek	53	15	37	12	19	4	38	7	128	192
Maclaren	88	10	24	0	12	4	66	9	48	52
Total	60	13	34	10	18	4	41	8	86	244
10/9/57										
Susitna-Jay Creek Area	86	16	31	9	14	5	77	14	52	91

Table No. 7. An index to the survival of bull calves to 18 months.

Area	Bull Calves:100 Cows 1956	Young Bulls:100 Cows 1957	Indicated Percent Survival
Lower Susitna-Matanuska Valley			
Matanuska Valley	27	5	19
Willow	14	6	43
Kashwitna	14	8	57
Kahiltna & Susitna & Beluga Mountains	22	12	55
Susitna Flats	?	17	--
All Anchorage Areas	?	5	--
Upper Susitna-Copper River Valley			
Lake Louise	15	13	87
Maclaren River	14	11	79
Clear Creek	14	6	43
Alphabet Ridge	?	20	--
Oshetna-Nelchina	15	22	?
Clarence Lake-Black River	?	12	--
Mt. Drum	16	7	44
Upper Gakona River	?	?	--

Table No. 8. Comparison of sex and age ratios in moose populations of Alaska.

Area	Total Bulls/ 100 Cows	Young Bulls/ 100 Total Bulls	Calves/ 100 Cows	Twin Calves/ 100 Cows w/Calf	Calf Percent in Total Herd	Young Bull Percent in Total Herd	Young Bulls/ 100 Bull Calves	Total Moose in Sample
<u>Susitna-Matanuska Valley</u>								
1957	31	28	44	8	25	4	31	2374
1956	27	25	40	6	24	4	33	1276
1955	28	25	35	4	21	4	39	2850
1954*	63	--	30	2	16	--	--	601
1953	48	14	39	8	21	3	33	2700
1952	42	27	44	10	24	6	51	1421
1951	61	28	60	13	27	8	56	1867
1950	--	--	--	--	16	--	--	1140
Mean	43	24	42	7	22	5	41	1778
<u>Upper Susitna-Copper River Basin</u>								
1957	69	30	42	6	23	5	76	2386
1956	67	19	27	2	14	7	95	1154
1955	98	29	52	10	21	12	108	2500
1954	109	26	79	16	27	10	72	1700
1953	107	36	90	17	29	12	85	1100
1952	61	22	40	17	20	7	67	683
Mean	85	27	56	11	22	9	84	1587

Table No. 8. (Continued)

Area	Total Bulls/ 100 Cows	Young Bulls/ 100 Total Bulls	Calves/ 100 Cows	Twin Calves/ 100 Cows w/Calf	Calf Percent in Total Herd	Young Bull Percent in Total Herd	Young Bulls/ 100 Bull Calves	Total Moose in Sample
Kenai**								
1957	43	18	35	12	20	4	45	3155
1956	51	13	24	10	14	4	54	3786
1955	50	14	19	10	13	4	75	3109
1954	84	14	27	6	12	6	90	2048
1953	62	12	26	7	14	4	39	2900
1952	50	33	21	6	12	10	156	1136
1951	69	18	23	16	12	7	108	1513
1950	--	--	--	--	7	--	--	1158
Mean	58	17	25	10	13	6	81	2350
Tanana Valley***								
1957	60	32	42	2	20	7	71	236****
1956	84	20	47	6	20	7	71	405
1955	123	40	53	13	19	18	186	410
1954	85	35	47	5	20	13	127	109
Mean	88	32	47	7	20	11	114	290

* Limited sample may not be representative.
** Data from Refuge Supervisor Spencer.
*** Young bull-adult bull identification uncertain.
**** Does not include same areas as previous years.

RECOMMENDATIONS

The results of the 1957 sex and age composition counts suggest the following recommendations.

1. Sex and age composition counts should be made during the period of rut, in late September and early October.

2. The possibility of obtaining another measure of first-year survival should be tested by making calf:adult counts on certain key populations in April and early May.

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Date: January 31, 1958

JOB NO. 4: Distribution, Movements and Dynamics of the Railbelt Moose Populations

PERIOD COVERED: January 3, 1956, to January 1, 1958

ABSTRACT

A study of the railroad-moose conflict in the Lower Susitna Valley area was conducted from January 3, 1956, through May 15, 1956, and from November 1956 through June 15, 1957. A study of moose population dynamics was conducted in conjunction with the railroad-moose study.

The problem is created by the combination of the following factors: (1) an abundant moose population, (2) deep snow, and (3) large quantities of winter moose browse along and adjacent to the right-of-way.

The critical kill area is between Houston (Mile Post 172) and Talkeetna (Mile Post 226), a distance of 54 miles.

In December 1956 a system for reporting all railroad killed moose was devised.

Two hundred twenty-five moose were reported killed in 1955-56 and 93 in 1956-57. The reporting system is not accurate. The adjusted total kill was 366 and 179, respectively.

Several temporary moose saving technics, suggested in 1955-56, were evaluated in 1956-57. The following are worthy of implementation: (1) daylight train operation through critical areas, and (2) reduced train speed through critical areas.

Understanding the factors influencing seasonal moose movements is believed to be the key to formulating plans for keeping moose away from the right-of-way.

Some moose populations inhabiting the Lower Susitna Valley exhibit seasonal altitudinal migrations. The magnitude and extent of these migrations are not fully understood and warrant further investigation.

Bulldozed trails and feed yards, as a means of keeping moose off the right-of-way, were experimented with and found partially successful.

Moose guards were tested, but no definite conclusions are drawn.

Approximately 40-45,000 pounds of moose meat were salvaged and distributed to charitable institutions in 1956-57. This represents 80-90 percent of all salvable meat and an increased salvage efficiency of 100 percent over 1955-56.

The direct cost of the moose problem to the railroad over the past ten years is not known, but has amounted to thousands of dollars annually.

The moose populations of the Lower Susitna Valley are probably the most valuable herds in Alaska. Future research must be directed towards goals which will benefit both the railroad and the moose.

The study of moose population dynamics revealed the following information:

1. Yearling bulls (16-18 months) are sexually mature.

2. Spermatozoa, presumably viable, are present in the epididymis from August to December.

3. Most cows breed first at 28-30 months of age, although a few yearling cows do breed.

4. Eighty percent of the cows in this population breed during a 15-day period in late September and early October.

5. Fifty percent of the cows have calves by late May.

6. One hundred twenty-four sets of lungs were examined for the presence of hydatid cysts, Echinococcus granulosus; 25, or 20 percent, were infected.

7. Ninety-eight cows were examined for pregnancy data; 87 of 93, or 94 percent, Age Class II or above were pregnant.

8. Weights and measurements of 69 fetuses and 83 calves and adults are presented.

9. Age determinations made on the mandibular teeth of 240 railroad killed moose revealed that there is a predominance of "middle" and old age females and that sex selective mortality factors probably affect males excessively.

OBJECTIVES

1. To determine the patterns of distribution, seasonal movements and population identities of moose in the Railbelt area from Turnagain Arm to the Alaska Range, and in cooperation with the Alaska Railroad to seek a solution to the problem of railroad-moose conflicts.

2. To obtain data on reproduction, mortality, age structure, rate of growth and health as a basis for interpreting the dynamics of these populations.

TECHNIQUES USED

Data on seasonal movements, distribution and population identity were obtained by making aerial counts of the moose inhabiting the Railbelt area, by examining the railroad kill reports and from field observations.

Experiments with bulldozed trails and feed yards, moose guards and slow orders on trains were conducted in an effort to find a solution to the railroad-moose conflict.

Examination of approximately 450 railroad killed moose provided data on reproduction, sex and age composition, growth and health of the Railbelt moose populations.

FINDINGS

Railroad-Moose Conflicts in the Susitna Valley

The Problem: The Alaska Railroad traverses the winter range of some of Alaska's most abundant moose populations, in the Lower Susitna Valley and on portions of the Kenai Peninsula. These areas frequently have severe winters and the ground may be covered with 60 or more inches of snow during portions of late January, February, and March. Moose have great difficulty traveling through this snow and frequently enter the snow-free railroad right-of-way, obstructing train operations, and often being killed. The number of moose killed, which depends partially on the severity of the winter, has averaged several hundred annually for the past few years. This represents an undesirable destruction of a valuable resource, as well as an additional expensive and dangerous operating hazard to the Railroad.

In January of 1956 the Alaska Railroad in cooperation with the U. S. Fish and Wildlife Service started an investigation of the moose versus railroad problem. This study was continued during the winter of 1956-57, as a Federal Aid in Wildlife Restoration research project.

The problem, though having many facets, was studied with two major goals: (1) to investigate methods of removing the moose from the right-of-way without injuring them and without causing undue delay to train operations; and (2) to investigate methods of keeping moose off the tracks and away from the right-of-way. A preliminary report on the studies conducted from January through May of 1956 was submitted in July of 1956. The present report combines pertinent data from the preliminary report with that obtained during the winter of 1956-57.

The investigations of the railroad versus moose conflict have not solved the problem, but a basic understanding and definition of the problem has been gained; the magnitude and probable effect of the kill is known; several recommendations for alleviating the situation during critical periods have been made and evaluated; and a study of moose population dynamics, which may be the key to the entire problem, has been initiated. Continued research on a limited basis promises to unveil more answers, and is discussed in detail in this report.

History of the Problem: Moose populations in the Lower Susitna Valley, specifically the area between Matanuska and Talkeetna, were not considered abundant until about 15-18 years ago. Available records and interviews with long-time valley residents suggest that moose were scarce in the valley in the late 1920's and early 1930's. Chatelain (1951) states that great numbers of moose first appeared in the Matanuska Valley about 1947-48, and that large numbers of moose had wintered along the railroad only since the early 1940's. The first records of significant moose versus train conflicts are from 1946.

It is believed that the moose populations of the Lower Susitna Valley, excepting the area around Wasilla, Palmer and Matanuska, probably reached their peak about 1950, and have slowly declined since then. A shortage of winter browse, concurrent with several unusually severe winters, is believed to have caused the gradual reduction in moose numbers. Despite the great numbers of moose present in the late 40's and early 50's, they were not sufficiently numerous to retard ecological "plant succession", and dense stands of birch, 20 to 30 feet high, now dominate much of the former winter range. This winter range, which initially provided for the greatly increased moose populations, was created by fires and clearing operations concurrent with construction of the railroad right-of-way and subsequent settlement activities in the late twenties.

The residual moose populations, which are considerable, now concentrate in the remaining winter browse areas along the railroad during the late winter months. These browse areas, created in the last 10 to 15 years, also are the result of man's activities. The more important areas are as follows: Willow airstrip, constructed in 1940-42; Kashwitna River burn, 10-15 years ago; Caswell Creek, a natural river valley; Montana Station burn, 1940-45; other burns of 10 to 15 years ago at Mile Posts 213-215, 217-220, 222-223, Talkeetna C.A.A. installation and airfield (exact date unknown), and a burn extending from Mile 228 to 232 which is just beginning to produce quantities of winter browse. These areas have been sites of major moose concentrations since the mid-1940's, and areas of critical friction between the railroad and moose since 1946 (Chatelain 1951). The problem first gained widespread public attention in 1948.

The 54 mile segment between Houston and Talkeetna has apparently been the major critical area from the start of the conflict. An aerial count of moose within a strip one-quarter of a mile wide, using the railroad as the center line of the strip, on January 12, 1950, by Scott and White of the Fish & Wildlife Service, revealed 164 moose between Houston and Talkeetna (Table No. 1).

Table No. 1. Aerial count of moose within 1/4 mile of right-of-way, January 12, 1950.

Section	West	On Tracks	East	Total
Houston-Willow	13	2	14	29
Willow-Kashwitna	25	4	12	41
Kashwitna-Caswell	23		8	31
Caswell-Montana	28		2	30
Montana-Sunshine	23		1	24
Sunshine-Talkeetna	4		5	9
Total Mileage--Approximately 50			Total Count -	164

In late March of 1951 Chatelain reports having counted the remains of 104 railroad-killed moose between Houston and Talkeetna, and the remains of 93 in the same area again in 1952. Watson (viva-voce) reports counting 99 railroad-killed moose on the same area during 1953. Chatelain estimated that 75 percent of the total kill occurred on the Houston-Talkeetna segment. In late April of 1956 the writer counted 219 different carcasses and gut piles on the same area. In 1956, data from the reported kill and records from meat salvaged indicated that 60 percent of the entire railroad moose kill occurred on this 54 mile (11 percent of total mileage) segment of the railroad. Again in 1957 this area accounted for 75 percent of the total known kills.

It is assumed, and interviews with railroad personnel and valley residents corroborate the assumption, that the moose kill equaled or exceeded that of 1955-56 during years of deep snow such as 1947-48 and 1953-54, and conversely was much reduced in years of lesser snowfall such as 1956-57. However, factors other than snowfall help determine the magnitude of the kill (see Magnitude of the Kill).

The combination of deep snow, choice winter range and great moose concentrations are the elements necessary for producing a critical moose versus railroad problem. As indicated in the previous discussion there are several such areas in Alaska. This situation is unique in North America. Correspondence with wildlife administrators in various Canadian provinces which have abundant moose populations and associated railroads indicated that a few moose are killed annually, but that no critical areas comparable to the Houston-Talkeetna area exist. Reports and correspondence from Norway show that they have a moose versus train problem of equal or greater magnitude. In an interview with a former Norwegian railroad conductor, now living in

Anchorage, he stated that 350-500 moose were killed annually on one segment of the railroad. He also stated that they had found no satisfactory means for keeping the moose off of or for scaring them from the tracks. However, he stated that no effort had been made to do either at that time (1945-46) as there was a serious meat shortage and over-population of moose, the latter brought about by curtailed hunting during the war. It is hoped that more detailed information will be obtained from correspondence with Norwegian game administrators.

Magnitude of the Kill: One of this project's initial objectives was to determine, accurately, the number of moose killed annually by trains. In December of 1955 a reporting system was devised (see 1956 Preliminary Report). The investigations conducted in 1955-56 and 1956-57 show that the present reporting system is not satisfactory, as only 60 percent of 224 known kills on the project area were reported in 1955-56, and 52 percent of 104 kills were reported from the same area this year. Some of the reasons for the failure of the system were reported on in 1956. One of these reasons involved freight trains, which are required by railroad rules to come to a stop and make a train inspection after hitting a moose or any other large obstruction. This is a safety measure. Evidence accumulated in 1955-56 indicated that many trains did not observe this rule, and to avoid possible recriminations, should an accident occur after hitting a moose, the trainmen did not report having hit a moose. An analysis in 1956-57 of known moose kills versus reported moose kills revealed that only about 80 percent of all train-killed moose were killed by passenger trains, whereas, the weekly kill report indicated 94 percent of all kills were by passenger trains. This further substantiates the conclusion that freight trainmen fail to report many of the moose hit by their trains.

It has been suggested that perhaps significant numbers of moose run into the side of a passing train and are not observed by the train crew. Detailed observations of over 200 moose fatalities and of nearly 150 moose versus train encounters failed to find a single incidence of moose running into the side of a train. It is possible that moose may occasionally be killed in this manner, but this kill does not account for the differences between observed and reported moose fatalities.

At present, no satisfactory method for improving the reporting system is known. Perhaps continued solicitation for cooperation of the trainmen will eventually stimulate an interest comparable to that evinced by the section personnel toward moose salvage problems.

An accurate reporting system will greatly help in formulating temporary moose-conserving measures, such as localized slow orders, and would provide a measure of local population fluctuations. It is suggested that continued effort to enlist the cooperation of trainmen in reporting railroad killed moose be continued and, if possible, pursued further.

Utilization of Railroad Killed Moose: Some of the problems involved in salvaging railroad-killed moose were discussed in the 1956 Preliminary Report. Data obtained in 1955-56 show that the sections of Willow, Caswell and Sunshine salvaged only 42 percent, or 94 of 224 railroad-killed moose (Table No. 2). This past winter's kill, as illustrated by Table No. 2, shows that nearly 80 percent of all railroad killed moose on these same three sections were salvaged. In 1955-56 it was determined that approximately 10 percent of the railroad-killed moose were totally destroyed and thus not salvable. The determination of what constitutes salvable meat varies and the writer's estimates are somewhat higher than those of the people actually salvaging the meat. Nevertheless, only about 10 percent of the salvable kill was not utilized. This may represent the minimum loss under the present system of reporting and salvaging kills.

In addition to the moose not reported during the work week, another loss is incurred by the moose killed on Saturday morning by southbound passenger No. 7. Many of these moose are not on the Saturday morning lineup and as no sections work on Sunday they are not salvaged. Moose killed on Sunday could not be salvaged until Monday. Also, heavy snowstorms make it impossible to operate gas cars and moose killed during such storms are not salvaged.

The salvage effort and results the past season are most encouraging. The reason for this greatly increased success is largely due to increased interest and cooperation from the section personnel. Another factor of unknown significance was the presence in the area of one and occasionally two men representing the Railroad and the Fish and Wildlife Service on moose investigations. Still another factor was the kill itself which was not as great as that of 1955-56 and consequently the section crews were not faced with the unpleasant task of butchering moose every morning--not quite! Although the total kill was less, one section salvaged nearly 80 percent more moose in 1956-57.

It is the writer's opinion that this increased success in salvage operations was due largely to the increased awareness of the overall problem and subsequent determined effort by the section personnel. This awareness and cooperation was stimulated by the continued interest shown by the Alaska Railroad and the Fish and Wildlife Service. The impact, public-relationwise, of this increased utilization of a valuable resource should not be minimized. That 80-90 percent of all salvable meat was utilized and distributed to charitable institutions is, in itself, a considerable accomplishment.

Table No. 2. Moose salvaged on project area, 1955-56 and 1956-57.

Location	Salvaged	Unsalvaged	Percent Salvaged	Total Moose	Percent of Total	Percent of Total Excl. Talkeetna
1956-57						
Willow	19	6	76	25	19.5	20.5
Caswell	29	12	71	41	32.0	33.6
Sunshine	48	8	83	56	43.7	45.9
Talkeetna	3	3	50	6	4.8	
Totals			77	128	100	100
			79 excluding Talkeetna			
1955-56						
Willow	38	12	76.0	50	22.3	
Caswell	30	50	37.5	80	35.7	
Sunshine	27	67	30.3	94	42.0	
Totals	95	129	42.4	224	100	

Temporary Expedients

Technics for removing moose from the right-of-way without killing them and without unnecessarily delaying train schedules fall into the category of temporary expedients, because while they may alleviate the problem they do not solve it. Several such experiments were tried and reported on in 1956; three--(1) manipulation of horn and lights, (2) slow orders, and (3) daylight train operations--were studied and tested again in 1956-57. The results of these studies are discussed in this section.

1. Horn Blast-Light Manipulation Technic. The possibility that many moose could be saved through proper horn-light manipulation by the train's engineer was investigated and reported on in 1956. This technic was further investigated during the winter of 1956-57. A total of 150 train versus moose encounters were recorded for the past two years. In 1955-56, 23 of 115 moose encountered were killed; 7 of 40 were killed in 1956-57. However, the variables of moose abundance,

snow depths, and personalities are such that direct comparison of the results is not possible. The only conclusive result seems to be that sounding the train's horn at a distance greater than 100 yards from a moose is unwise; although the sound of the horn initially frightens the moose into leaving the tracks, prolonged or early sounding confuses or angers the moose and it frequently reenters the tracks before the engine has passed. Dimming or turning off the headlights has no apparent effect on the behavioral response of the moose. Most engineers sincerely attempt to avoid hitting moose, and many have developed technics for avoiding and scaring moose encountered on the tracks. However, the value of present moose scaring technics is questionable.

2. Speed. Train speed is an important factor in determining the fate of moose encountered on the tracks. Comparison of a number of train versus moose encounters at speeds greater and less than 30 miles per hour reveal that, other factors being equal, the train traveling 30 miles per hour or less kills fewer moose. This fact has definite moose saving possibilities, since critical areas along the right-of-way can be determined in advance by making aerial counts of moose populations along the railbelt (Figures 1 and 2). Also, the data obtained in 1955-56 demonstrated that the areas along the right-of-way having the combination of good winter moose browse, deep snow and great moose concentrations also have the greatest annual railroad moose kill.

If a slow order is placed on night train operations through these areas, considerably fewer moose will be killed. One such area was detected this past winter; the area between Mile Posts 198 and 224. On February 7, 1957, a slow order was placed on Train No. 8, night passenger to Fairbanks. The writer recorded 17 moose versus train encounters while riding in the cab of the slow-ordered train; no moose were killed. Prior to the slow order as many as 10 moose had been killed in one night.

The greatest concentrations of moose appear along the right-of-way at different periods throughout the winter months (Table No. 4). Normally the moose do not remain in one locality long, and the affected areas are not extensive; thus it is seldom that an area greater than 15-30 miles would need to be slow-ordered. This should not cause excessive delay to train schedules and, in fact, should significantly reduce delays caused by moose fatalities.

Slow orders, like other temporary expedients, will not solve the problem, but will reduce the number of moose fatalities and possible train damage and delay resulting from moose-train encounters.

Figure No. 1. Number of moose counted within 1/8 mile of tracks on 19 periodic aerial counts; winter 1956-57.

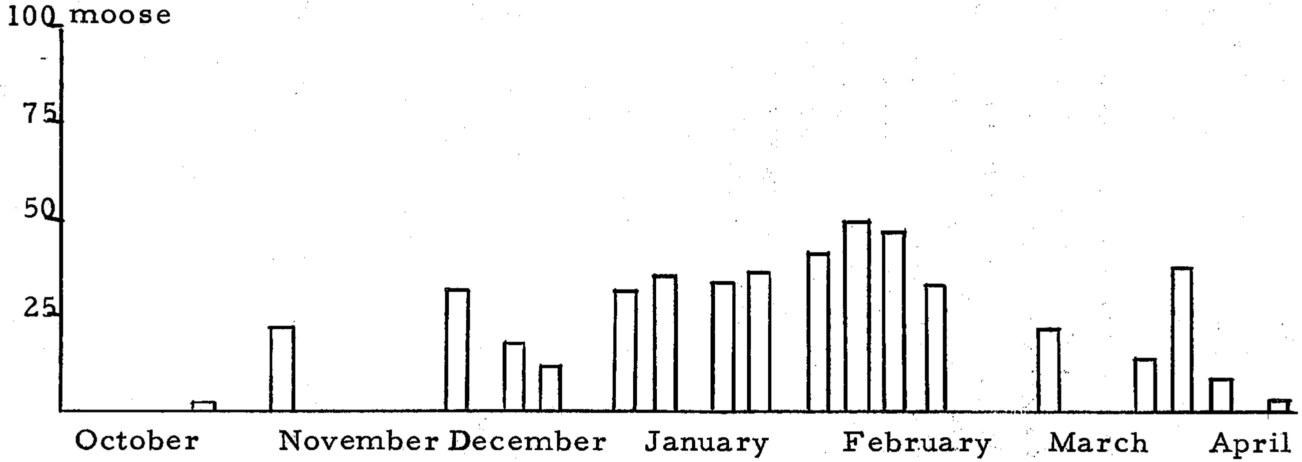
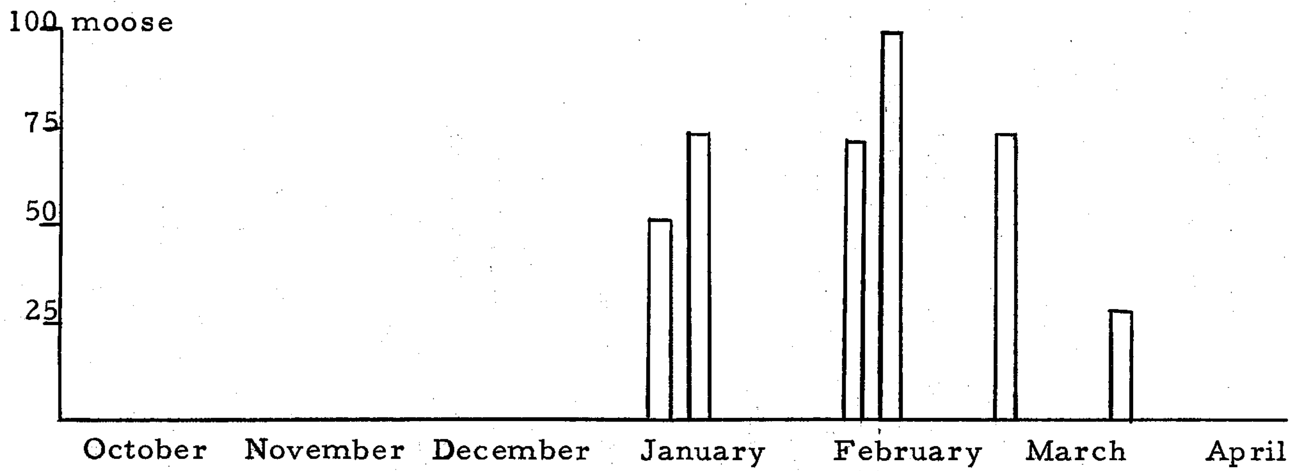


Figure No. 2. Number of moose counted within 1/8 mile of tracks on 6 periodic aerial counts; winter 1955-56.



3. <u>Day versus Night Train Operations.</u> Data obtained from aerial counts of the railbelt moose populations, observations from the cab of train engines, ground reconnaissance work and numerous interviews with train crews indicate that relatively few moose are encountered on the tracks during the daytime. Aerial counts made on 1,840 moose during the past two winters reveal that approximately 70 percent of them were bedded down during the day. It is generally believed that moose are most active in the early morning and evening, and that they usually are bedded down during the middle of the day. The data obtained during the present study further supports this belief.

In an attempt to determine which trains accounted for the most moose, section crews were requested to keep a record showing the time of day and train involved in each moose fatality. This information showed that approximately 80 percent of this year's total kill occurred at night or in the early morning, i.e., prior to 0600. This information also indicated that the night passenger trains to and from Fairbanks accounted for nearly 80 percent of the moose fatalities. These were the only regularly scheduled night train operations.

Due to traffic schedule changes a majority of the trains operated through the Houston-Talkeetna area during daylight hours in the winter of 1956-57, yet these trains accounted for only 20 percent of the total number of moose fatalities.

Train operations through critical kill areas should be scheduled for daylight hours whenever it is economically feasible.

<u>Keeping Moose Away from the Tracks</u>

A successful means for ending the moose versus train conflicts in the Lower Susitna Valley will be obtained only by removing or diverting the moose populations from the right-of-way. This is one of the few abundant moose populations in Alaska that is readily accessible to hunters and vacationists, either by car or train, and since it is also located near Alaska's largest city, Anchorage, the herd is of tremendous economic and aesthetic value. A major reduction in numbers of moose is not considered a logical or satisfactory solution to the problem.

It is recognized that before a permanent program can be formulated for keeping moose away from the right-of-way the seasonal movements of the moose populations involved must be more fully understood. Moose are known to exhibit definite seasonal migrations in parts of British Columbia and Norway. The seasonal influx of moose into choice winter browse areas along the railroad is believed to represent this type of movement; however, the distances and magnitude of these movements are not yet known.

Movements. The Alaska Railroad from Houston to Talkeetna roughly parallels the Susitna River, ranging from several miles east of, and to the river's edge. Numerous tributary streams of the Susitna River cross the railroad and form excellent avenues of approach, complete with choice winter browse, for the moose. The headwaters of these streams are in the Talkeetna Mountains some 10-30 miles east of the railroad. The foothills and timberline areas of these mountains comprise the fall and early winter range of great numbers of moose. Aerial sex and age composition counts made in October have counted several thousand moose near or above timberline from the headwaters of Montana Creek to the Little Susitna River. These counts are not designed to indicate total population but merely to provide sex and age composition data. Most of the moose are still in small bands or "harems" when October counts are made. In November, these groups disband and some of the moose apparently begin the annual movement to the wintering areas adjacent to the right-of-way. Aerial counts and the railroad kill (Figure Nos. 1, 2, and 3) indicate that the first incidence of increased moose activity along the tracks begins in November. The timing and magnitude of this first movement may be influenced by snowfall as well as social and behavioral factors. In 1956, early snowfall in the timberline areas apparently caused an early migration into the lowland areas. This was reflected by the hunter kill during the November moose season when at least 200 male moose were killed in the valley areas, at least 20 of which were killed in the immediate vicinity of Willow airstrip. In contrast, the hunter kill in November of 1956 was less than 100 animals and no moose were killed around Willow airstrip.

The aerial counts and railroad kill of the past two years reveal striking similarities in population densities and corresponding increases or decreases in moose fatalities (Figure Nos. 1, 2, and 3). Moose populations and fatalities reached their peak in February of both years, with nearly 50 percent of the total kill occurring in this month (Figure No. 3). This corresponds, also, with the time of deepest snow cover (Table No. 3). Snow depths definitely influence the magnitude and in some instances the date of greatest moose kill. However, the close correlation between the peak of moose population densities and subsequent dispersal for the past two years, years of great contrast in snow depths, suggest that the population movements may represent basic seasonal movements--movements influenced but not caused by the depth of snow cover (Figure Nos. 1 and 2).

Figure No. 3. Percent of total railroad killed moose, by month, 1955-56 & 1956-57.

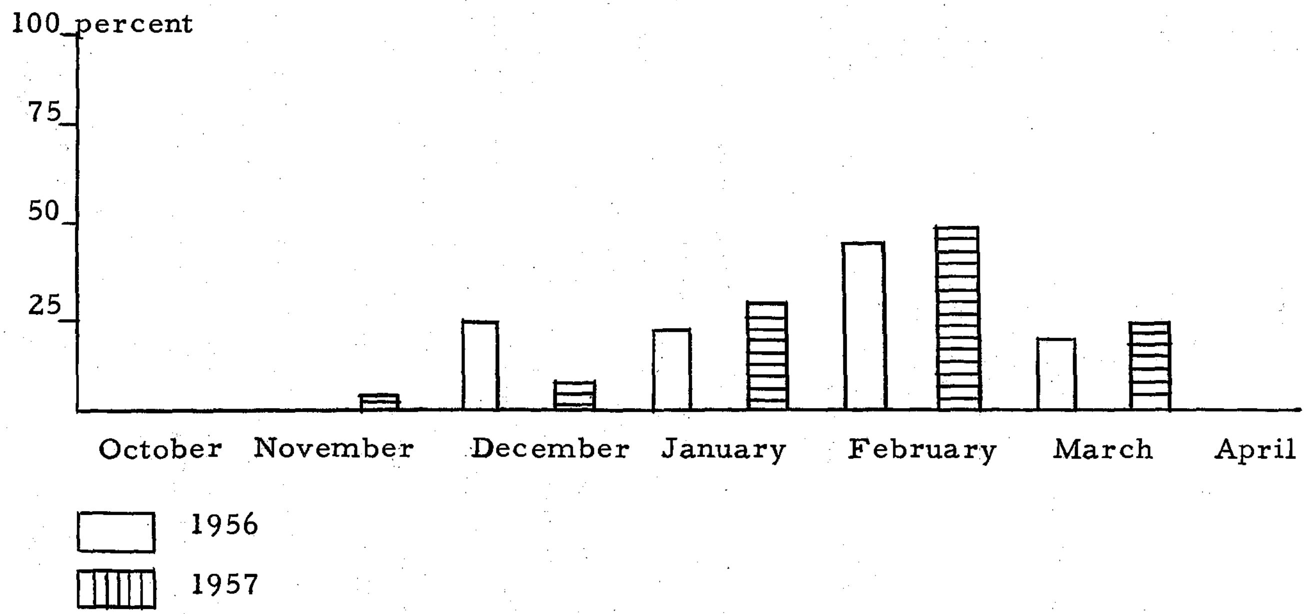


Table No. 3. Snow depths winter 1956-57.

Area	Date	Average	Range
Willow--M.P. 186	12/17/56	17"	9-26
"	12/28/56	19"	12-27
"	1/18/57	30"	15-44
"	3/5/57	33"	27-45
Caswell--M.P. 202	12/26/56	27"	24-27
"	1/16/57	39"	36-43
"	1/23/57	37"	34-39
"	4/3/57	39"	---
Sunshine--M.P. 216	12/20/56	24"	18-33
"	1/17/57	34"	20-45
"	2/15/57	43"	36-52
"	2/27/57	39"	33-46
"	3/1/57	44"	35-52
"	4/2/57	38"	33-46

Measurements were taken from five representative terrain types at each location.

Examination of the kill by area shows that the area first evidencing increased winter moose populations is Willow, where the kill may begin in October (Figure No. 4). This area has sustained great kills in the past years, including 1955-56; however, the kill in 1956-57 was relatively light. Interpretation of moose movements on this area is complicated by the fact that aerial counts indicate very few moose wintering adjacent to the tracks (Table No. 4). Winter browse is very limited along this portion of the track, and that available is adjacent to the right-of-way. It is possible that the relatively great kill on this section reflects a browse shortage rather than an abundant moose population.

The greatest percentage of the kill on this section occurs prior to February, whereas the peak of moose abundance and moose fatalities occur in February on the Caswell and Sunshine areas. Aerial observations, combined with several fortuitous snowfalls, enabled the investigator to trace the progress of a major movement of moose into the above areas. Aerial counts made in late January revealed great numbers of moose tracks and moose along the tributary streams of the Susitna, principally the Talkeetna River, Kashwitna River, Montana Creek, Goose Creek, Sheep Creek, and Caswell Creek. Presumably the moose were headed toward the winter browse areas along the Susitna River and the Alaska Railroad. At the time of this movement the

Figure No. 4
1955-56 & 1956-57 Railroad Moose Kill
Percent of Kill, by Sections, for Each Month

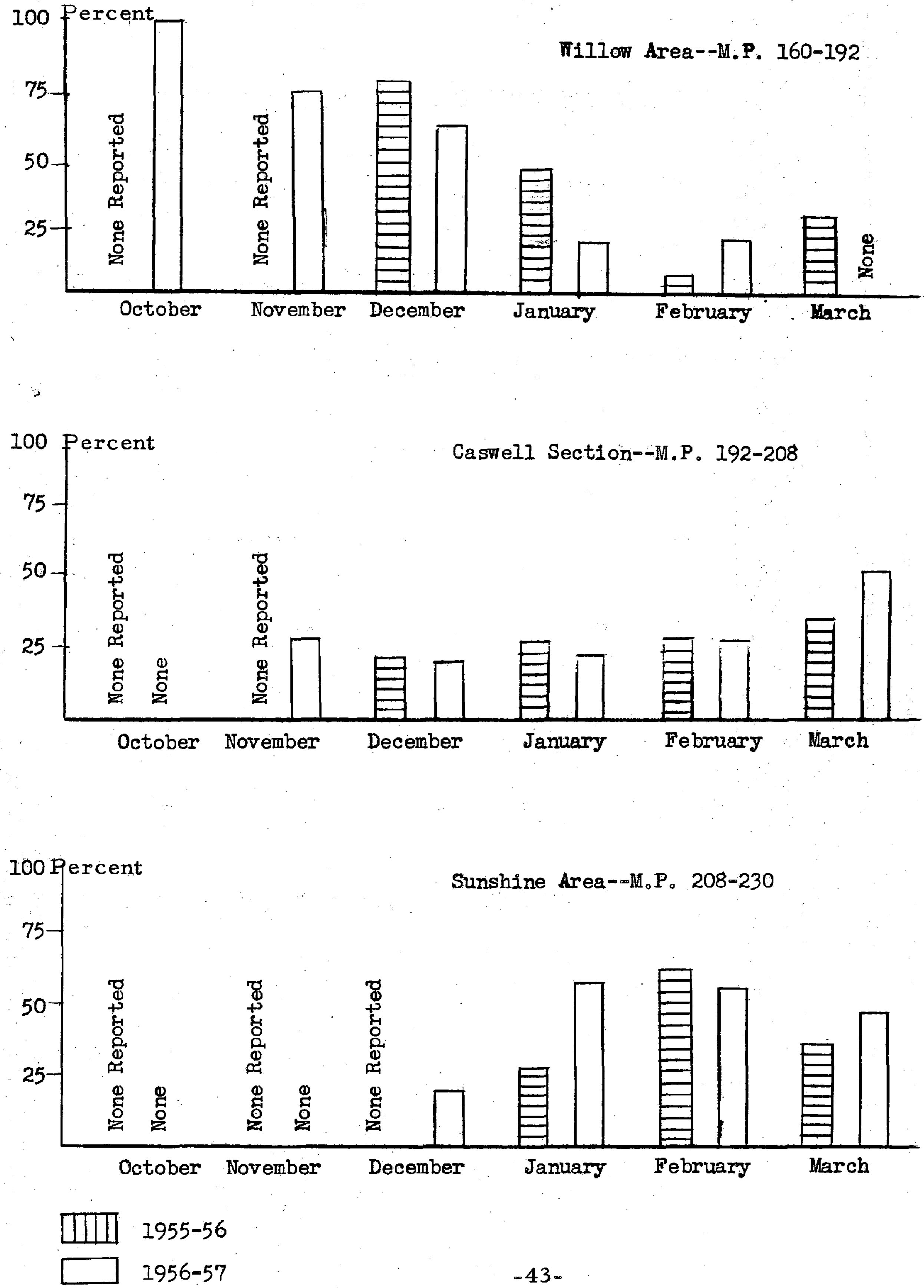


Table No. 14. Aerial counts of railbelt moose populations

Date	Eklutna Matanuska	Matanuska Pittman	Pittman Houston	Houston Nancy	Nancy Willow	Willow Kashwitna	Kashwitna Caswell	Caswell Montana	Montana Sunshine	Sunshine Talkeetna	Total Moose	Ave. 19 Flights
10/21/56			2					2			4	
11/8/56		9	6		2	1		7	6	8	39	
11/23/56			11	2			4	1			18	
12/3/56	19	37	3	3		2	14	5	4	5	92	
12/11/56	17	39	2		3	1	1	2	1	11	77	
12/17/56	19	41	3	2	1	4				6	76	
12/29/56	4	7	15	1	2		5	11	2	12	59	
1/7/57	14	32	9	1			8	5	3	20	92	
1/16/57	2	49	16				7	13	1	14	102	
1/21/57							12	6	6	13	37	
1/31/57	19	36	6				14	16	4	8	103	
2/5/57	13	47	4			1	11	12	11	16	115	
2/11/57	14	31	2	2		2	12	9	5	17	94	
2/20/57	13	75	8			5	5	8	3	13	130	
3/5/57	16	16					1	10	3	8	54	
3/19/57	13	12		2	1	5		3		4	40	
3/25/57	8	9				3	9	5	10	11	55	
4/1/57		6	2			1	3		2	4	18	
4/12/57							1		1	2	4	
Totals	171	446	89	13	9	25	107	115	62	172	1,209	63.6
Percent of Total	14.1	36.9	7.4	1.1	.7	2.1	8.9	9.5	5.1	14.2		
Percent of Kill	2.5	5.8	4.9	4.1	4.1	7.4	12.3	18.1	12.3	28.0		

All moose within 1/8 mile either side of track are counted.

snow was not deep enough in the foothills or at timberline to seriously hamper moose foraging activities. A possible important factor was the freezing over of the upper reaches of the streams and rivers; thus affording the moose an easy avenue of travel. The moose reached the tracks on or about the first week of February, and this was immediately reflected in the increased railroad kills (Figure No. 3), moose counted (Table No. 4), and general moose sign. The snow accumulations were not great enough to seriously hamper moose movements and the majority of the moose moved across the tracks to winter browse areas along the Susitna River or settled in the browse areas adjacent to the right-of-way. The number of moose killed by trains declined sharply concurrent with the moose dispersal.

During years of great snow accumulations, such as 1955-56, it is believed that a greater portion of the moose would have remained along the railroad with its combination of available browse and easy walking.

Winter Browse Areas. Localization of moose populations along the railbelt area is believed to be a possible solution to the current problem.

In an attempt to evaluate the effectiveness of winter browse areas as moose localization agents, a large (approximately 10 square miles), recently burned over area which contains large quantities of favored winter moose browse was selected for study. This area, located about 10 miles northeast of Willow, was known to have over-wintered a large number of moose in 1955-56. Periodic aerial counts of moose utilizing this area were made from mid-October, 1956, through mid-April, 1957 (Table No. 5). Although several distinct population fluctuations were noted, at least several hundred moose are known to have over-wintered on this area, without approaching the railroad.

Several other browse areas were periodically counted during the past winter (Table No. 6). Information obtained from these observations indicate that strategically located winter browse areas could attract many of the problem moose; however, until the nature of the fall and winter migrations are more fully understood, no detailed recommendations for creating such areas can be made.

Table No. 5. Compilation of aerial counts of moose inhabiting the Willow Burn.

Area	Date	Total Moose	Adult	Calf	Calf: Adult	Counting Conditions	Moose Per Hr.
Willow	10/21/56	122	95	27	28:100		
Burn	11/8/56	125	95	30	32:100	Poor	300
"	11/23/56	101	71	30	42:100	Very Poor	224
"	11/23/56	46	34	12	35:100		
"	12/3/56	199	137	62	45:100	Very Good	398
"	12/17/56	191	144	51	35:100	Good	370
"	12/29/56	119	90	29	32:100	Fairly Good	238
"	1/7/57	107	81	26	32:100	Fairly Good	214
"	1/16/57	166	123	43	35:100	Good	200
"	1/21/57	114	87	27	31:100	Good	201
"	2/5/57	122	108	14	13:100	Good	236
"	2/11/57	130	101	29	28:100	Fair	243
"	2/20/57	88	77	11	14:100		220
"	3/5/57	76	59	17	28:100	Poor	127
"	3/19/57	63	50	13	26:100	Very Good	151
"	3/19/57	43	30	13	43:100	Very Good	103
"	3/28/57	111	90	21	23:100	Good	175
"	3/28/57	100	82	18	22:100	Good	187
"	4/1/57	23	18	5	28:100	Poor	160
"	4/12/57	15	12	4	27:100	Fair	48

Table No. 6. Compilation of aerial moose counts on other areas.

Area	Date	Total Moose	Adult	Calf	Calf: Adult	Counting Conditions	Moose Per Hr.
Montana	12/29/56	9					
Burn	2/5/57	33					
"	2/11/57	21					
"	3/5/57	17	14	3	21:100		168
"	3/25/57	33					396
"	4/1/57	44					
"	4/12/57	1	1				6
Sunshine	11/8/56	36	25	11	44:100		
Burn	1/16/57	13	11	2	18:100		
"	2/20/57	18	15	3	20:100		135
"	3/5/57	22	19	3	16:100		165
"	3/19/57	15	12	3	25:100	Very Good	180
"	4/12/57	10	8	2	20:100	Good	60
Wasilla	12/17/56	123					
Burn	12/29/56	38	25	13	52:100	Fair	
"	1/7/57	30	22	8	36:100	Fairly Good	180
"	1/16/57	43	26	17	65:100	Very Good	258
"	2/5/57	15	10	5	50:100		150
"	1/31/57	13	10	3	30:100		156
"	2/20/57	34	26	8	31:100		140
"	3/5/57	18	15	3	20:100		135
"	3/19/57	2	2	0	0:100	Very Good	24
"	4/12/57	0	0	0		Poor	0

Bulldozing Experiments. Creating trails parallel to the right-of-way in an effort to divert the moose from the tracks was tested by bulldozing trails in the Houston-Willow and Montana areas in January of 1956. The results of this experiment indicated that bulldozed trails might be an efficient temporary expedient for keeping moose off the tracks.

In addition to walking along the trails the moose utilized the browse created by the trail clearing operations. However, numerous moose persisted in leaving the trails and crossing the tracks, often wandering up and down them, feeding on the browse available and obstructing train traffic. The possibility that a combined trail, feed yard and "moose guard" operation might localize certain moose populations was proposed and investigated this past winter.

The feed yards were created by bulldozing down quantities of aspen, birch and willow trees in conjunction with the trail-making operations. The moose guards are adaptations of cattle guards, placed on the railroad tracks at points where the bulldozed trails cross them to prevent the moose from entering the right-of-way.

The area selected for this combination experiment was the critical kill area at Montana, Mile Posts 207-212. This six-mile area accounted for 25 percent of last year's total known kill, and also borders one of the few remaining areas of high quality winter range. Originally, the plan was to be effected in November, but an equipment shortage delayed inauguration until February. Fortunately, the moose populations by-passed this area in early winter and located along the Susitna River and near Sunshine. In February, when construction of the project was completed, the moose population present was so low that little quantitative data was obtained; however, in March between 40-50 moose moved into the immediate area, using the trails, feed yards and frequently crossing the right-of-way. These moose seemed perfectly content to eat the browse provided them by the feed yards and to wander about on the trails, occasionally making short journeys to choice browse areas, but almost invariably returning to the trails. Snow conditions during this period were not critical to moose movements and the use of the trails would doubtless have been greater had the snow been deeper.

The moose guards proved only partially effective. Initially a snow berm was placed between the trail and edge of the guard to prevent moose from circumventing the guard. However, by March this had been destroyed by snow removal operations and frequently the guard was clogged with snow. A few moose did cross the guard or walk around it, but they generally wandered up or down the tracks a few hundred yards and then returned to the trails. Several instances of moose, frightened by trains or gas cars, crossing the moose guard were recorded, but no instances of moose voluntarily crossing the guard when it was functional were recorded.

Only two moose were killed on this area during the period of great moose abundance. This total cannot be compared directly to the 1955-56 total, because snow depths and moose abundance were not the same. However, this area did have a greater moose population, snow as deep or deeper, and fewer moose fatalities than similar areas north of Sunshine.

The data obtained from these experiments indicate that certain moose populations can be effectively localized and kept off the tracks by creating alternate trails and feed yards for them. The proposed routes for the trails should be marked and initially constructed in November prior to deep accumulations of snow. This will alleviate possible damage to equipment and reduce the time required for clearing the trails in mid-winter. In all probability the trails will have to be cleared but once, because the moose will keep them open once they have found them. The feed yards could also be made in November.

The moose guards, which need more testing, should be kept free of snow at all times, and the snow berm protecting the end of the guards should be maintained. The aerial counts and ground reconnaissance studies have identified the major winter ranges adjacent to the right-of-way. In all probability these areas, listed in the 1955-56 report, will continue to be associated with the majority of the moose-train conflicts in the Lower Susitna River valley.

It is recommended that moose trail, feed yard and guard experiments be further tested in 1957-58, preferably by selecting one general area such as the Montana-Sunshine section; bulldoze the trails and feed yards in November or early December; make equipment available on a priority basis; investigate the possibilities of using the land clearing "ball and chain device" for creating feed yards.

The Kill. Analysis of the sex and age composition of the sample of moose obtained from the railroad kill provides much valuable biological information pertinent to proper management of this important moose herd. The data obtained on the sex and age composition of the railroad kill of the past two years is illustrated in Table No.16. The sample from 1955-56 is believed to constitute a representative cross section of the moose populations present along the railbelt, and it corresponds closely to the aerial sex and age composition counts made in November of the same year. However, the 1956-57 kill seems to have been selective for calves, indicating a calf:cow ratio of 68:100, whereas the aerial counts indicated a calf:cow ratio of 27:100.

Observations of moose confronted by an oncoming train suggests that during years of shallow snow cover trains may be selective for calves. Moose calves remain with the female until they are at least one year old, following her at all times, especially during the winter months when snow hampers the calf's movements more readily than it does the adults. It is this behavioral trait that accounts for a disproportionate kill of moose calves. Frequently the female leaves the right-of-way only several yards in front of the oncoming train; the calf trailing her does not make it, and is killed. When the snow is deep, such as 1955-56, neither moose leaves and both are killed. Also, if the cow is killed and the calf is not, the calf fails to make the necessary adjustments in fending for itself and almost invariably is killed within a few days.

In general, the railroad kill is believed to sample proportionately the winter moose populations inhabiting the railbelt area, though calves may be disproportionately represented under certain conditions.

Economic and Other Aspects of the Problem

The problem of evaluating the economics of the moose versus railroad conflict involves many considerations, including certain aesthetic values on which the dollar sign of economics is difficult to place. Among the more important values which must be considered, two seem outstanding: (1) the direct costs to the railroad; and (2) the importance of the wildlife resource involved.

1. Direct Costs. The cost to the railroad for salvaging a moose is approximately twenty-five dollars. This cost has averaged several thousands of dollars annually for the past decade. In certain years, additional funds were expended for removing unsalvaged moose carcasses from the right-of-way in the spring. Trains are occasionally derailed by moose, and this, perhaps, is the most expensive type of damage caused by moose. Several such accidents are reported to have cost many thousands of dollars. In February of 1956 a moose caused the derailment of a loaded flatcar at Montana Station, Mile Post 209. Mr. Whalen, Chief Clerk of Engineering, the Alaska Railroad, has estimated the damage to equipment and freight at three thousand dollars. In addition, considerable expense was incurred for labor expended on repairing track, switch and rolling stock, and for delayed train schedules.

In mid-winter, when moose populations are abundant along and on the right-of-way, trains are frequently delayed several hours by moose encounters and subsequent accidents. This, also, costs money as well as inconvenience to passengers who have business appointments or plane connections to meet.

The combined total cost of these various expenses and inconveniences are not known, although they are considerable. In 1955-56 the total cost of salvage operations and equipment damage was calculated to be ten thousand dollars. The costs of labor, delays and inconvenience for the same period are not known, but are believed to exceed the cost of salvage operations and equipment damage. These operational expenses are cumulative and continuing, and should be considered when planning future winter railroad operations, as well as future research projects.

The determination of a cash value for game meat is an arbitrary matter; however, cold storage plant operators in Anchorage who have had considerable experience dealing with meat values, agree that a value of 25 cents per pound of railroad salvaged meat is not excessive. In 1955-56 the cost to the railroad for salvaging approximately 63,000 pounds of moose meat was 4,266 dollars; a cost to the railroad of about seven cents per pound. Thus, the intrinsic value of the meat is three times greater than the cost of salvaging it. This substantiates the belief that salvage operations are justified economically, as well as being a moral responsibility.

2. Importance of the Wildlife Resource Involved. This problem, unique in North America, apparently had little significance at its inception, and at that time the moose population was very abundant. However, the human populations of the Lower Susitna Valley have increased many-fold since 1946, and land use policies have been affected accordingly. The result is an inverse ratio; as human populations and land clearing operations increase, available winter moose range decreases. Concurrent with the decreasing moose population have been increased recreational demands upon it. This trend will result in greatly increased moose values, real and aesthetic. The current flurry of land withdrawals, particularly of choice winter range along the right-of-way, which have easy access, and are also more economical to clear, illustrates the foregoing discussion of future moose population trends.

At present, available winter range during severe winters such as 1955-56 is believed to be a limiting factor on moose numbers between Houston and Talkeetna. As discussed above, this range is shrinking due to human encroachment and to normal plant succession. This combination of limiting factors dictates a reduced moose population in the affected areas. However, the remaining moose population will continue to concentrate on the favorable winter ranges along the right-of-way. Should the progression of events occur as outlined, then the annual kill by the railroad could significantly reduce the number of moose available to the hunter, and under certain conditions of severe winters actually become the major limiting factor to the moose population.

Public relations is another important factor to be considered. The public, as has been amply demonstrated in the past years, reacts quite violently to any seeming disregard for our wildlife resources. This factor must also be given ample consideration in future moose policy formulation.

The only foreseeable alteration of the events outlined in the previous discussion would be an uninterrupted series of mild winters; creation of more winter range through catastrophe, i. e., fire or wind, or through artificial means such as the use of herbicides, cutting or bulldozing.

The problem of moose shortages is certainly not present today, except locally, but the need for careful formulation of future policy toward winter railroad operations and proper management of wildlife resources makes it imperative that the growing problems be recognized now. As a result, future work on this problem should be directed toward projects which will result in benefits to both the railroad and the moose population.

Reproduction

Quantitative data illustrating the age of sexual maturity, period of rut, and fertility rates for the moose of North America, and particularly for the Alaskan subspecies, are extremely limited or totally lacking. The data presented in this report represent some of the results obtained from examining moose killed accidentally, illegally, or by hunters, and from aerial and ground observations made of the moose populations inhabiting the Matanuska Valley and Railbelt areas. These data were collected between January 5, 1956, and January 9, 1958.

Age of Sexual Maturity: Most workers have not considered yearling (16-19 months) males important contributors to the reproductive segment of moose populations. Skuncke (1949) indicates that in Sweden male moose may be capable of fertilizing cows when two and one-fourth years old, but that the larger bulls seldom allow them the opportunity. Peterson (1955) mentions that the age of sexual maturity in moose is not definitely known, but that some authorities believe bulls are capable of breeding at 16 months although they seldom have the opportunity to do so.

In the Matanuska Valley, hunting has significantly reduced the male segment of the population, and has altered the age composition of the remaining males to approximately 90 percent yearlings above Age Class Calf. Here it is believed that yearling males are an important factor in the continued high fertility rate among the female moose in this area (see Fertility Rate).

Observations of moose rutting behavior by this writer have been limited to, largely, the period immediately pre- and post-rut periods when the "harem-like" groups consist of both adult and yearling males seemingly intermingled with the accompanying cows and calves, apparently without conflict. However, several instances of moose jousting or pushing one another were observed.

In the Matanuska Valley groups of 10-30 animals consisting of cows, calves, and 1-4 young bulls were observed in late October and one instance of what appeared to be successful mating by a yearling bull with an adult cow was observed on October 29, 1957.

Aerial sex and age composition counts of the Matanuska Valley indicate a bull:cow ratio of 10:100. Thus, since 90 percent of the bulls are yearlings, the older bulls would be required to service 100 cows each; if one assumes that yearlings are not capable of fertilizing cows.

Further confirmation that yearling male moose are capable of fertilizing cows is provided by Buckley (viva voce), who reports that examination of the epididymis contents of three yearling male moose collected near Fairbanks on September 7, 12, and 17, 1953, respectively, revealed that spermatozoa, presumably viable, were present in each instance. Microscopic examination of the epididymis contents of 17 yearling moose killed in August, September, and November, 1957, in the Matanuska Valley yielded similar findings (Table No.7).

Table No.7 . Breeding condition of bull moose as indicated by the presence of spermatozoa in the epididymis.

Collection Date	Spermatozoa Present	Age	Accession No.
8/22/57	Yes	I	892
8/22/57	Yes	I	636
8/22/57	Yes	I	897
8/22/57	Yes	I	895
8/24/57	Yes	I	615
8/25/57	Yes	I	558
8/25/57	Yes	I	832
9/1/57	Yes	I	532
9/2/57	Yes	I	519
9/2/57	Yes	I	917
9/8/57	Yes	I	923
9/8/57	Yes	I	822
9/15/57	Yes	I	668
9/18/57	Yes	I	588
11/2/57	Yes	?	793
11/3/57	Yes	I	800
11/23/57	Yes	I	778
12/8/57	Yes	(4-5 ?)	
1/8/58	Yes*	VIII	965
3/31/57	Yes*	I	444
12/20/56	? **	Calf	

* Very few spermatozoa--no spermatozoa w/tails observed.

** A very few developing spermatozoa in testis and what appeared to be decomposing spermatozoa in the epididymis.

Yearling male moose are capable of and do fertilize cow moose, and may become an important factor in the reproduction of a heavily hunted moose population, such as that of the Matanuska Valley.

Information regarding the age at which female moose first breed is seemingly as speculative as is the same information on male moose.

Peterson (1955), citing Lönnberg (1923) and Skuncke (1949), postulates that a few females probably breed at 16-18 months, but that most breed at 28-30 months. Skuncke states that yearling females occasionally conceive and that most females breed first as two-year-olds, but that frequently they do not breed until they are three. Ritcey and Edwards (personal communication) found no pregnant yearlings in a sample of 15 uteri collected from yearlings during the period when moose normally are pregnant. They further express the belief that no females of this population (Wells Gray Park, B. C.) breed prior to their third fall.

During this study the uteri and ovaries of 31 moose, Age Class Calf to Class III, were examined. Examination of the uteri and ovaries of seven calves revealed no instance of ovulation or pregnancy. The uteri or ovaries of nine yearlings have been examined. Six of the yearlings were collected during the winter months and three during the late fall. One, a very large yearling, collected in Spenard, Alaska, on March 19, 1957, was pregnant. The ovaries of a yearling collected on November 10, 1957, showed a corpus luteum, partially lutenized; no fetus was found. The corpus luteum may have represented an ovulation which did not result in pregnancy, or it is possible that the embryo had not attached to the uterine wall and was lost during examination. No indications of ovulation or pregnancy were observed in five other yearlings examined. Examination of uteri and/or ovaries from 17 Age Class II and III individuals collected between November and May showed that only two were not pregnant. Ovarian analysis in this age group revealed an average of 1.4 corpora albicantia of corpora lutea of pregnancy per pair of ovaries (Table No.8). This suggests that both two and three year old moose are represented in this sample.

These data indicate that no calves of the year breed or ovulate; that a few yearling females do breed, although the data is too limited to be significant; and that 88 percent of two and three year old females were pregnant, indicating that most female moose on this range breed first at 28-30 months.

Period of Rut: The period of rut or breeding of moose, similar to many other facets of its reproductive cycle, is known only in a general sense.

Most authorities agree that rut activities commence in early September and continue through most of October. However, exact

Table No. 8. Corpora albicantia incidence in moose ovaries.

Age Class	No. Pairs Ovaries	No. Individual Ovaries	No. Corpora Albicantia in Paired Ovaries	No. Corpora Albicantia in Individual Ovaries	Total Corpora Albicantia	Total Ovaries	Corpora Albicantia Range	Ave. No. Corpora Albicantia per Pair of Ovaries	Ave. No. Corpora Albicantia per Ovary
I	6	2	0	0	0	14	0-0	0	0
II & III	5	1	7	0	7	11	0-2	1.4	.64
IV & V	6	2	20	5	25	14	0-5	3.3	1.78
VI & VII	8	-	53	-	53	16	0-7	6.6	3.3
VIII & IX	6	-	58	-	58	12	2-7	9.6	4.8
Totals	31	5	138	5	143	67	0-7	4.4	2.1

dates and true peak of ovulation and conception are not known. Ritcey and Edwards (personal communication) state that most cows in Wells Gray Park, British Columbia, breed during a ten-day period in late September, and that three periods of oestrous occur from early September through October. Skuncke (1949) reports that moose in Sweden breed during the first two weeks of October. Specimens or observations of four phases of the reproductive cycle of the moose populations inhabiting the Matanuska Valley and Railbelt areas were collected in an attempt to more accurately delineate the period of sexual activity. The data obtained include the following:

A. Collection of moose testes.
B. Periodic aerial counts of moose inhabiting known calving areas during late May and early June.
C. Collection of moose embryos and fetuses.
D. Collection of moose ovaries.

A. Testes Collected. Testes of certain cervids reflect the period of sexual activity through increased size and weight. Cheatum (1956) reported that volumetric determinations of white-tailed deer testes indicated a fall peak in size. He presented data which shows that the peak of testes size, which occurs in November in that area, coincides with the peak of conception.

One hundred and sixty-seven pairs of moose testes were collected during the winter of 1956-57 and the fall and winter of 1957-58. The testes were preserved in 10 percent formaldehyde. Standardization of the portions of the testes used for weight and volumetric determinations was obtained by dissecting the testes free from the tunica vaginalis, and by severing the vas efferentia from the testes. This process removed all extra tissue from the testes, particularly fat deposits, which were considerable on testes collected in August and September. The testes were then weighed to the nearest gram and volumetric measurements, using the water displacement technic, were taken to the nearest cubic centimeter. In this report only the weight measurements are used.

Male moose vary greatly in body size, both with respect to age and individual variation. It is believed that body size and testis size are proportional. The greatest proportional difference between both body and testis size is between Class I bulls and older age class bulls. Because of the great proportional difference the two age categories are considered separately. If a larger sample of testes from known age animals were available, division according to age classes might reduce the great range in testis weights and give some indication as to which age group first reaches a peak of breeding condition, if such a difference exists.

The weights of the testes from yearlings clearly indicate a weight increase from August 20 to September 20, but a definite decrease in weight is not apparent until December and succeeding months. The sample of testes from November, however, is small and in view of the great size variations within this age class it is possible that this sample is not representative.

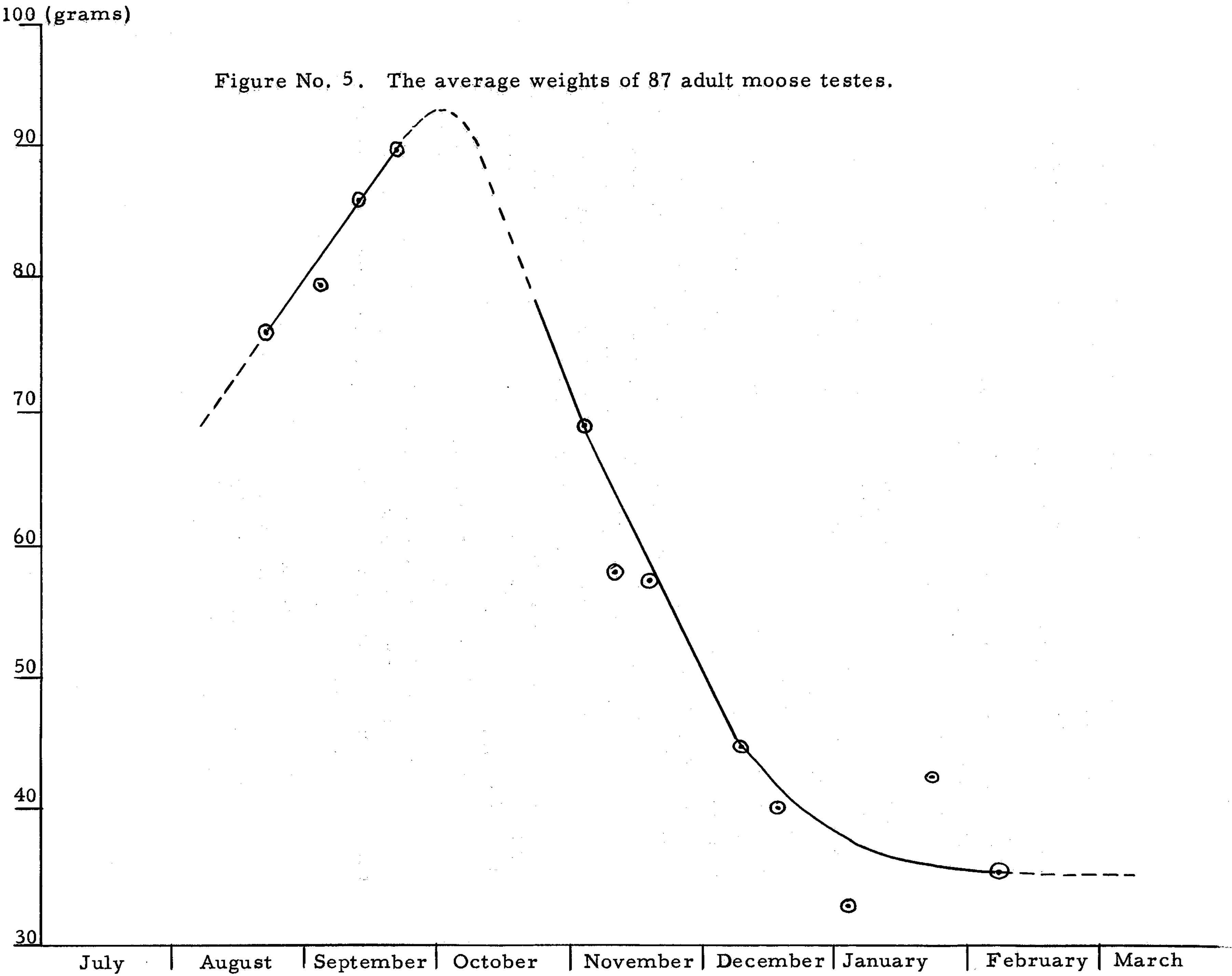
The curve, established from the weights of 87 testes collected from moose older than Class I and averaged by periods, is illustrated in Figure No. 5. Again the range in weight is great (Table No. 9). The points for the generalized curve were obtained by averaging the testis weights by 5 and 10 day periods from August 20 to September 20 and from November 1 to 30. Testes collected later were averaged by two week periods. These data indicate a definite weight increase from August 20 through September 20 and a corresponding decrease through November and December with a possibly constant weight from January through March.

If the curve in Figure No. 5 accurately portrays moose testis development, the peak of male breeding condition occurs about October 1. Unfortunately this coincides with a closed hunting season and no testis weights are available for this period.

Table No. 9. The average and range in weight of 87 testes from adult moose.

Date	No. Testes	Ave. Weight (grams)	Range
August 20-25	27	76.0	52-92
August 30-Sept. 7	8	79.4	59-109
September 8-14	9	86.3	63-110
September 15-20	11	90.0	68-120
November 1-6	1	69.0	69-69
November 7-13	3	58.3	56-62
November 14-20	4	57.2	46-66
December 8	2	44.5	42-47
December 18	2	40.0	35-45
January 1-4	4	32.7	32-34
January 8-31	6	42.3	34-56
February 1-14	10	35.4	28-43
Total	87		

Figure No. 5. The average weights of 87 adult moose testes.



B. Parturition. Aerial counts of moose inhabiting favored calving areas in the Matanuska Valley and along the Railbelt were made between May 20 and June 4, 1957. These counts are summarized in Table No.10. Calving was in progress by May 20 and the counts indicated a ratio of 14 calves per 100 cows. This ratio increased to 41, 57, and 52 per 100, respectively, on succeeding counts. The above ratios are actual calf:cow observations, with twins considered as one incidence of pregnancy.

Cows about to give birth and those with newborn calves generally frequent lowland areas. The lowlands are generally swampy and frequently are covered with 8-20 inches of water in the spring of the year. The overall vegetation varies greatly but in general gives the impression of a patchwork of spruce islands and heath, sedge and sedge-bog openings, with dense borders of alder and willow. The calves are frequently hidden in the alders or in the spruce islands and are also very difficult to see in the heath or sedge openings if they are lying down. Cow moose exhibit no definite response pattern to airplanes. Most cows with calves, however, either run to the calf or face in the direction of the calf. When the cow refuses to run to the calf or if the calf remains quiet, the observer frequently is unable to decide definitely if a calf is present. The tendency of some cows to hide their calves may seriously hamper aerial calf:cow counts. At present it is not known what age group of calves are most frequently hidden, or if a specific age group is involved. The time of day that the counts are made may also influence the distribution and activity of cows, cows with calves, and calves.

The estimated calf:cow ratios in Table No. 10 are a result of including the instances when no calf or calves were observed even though the female responded to aerial buzzing in a manner that indicated a calf was present.

The spring aerial calf:cow counts, which possess certain previously discussed variables, show that 50 percent of the cows in the populations counted have calves by late May (Table No.10 and Figure No. 6). Thus, if moose have a gestation period of 240-246 days (see Gestation Period), 50 percent of the cows were bred prior to October 1.

Figure No. 6. Progression of moose calving.

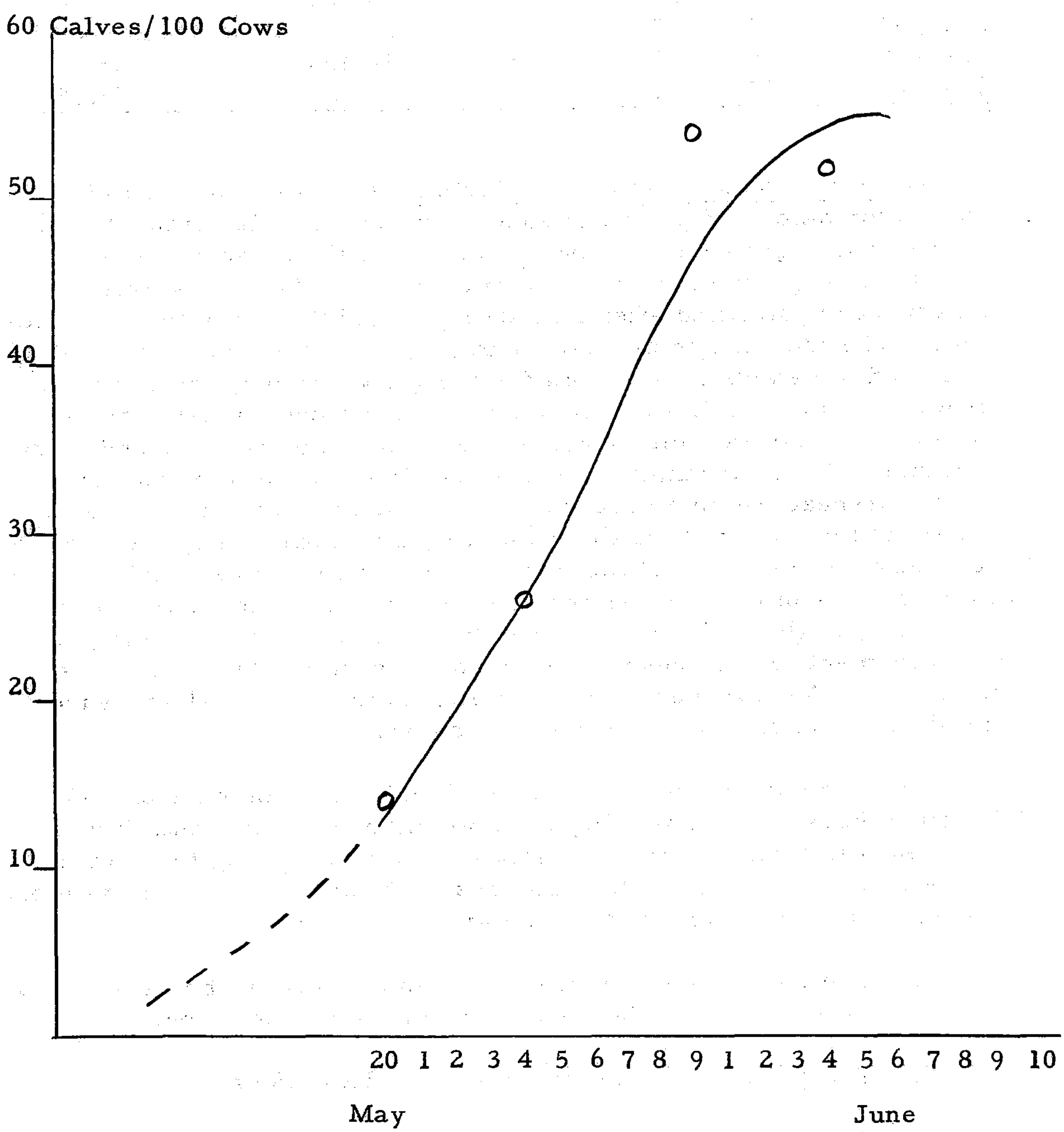


Table No.10. Progression of moose calving as revealed by aerial calf:cow counts in the Lower Susitna Valley.

Date	♀ w/0	♀ w/1	♀ w/2	Observed Calf:Cow Ratio	Estimated Calf:Cow Ratio
5/20/57	57	7	1	14:100	14:100
5/24/57	69	21	3	26:100	53:100
5/29/57	28	27	6	54:100	69:100
6/4/57	29	25	6	52:100	78:100

C. Embryos and Fetuses Collected. Another indication of conception dates and period of successful breeding is obtained from the estimated growth curve established from the measurements of 63 unknown-age moose fetuses (Figure No. 7). In general this treatment is patterned after Armstrong's (1950) work with white-tailed deer. The total length measurement (following the body contours) was used to establish the points for the growth curve, instead of the crown-rump or forehead-rump measurements used by Armstrong, because, on moose, this measurement was more sensitive and more reliable. The total length measurement is believed to be superior to the forehead-rump measurement because the points of reference, the tip of the nose and the tip of the tail, are more easily and accurately located than are the forehead-rump points of reference which are the intersections of the coronal and sagital sutures of the skull and the tuberosity of the ischium. Another factor favoring the total length measurement is the tendency for fetus to assume a "C" shape when preserved. This tendency does not affect the total length measurement but does affect the forehead-rump measurement.

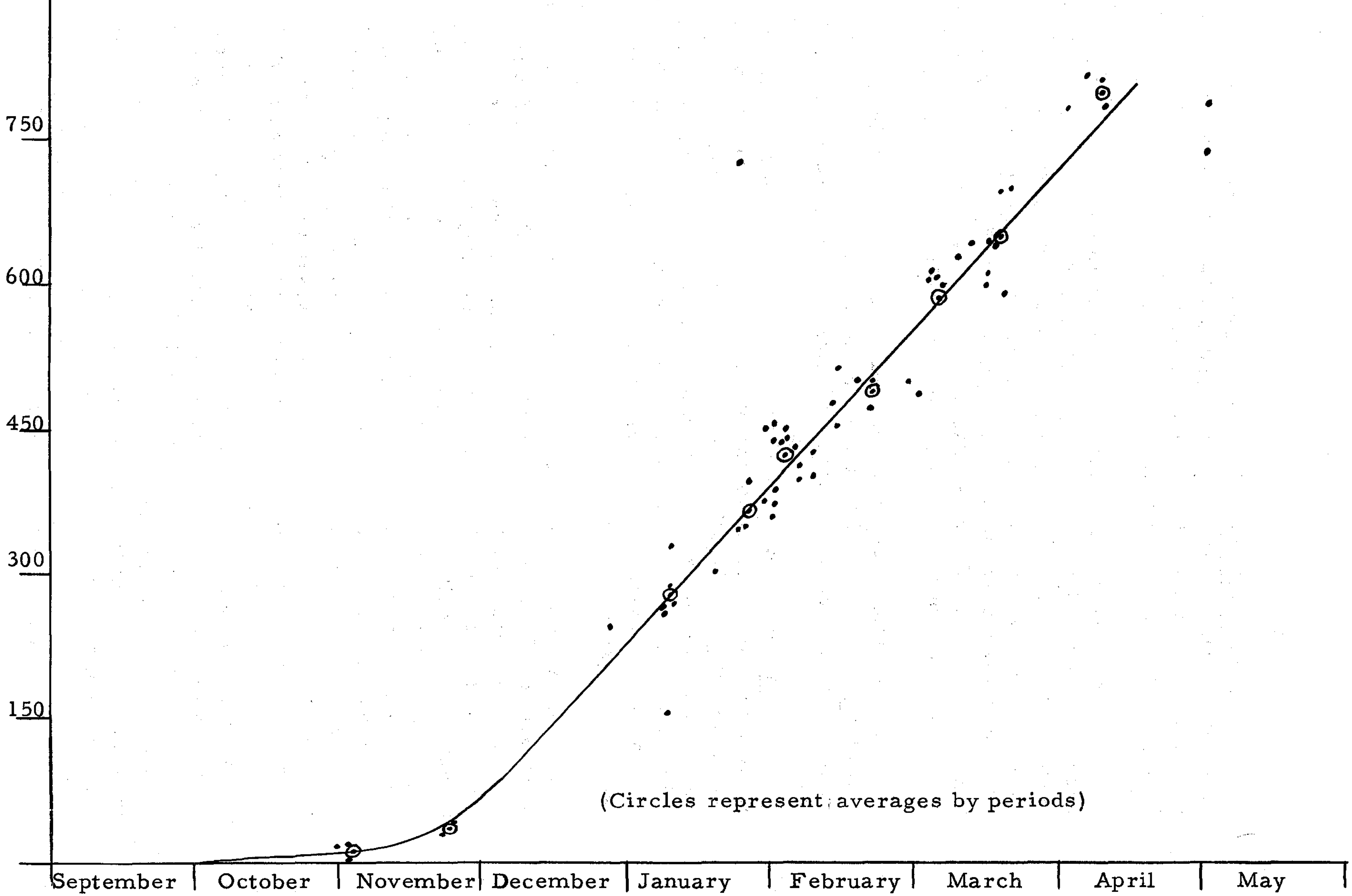
Since no known-age fetuses are available for comparison and because there is no possibility of obtaining any, at present, it was necessary to make several assumptions in constructing the growth curve from the present data. The assumptions are based on the most complete available information and are as follows:

1. The embryo-fetus transition in moose occurs between 40-43 days, probably about 42 days following conception.

2. The gestation period for moose is 240-246 days.

3. That all fetuses grow at approximately the same rate.

Figure No. 7. Average growth curve for moose fetuses based on total length measurement of 63 embryos and fetuses.



1. Embryo-Fetus Transition. The embryo-fetus transition is an arbitrary but useful designation and has been described by Winters (1942) as that time at which organogenesis is complete and the remaining fetal growth is largely development of existing organs.

The embryo-fetus transition for white-tailed deer, cattle, and sheep is estimated by Armstrong (1950) and Winters (1936, 1942) to occur at 37, 45, and 34 days, respectively. The period of the embryo occupies about 18 percent of the total gestation in the previously discussed mammals. Applying this figure to the moose's gestation period of about 240-246 days indicates that the embryo-fetus transition would occur at about 42-43 days following conception.

2. Gestation Period. The assumption that moose have a gestation period of 240-246 days is based on estimates by a number of writers none of whom cite specific examples. Peterson (op. cit.).

3. Rate of Growth. The assumption that fetuses tend to grow at the same rate is based on the observations of Winters (1936, 1942) and Armstrong (1950). The previously mentioned workers concluded that fetus size is primarily a function of growth time and that while individual variations and variations between single and multiple pregnancies do exist, these variations do not significantly affect the generalized growth curve.

The curve which was fitted to the embryo-fetus data, illustrated in Figure No. 7, uses October 1 as its origin. This is an arbitrary date, but data presented in the previous sections on testis weights and parturition dates tend to substantiate an early October peak of conception. In addition the sizes and development of the embryos and fetuses collected in October and November indicate conceptions in late September and early October. It is realized that the peak of conception may not fall on October 1, but all available data indicate this is a reasonable approximation. If the curve in Figure No. 7 accurately reflects the growth of moose fetuses then important information pertaining to the duration and peak of conception can be obtained from it. If the growth curve is used as a constant to which the other fetuses are compared, then all fetuses lying to the left of the curve were conceived prior to the average date, and all fetuses to the right of the curve were conceived after the average date. The variance in time of conception, measured in days, can be obtained by dropping two straight lines to the abscissa of the curve. One line is dropped from the point representing the total length of the fetus. The other is dropped from the point on the average curve equal in total length to that of the fetus in question. The distance between the two lines represents the difference in time of conception. The scale on Figure No. 7 provides a means for translating the distance into days.

The data obtained from determining the variance in conception dates are illustrated in Figure No. 8. The average growth curve was constructed by combining the daily percentages into three-day periods and plotting them as a frequency distribution. These data reveal that 60 percent of the fetuses in this sample were conceived in a 10-day period; that 80 percent were conceived within a 15-day period; and that all individuals in this sample were conceived within a 40-45-day period. This curve indicates that the peak of conception occurs in early October. This is in agreement with the peak of testis development (Figure No. 5) and the peak of calving (Figure No. 6).

If the curve and the October 1 starting point are essentially correct then the earliest conceptions occur in mid-September and the latest in late October, roughly a period of 40-45 days. This period indicates one or possibly two additional oestrous cycles in moose not conceiving during their first oestrous, or an extended period of ovulation possibly due to age-differential ovulation.

Deer are known to experience several oestrous cycles annually if they do not conceive during the first (Cheatum 1946). Data illustrating additional oestrous periods in moose are very meager. Examination of the ovaries from a Class IX female killed on November 14, 1956, at Mile Post 184.4 on the Alaska Railroad revealed what appeared to be a degenerating corpus luteum of oestrous and a developing follicle which burst when handled. It is believed that this animal was about to ovulate. No other examples possibly illustrating a second oestrous are known to this writer. However, the uniformity of the conception dates of three fetuses which fall far to the right of the average growth curve suggest a possible second oestrous in Alaskan moose. The data, based on fetus size distribution, from moose in the Wells Gray Park in British Columbia clearly indicate at least three oestrous cycles (Ritcey and Edwards, personal communication).

Data suggesting an age-differential ovulation are similarly meager. Fetus no. 979, Table No. 11, from a Class I female was probably conceived late in October. Female No. 806, Table No. 12, collected November 10, 1957, also a Class I individual, had ovulated, but the corpus luteum had not completely lutenized, suggesting a recent ovulation. The sizes of the fetuses from Class II and III females appear to be randomly distributed (Table No. 11). Yearling females possibly ovulate later than older animals, but since few of them ovulate

Table No. 11. Moose fetus data.

Collection Date	[1] Measurements in millimeters: Ear	H. F.	H. L.	F. L.	T. L.	H. C.	Girth	Sp. Pb.	Zygo. Arch	Weight (Lbs.)	Sex	Age of Female	Acc. No.
10/31/57					20						?[2]	II	677
11/1/56					10							III-IV	302
11/3/57					6						?	XI	676
11/20/56					35						?	II	315
11/24/56					37						?	VIII	286
12/25/56	15	60	80	80	250	135	145	100	32	0-7	♂	VI	307
1/6-9/58	15	60	84	82	267	129	142	107	30		♂	IV	976
1/6-9/58	15	59	84	83	266	127	141	105	34		♀	IV	976
1/9/58	7	27	42	42	156	87	92	61	24		♀	I	979
1/9/58	22	87	118	117	328	154	195	132	41		♀	Unkn.	981
1/8-9/58	20	79	106	108	294	149	188	123	38		♂	V	980
1/10/57	19	65	97	95	270	145	170	110	35	0-11	♀	IV	422
1/10/57	19	65	100	95	275	150	175	130	37	0-12	♂	IV	422
1/16/57		71				140			34		♂		344
1/18/56		75	112	95	305				35	0-11	♀	III	187[3]
1/23/57	23	90	125	120	350	170	200	160	42	1-4	♀	IV	330
1/25/57	26	100	140	135	355	175	215	150	46	1-9	♂	V	435
1/26/57	37	115	155	145	400	200	230	190	46	2-0	♀	VI	337
1/29/57		105		135	350	190	220	180	45	1-12	♀	III	355
1/29/57	41	125	185	175	455	220	255	200	51	2-11	♂	III	336
2/1/57	42	125	170	160	460	210	255	205	50	2-9	♀	IV	358
2/1/57	41	125	165	170	440	215	255	195	50	2-10	♀	IV	358
2/1/57	33	105	145	145	395	185	220	190	45	1-14	♂	V	349
2/1/57	33	105	145	135	385	185	210	165	44	1-9	♂	VII	347
2/1/57	32	105	150	140	375	185	205	180	46	1-9	♂	VII	347

Table No. 11 (Continued).

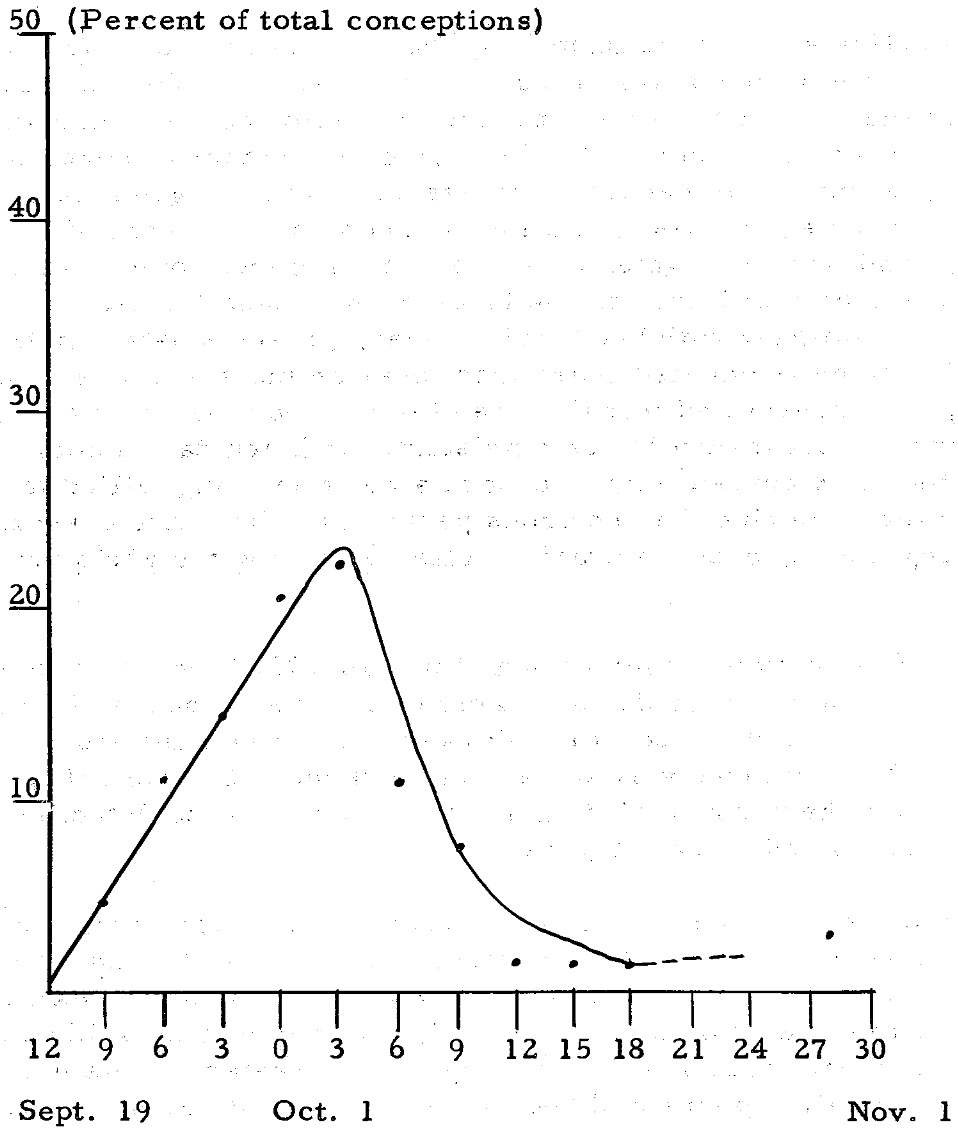
Collection Date	Measurements in millimeters Ear	H. F.	H. L.	F. L.	T. L.	H. C.	Girth	Sp. Pb.	Zygo. Arch	Weight (Lbs.)	Sex	Age of Female	Acc. No.
2/4/57	45	135		170	450	220	250	190	54	2-14	♂	III	367
2/4/57	38	115	160	155	430	205	250	200	49	2-6	♂		---
2/4/57	42	120	180	170	440	225	250		51	2-13	♂	IV	373
2/4/57	38	120	160	150	440	210	250	180	49	2-5	♂	V	365
2/4/57	36	120	165	150	430	205	230	185	50	2-5	♂	V	365
2/6/57	44	125	175	165	415	220	275	190	54	3-2	♀	VIII	329
2/6/57	42	115	180	160	400	195	230	165	52	2-4	♀	IX	341
2/6/57	44	125	185	175			240	225	51		♀	III	388
2/9/57	38	135	205	165	440	210	250	185	49		♀		390
2/9/57	40	130	205	170	405	220	255	195	50		♀		390
2/13/57	40	145	210	190	480	230	285	210	52	3-6	♀	IV-V	378
2/14/56		155	230	200	461				64	4-3	♀	VI	199.3
2/14/57	53	155	230	210	510	240	285	220	59	4-7	♂		382
2/19/57	54	148	200	195	505	225	300	230	59	2-10	♂	IV	434
2/21/57	50	140	200	190	470	230	275	195	54	3-6	♀	IX	398
2/21/57	50	145	220	185	500	220	300	180	53	3-5	♀	IX	398
2/24/56		155	240	210	495				58	4-11	♂	IV	194
Feb. 56		165	250	215	500				65		♂	Unkn.	209
3/2/56		185	280	240	520				65	5-15	♀	IV	202.3
3/2/57	45	155	210	185	480	220	290	210	58	3-15	♀	II-III	401
3/3/56		195	315	260	610				69	7-2	♀	V	212
3/4/56		195	310	260	610				69	6-11	♂	VIII	208.4
3/4/57	75	219	295	275	610	260	390	280		8-7	♂	II	415
3/5/57	75	200	290	270	600	290	360	270	69	7-10	♂	V	414
3/9/56		205	330	285	627				72	7-14	♂	VII	211.4

Table No. 11 (Continued).

Collection Date	Ear	H. F.	H. L.	F. L.	T. L.	H. C.	Girth	Sp. Pb.	Zygo. Arch	Weight (Lbs.)	Sex	Age of Female	Acc. No.
	Measurements in millimeters												
3/9/57	70	205	280	265		280			67	7-0	♀	VI	417
3/12/57	78	215	290	285	640	275	370	305	72	9-9	♂	III	429
3/14/57	64	200	265	250	615	255	340	290	70		♂	IV	430
3/14/57	65	195	265	250	600	255	330	270	71	6-14	♂	IV	430
3/19/57	68	200	270	255	590	265	340	351	68	8-4	♀	I	428
3/19/57	80	225	335	290	700	270	350	290 ?		10-8	♀	V-VI	---
March 56		195	290	255	580				67		♂	Unkn.	208.7
March 56		215	320	280	650				71	7-12	♀	Unkn.	---
4/2/57	100	280	395	375	780	305	430	360	80	13-0	♂	VI	448
4/9/57	111	330	450	430	820	320	450	410	90	19-5	♂	IV	450
4/10/56		320	480	415	810				82	14-0	♀	III	190.4
4/10/57	104	290	370	360	780	310	410	350	78	15-0	♀	IX	451
5/2/56		335	500	435	790				81	14-0	♀	VIII	---
5/2/56		310	455	395	740				81	14-0	♂	VIII	---
Fetuses from Fairbanks													
1/29/55	20	70	102	99	280	131	156	117	40	0-11	♀	Unkn.	JLB285
2/21/55	44	135	199	193	420	211	269	183	56	3-2	♂	Unkn.	JLB291
March	69	185	268	257	640	263	332	263	69	7-0	♀	Unkn.	JLB290
March	68	190	269		640	262	334			7-2	♂	Unkn.	JLB289
3/19/57	80	225	335	290	700	270	350	290		10-8	♀	Unkn.	---

[1] Measurements follow those described by Winters (1936), Winters, et. al. (1942).
[2] Identification of sex by external anatomy impossible at this stage of development.

Figure No. 8. The peak and duration of successful conception in moose as measured by the variance in total length of 63 fetuses which were compared to the "average growth curve" in Figure No. 7.



this does not markedly influence the age-size distribution of the fetuses. It is probable that the range in fetus sizes and conception dates is caused by cow moose experiencing additional oestrous cycles, if they do not conceive during the first cycle, and by normal variation in oestrous dates.

D. Analysis of Ovaries. During this study 31 pairs and five individual ovaries were collected from 36 moose Age Class I or older (Table No.12).

Connective scar tissue formed by the degenerating corpora lutea of pregnancy, the corpora albicantia, has been used by Cheatum (1949) to estimate the previous year's reproductive performance of certain white-tailed deer populations. In identifying the number of corpora albicantia present it was necessary to assume that all pigmented scars present represented the past gestation period's corpora lutea of pregnancy, and that the pigmented scars resulting from other ovarian functions could be eliminated on the basis of their smaller size. Golley (1957), working with black-tailed deer, presents data which indicate that some pigmented scars from ovarian functions other than pregnancy are present and that the fate of the corpora albicantia of the corpora lutea of pregnancy is not consistent. In black-tailed deer, this resulted in 18 percent more corpora albicantia being tallied in ovaries collected during the anestrous period than there are corpora lutea of pregnancy present in ovaries collected during the gestation period.

Seventy-nine moose ovaries listed in Table No.12 were sectioned, sagitally, with a razor blade and examined for the presence of corpora lutea of pregnancy and for corpora albicantia of corpora lutea of pregnancy. The sections were of varying thickness, but were thin enough to allow the passage of light and thereby permitted detection of pigmented bodies and large follicles.

In moose the corpus luteum of pregnancy is large, frequently 10-18 millimeters at its greatest diameter, and is easy to find. The corpora albicantia of corpora lutea of pregnancy are smaller, dark, pigmented scars, varying in color from light brown to almost black. The usual size was from 4-8 millimeters at the greatest diameter. Occasionally smaller pigmented bodies were observed, but these were not counted (Cheatum, op. cit., and Golley, op. cit.).

Examination of the moose ovaries collected during this study revealed a number of interesting data; of particular interest are the following:

Table No. 12. Notes on size and development of moose ovaries.

Acc. No.	Age of ♀	Wt. of I Ovary (mg)	Wt. of II Ovary (mg)	Corpus luteum of Pregnancy	No. of Fetuses	No. Corpus Albicans	Diameter of largest Follicle(mm)	Date of Collection
323	Calf	650	Lost	0	-	-	1	12/18/56
301	Calf	950		0	None	None	1	12/23/56
301	"		900	0	"	"	1	12/23/56
327	Calf	1000		0	"	"	2	1/26/57
327	"		1000	0	"	"	2	1/26/57
223.5	Calf	1000		0	"	"	1	2/3/57
223.5	"		950	0	"	"	1	2/3/57
379	Calf	1400		0	"	"	1	2/13/57
379	"		1400	0	"	"	1	2/13/57
389	Calf	350		0	"	"	1	2/14/57
389	"		Lost	0	"	"	1	2/14/57
543	I	1800		0	"	"	7	8/31/57
543	"		Lost					
536	I	1250		0	"	"	1	9/2/57
536	"		600	0	"	"	?	9/2/57
B-25	I	1100		0	"	"	?	Fall 1957
B-25	"		Lost					

Table No. 12(Continued).

Acc. No.	Age of ♀	Wt. of I Ovary (mg)	Wt. of II Ovary (mg)	Corpus luteum of Pregnancy	No. of Fetuses	No. Corpus Albicans	Diameter of largest Follicle(mm)	Date of Collection
806	I	3350		1 [1]	?	None	2	11/10/57
806	"		1300	0	None	"	2	11/10/57
840	I	1050		0	"	"	2	11/24/57
840	"		Lost					11/24/57
313	I	2700		0	"	"	1	12/18/56
313	"		2700	0	"	"	1	12/18/56
342	I	1250		0	"	"	6	1/17/57
342	"		1200	0	"	"	2	1/17/57
990	I	--		0	"	"	2	1/24/58
990	"		--	0	"	"	2	1/24/58
428	I	3550		1	1	"	10	3/19/57
428	"		1875	0	None	"	4	3/19/57
513	II	2350		0	"	"	9	9/2/57
513	"		1850	0	"	1	7	9/2/57
677	II	-- [2]		1	1	None	6	10/31/57
677	"		Lost					
415	II	3650		1	1	1 ?	8	3/4/57
415	"		1800	0		None	1	3/4/57

Table No. 12 (Continued)

Acc. No.	Age of ♀	Wt. of I Ovary (mg)	Wt. of II Ovary (mg)	Corpus luteum of Pregnancy	No. of Fetuses	No. Corpus Albicans	Diameter of largest Follicle(mm)	Date of Collection
559	II-III	2100		0	None	None	9	8/24/57
559	"		2650	0	"	2	11	8/24/57
979	II-III	1150		0	"	1	1	1/9/58
979	"		2600	1	1	None	4	1/9/58
401	II-III	3550		1	1	2	8	3/2/57
401	"		1615	0	None	1	4	3/2/57
528	III-IV	2650		0	None	None	12	8/22/57
528	"		2000	0	"	2	3	8/22/57
302	III-IV	5350		1	1	None	20	11/2/56
302	"		4000	0	1	"	20	11/2/56
378	IV-V	4900		1	1	4	5	2/13/57
378	"		2700	0	1	4	9	2/13/57
430	IV	1950		0	2	4-5	4	2/16/57
430	"		Lost					
177	IV	3450		1	1	None	-	3/2/56
177	"		Lost					
450	IV	4300		1	1	"	7	4/9/57
450	"		1750	0	1	1	1	4/9/57

Table No. 12 (Continued)

Acc. No.	Age of ♀	Wt. of I Ovary (mg)	Wt. of II Ovary (mg)	Corpus luteum of Pregnancy	No. of Fetuses	No. Corpus Albicans	Diameter of largest Follicle(mm)	Date of Collection
595	V-VI	4050		0	None	3	4	10/2/57
595	"		5150	0	"	None	10	10/2/57
980[3]	V	3250		0	"	"	14	1/9/58
980	"		6550	2	1	"	3	1/9/58
191	V	5700		1	1	1-2	6	3/3/56
191	"		3150	0	1	1	1	3/3/56
414	V	4700		1	1	3	7	3/5/57
414	"		2250	0	1	3	1	3/5/57
521	VI	4400		0	None	3	9	8/25/57
521	"		5000	0	"	7	5	8/25/57
531	VI	2800		0	"	4	3	9/2/57
531	"		3050	0	"	2	14	9/2/57
586	VI	3300		0	"	3-4	7	9/15/57
586	"		3000	0	"	3	3	9/15/57
222	VI	4900		1	1	5	6	3/4/56
222	"		2600	0	None	4	2	3/4/56
417	VI	4500		1	1	4	4	3/9/57
417	"		3750	1	1	5	3	3/9/57

Table No. 12(Continued)

Acc. No.	Age of ♀	Wt. of I Ovary (mg)	Wt. of II Ovary (mg)	Corpus luteum of Pregnancy	No. of Fetuses	No. Corpus Albicans	Diameter of largest Follicle(mm)	Date of Collection
448	VI	3400		1	1	4-5	--	4/2/57
448	"		1650	0	None	3	--	4/2/57
500	VII	2300		0	Lactating	3	4	6/9/57
500	"		2750	1	Lactating	3	4	6/9/57
184.4	VIII-IX	2650		1[4]	None	6-7		11/15/56
184.4	"		1500	0	"	5	6	11/15/56
676	IX	5450		1	1	4-5	3	11/3/57
676	"		4250	0	None	3	7	11/3/57
976	IX	3450		1	1	6	2	1/6-9/58
976	"		3750	1	1	7	7	1/6-9/58
341	IX	5500		1	1	4	5	2/6/57
341	"		3500	0	None	2	10	2/6/57
398	IX	5450		2	2	1[5]		2/21/57
398	"		2400	0	None	4	10	2/21/57
451	IX	4000		1	1	4	7	4/10/57
451	"		2150	0	None	6	1	4/10/57

1 Not definitely pregnant; had ovulated.
2 Partially destroyed.
3 Had decomposed somewhat--identification of corpora albicantia not possible.
4 May be corpus luteum of oestrous; not of pregnancy.
5 Did not complete dissection of this ovary.

1. Development of the follicles and time of ovulation.
2. Age of animal--number of corpora albicantia correlation.
3. Types of ovulation.

1. Follicle development and ovulation. Originally it was thought that a collection of ovaries from late August to October would help establish the period of successful breeding and conception. However, only ten sets of ovaries from this period have been collected. All ovaries from animals older than Class I had one or more developing follicles (Table No. 12). The follicles ranged from 3 to 14 millimeters in diameter. One Class I female had a developing follicle 7 millimeters in diameter. The ovaries from a Class VII individual collected in early June contained several small follicles 4 millimeters in diameter. It is not unusual for ovaries taken from pregnant cows to have follicles up to 10 millimeters in diameter.

In specimens 531 and 586, collected in September, the follicle wall was very thin. Female No. 595 collected on October 2, 1957, had three large follicles, one of which ruptured when handled. Although all the ovaries collected during this period had large follicles present, the data are too limited to indicate trends on ovulation dates.

2. Age of animal--number of corpora albicantia. The number of corpora albicantia or pigmented scars in moose ovaries has a direct relationship to the age of the individual (Table No. 8). This suggests that, in moose, the corpora albicantia of corpora lutea of pregnancy persist for a considerable time and possibly throughout the animal's life. However, estimating past reproductive success from pigmented scar counts other than in a general way is not considered feasible in moose because they exhibit multiple ovulation. Thus, if two or more ova are released simultaneously and only one is successfully fertilized the remaining corpora lutea of oestrous will lutenize and become corpora lutea of pregnancy although not representing a fetus. Ultimately they become corpora albicantia and would introduce an error in an estimate of past reproduction success based on corpora albicantia scar counts.

3. Types of ovulation. The number of corpora lutea of pregnancy present in moose ovaries usually corresponds to the number of fetuses present. Thus if twin fetuses were present two corpora lutea were present; however, several variations were observed. One pair of ovaries had a single corpus luteum and twins were present; another had two corpora lutea and a single fetus although no evidence of absorption of a second fetus was observed in this animal. In the case of twin fetuses, the corpora lutea were located one in each ovary, two in one ovary, and as previously mentioned, one instance of a single corpus luteum.

Cheatum (1949) indicates that corpora lutea of oestrous not resulting in pregnancy do not form pigmented scars. Several sets of ovaries from cows collected in October and November were examined and what appeared to be degenerating corpora lutea of oestrous were present, but at this stage it was impossible to determine if the scar tissue would be pigmented. Also, it was considered possible that the embryo was not yet attached to the uterine wall and lost in examination, and in one instance the cow was believed to have experienced an abortion or resorption.

Other Observations on the Progress of Rut Activities

Additional observations on the progress of rut were obtained from field examination of hunter killed animals and from aerial sex and age composition counts.

On September 17 this writer killed a yearling bull which had one large cow accompanying it. The pair were observed for 30-45 minutes before the bull was shot. During this period the male evidenced much interest in the cow but did not attempt to mount her. Examination of his stomach contents revealed he had ingested some urine--typical of rutting bulls. On September 20 R. O. Skoog killed a 3-4 year old bull near the Susitna River bridge along the Denali Highway. He reports that this bull had ingested a considerable amount of urine.

Aerial sex and age composition counts of the moose populations inhabiting the Clear Creek and Maclaren River drainages on October 8-9, and on the Susitna River area October 10 tallied 456 animals (see Sex and Age Composition Counts, Upper Susitna-Copper River Valleys). Most, 76 percent, of these animals were found in "harem-like" groups of 3-21 animals. The moose were generally distributed along the creek bottoms in dense willows 6-12 feet high.

Moose were under almost continuous observation for eight hours but no bulls evidencing interest in cows were seen. In fact some of the large bulls were leaving the breeding groups and others were beginning to eat again, suggesting that the period of active rut was past.

Evidence of recent rutting activity was abundant on willow-and-alder-covered benches some 200-400 feet above where the majority of the moose were tallied. Nearly 100 rut pits ("brunstgropen") were counted. These excavations are reportedly made by bulls alternately pawing, urinating and rolling in them during extreme excitement of the rut (Peterson 1955).

Mating reportedly takes place in the immediate vicinity of these pits (Lönnberg, 1923). This area was covered by 3-4 inches of snow some 3 to 4 days previous to the counts. Fresh trails led from the breeding area to where the moose had regrouped in the valley areas, a distance of approximately 1-2 miles. The presence of rut pits and the subsequent movement of the moose to another area also suggest that the peak of the breeding portion of the rut had passed.

Discussion of Rut

The breeding activities of the moose inhabiting the Railbelt and Matanuska Valley moose populations commence in early September, when the bulls first start polishing or rubbing their antlers, and continue through September, October, and early November.

Spermatogenesis, as evidenced by presence of spermatozoa in the epididymis has begun at least by August 20 and continues at least until December (Table No. 7). Examination of ten sets of ovaries in August and early September revealed that developing follicles were present but that none of the females had ovulated. One set of ovaries collected on October 2 had not ovulated, but the largest follicle ruptured when handled, possibly indicating that this cow was about to ovulate.

The combined data of testis weights, parturition observations, embryo and fetus measurements, ovarian analysis, and field observations, indicate that the peak of conception occurs sometime in late September or early October, probably about October 1-3. It is estimated that 80 percent of the fetuses in this sample were conceived within a 15 day period and that all of them were conceived within a 40-45 day period. This suggests that most females are bred during their first oestrous, but that subsequent oestri may occur if the female does not conceive during the first. It is also possible that the length of the period of conception is caused by age-differential ovulation. Possibly, both additional oestrous cycles and age-differential ovulation account for the extended period of successful conception.

Fertility Rate: Pregnancy data were obtained from 98 moose during the winters of 1955-56, 1956-57, and 1957-58. These moose were examined as a result of highway, railroad and illegal kills, and all were examined between late October and May when moose are pregnant. In most instances complete information was available and jaws, ovaries and fetuses, if present, were collected. The "barren cow moose" is a concept apparently accepted by many; theoretically, under certain adverse conditions a large percentage of the herd could

Table No. 13. Comparative reproductive data from 98 cow moose of Age Class I-IX

Age Class	No. Cows	Percent This Sample	Sets of Twins	Singletons	Barren Cows	Total No. Fetuses	Percent Total Fetuses This Sample	Fetuses: 100 Cows	No. Preg. Cows	Twins: 100 Pregnancies
I	5	5	0	1	4	1	.9	20	1	0
II-III	17	17.5	1	14	2	16	14.3	94	15	7
IV-V	30	31	9	21	0	39	34.9	130	30	30
VI-VII	14	14.5	2	11	1	15	13.3	107	13	15
VIII-IX	17	17.5	7	8	2	22	19.7	129	15	47
Unknown	15	15.5	5	9	1	19	16.9	127	14	36
	98	100	24	64	10	112	100	115	88	27
					Excluding Class I			123		
					Fetuses:100 Pregnancies			129		
					Pregnancies:100 Cows			90		
					Excluding Class I Individuals			94		

remain barren or lose their fetuses as a result of disease or malnutrition. This, however, does not appear to be a problem in the Matanuska Valley and Railbelt areas, where the bull:cow ratios are as low as 7 per 100 in some localities and where available winter browse appears to be a limiting factor in other localities, as 88 of 93 (95 percent) of all cows older than Age Class I were pregnant (Table No.13).

The present technics employed to age moose are not sufficiently accurate to assign a specific year to an age class. The age classes probably include several year classes, particularly in the older age categories (see Sex and Age Composition section). Thus, in an effort to measure the relative calf production of young and old moose and to minimize the aging technic problems, the eight recognizable age classes of breeding age females were lumped into four age categories. Yearlings, or Class I, individuals were considered separately (Class I individuals are discussed in Age at Sexual Maturity section).

The age category of Class II and III individuals, unfortunately the most difficult age classes to separate, includes the period at which female moose reach sexual maturity (see Age at Sexual Maturity).

The category of Age Classes IV and V, which probably includes moose of 3 1/2 to 6 1/2 years, coincides with early physical prime, and is represented by 30 individuals. No barren cows were found in this group.

The age category composed of Classes VI and VII probably represents moose of 6 1/2 to 10 1/2 years; only one of 14 other animals examined was barren.

The oldest group, Age Classes VIII and IX, probably represents moose 10 1/2 to 20 years old; only two of 17 cows examined were barren.

Although the present data are limited in number, there is no indication that female moose live past their reproductive age even though hunting is not at present used to manipulate the age structure of the herd.

Only one of 15 (above Age Class I) unknown-age females was barren. Thus, as mentioned earlier, 95 percent of all female moose examined, above Age Class I, were pregnant.

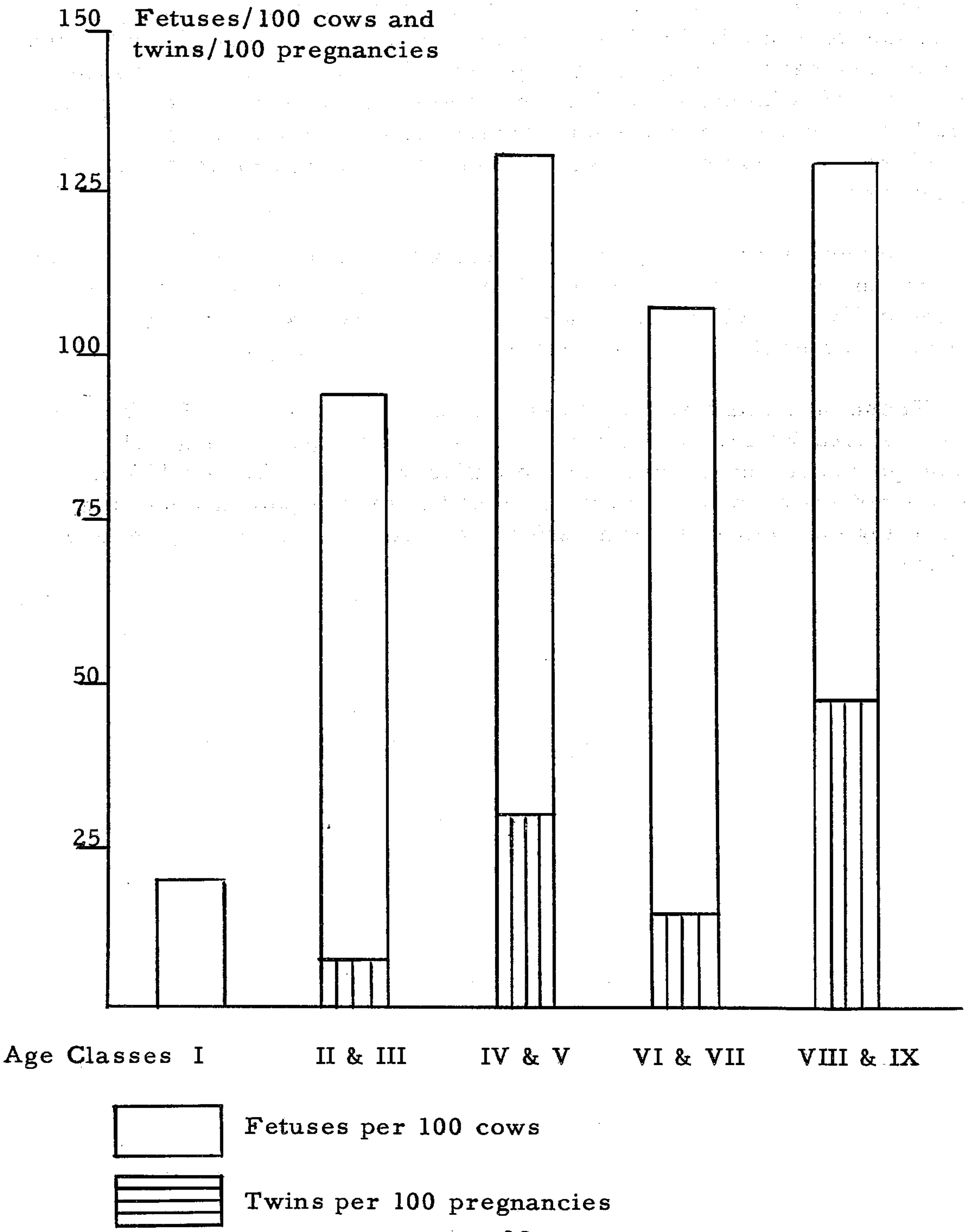
Another important factor in evaluating the relative reproductive importance of each age category is the number of calves produced. This is expressed as calves per 100 cows and the barren cows are included in the computations (Figure No. 9). These data reveal that the younger age groups, Age Class I and Age Classes II and III, produce fewer calves and that the oldest age group, VIII and IX, continue to produce calves.

The rate of twinning is still another factor relative to the importance of a particular breeding age group. Figure No. 9 indicates that the youngest breeding age group, Age Classes II and III, has the lowest rate of twinning as well as the lowest calf:cow ratio, excepting Class I individuals which are not considered a breeding age group. The oldest age group has the highest rate of twinning; 47 sets per 100 pregnancies.

The age category composed of Age Classes VI and VII, presumed to represent moose in late prime of life, is difficult to interpret as both the calf:cow and twinning rate are lower than expected. This is probably the result of a small nonrepresentative sample.

These data indicate that potential reproduction in the Railbelt and Matanuska Valley moose populations is very good; that great hunting pressure, even reducing the bull:cow ratio to 10 per 100 or less has not lowered the fertility rate of the moose populations; and that hunting only bulls is not an effective means of controlling moose numbers.

Figure No. 9 . Comparative potential reproduction of five age categories of cow moose.



Sex and Age Distribution of the Matanuska Valley and Railbelt Moose Populations

Sex and age data were obtained from 476 moose, from Age Class Fetus to Age Class IX, the oldest recognizable age category (Table No. 14). The sex and age information for Age Classes Fetus and Calf represents all specimens collected, and includes animals collected as a result of railroad and highway accidents and illegal kills. The specimens represented in Age Classes I-IX were killed by trains during the winters of 1955-56 and 1956-57 between Mile Posts 150 and 250 on the Alaska Railroad.

Sex Ratios. Initial sex ratios of many mammals, including cervids, approximate a 1:1 ratio with, perhaps, a slight numerical superiority of males indicated for some species. Sex ratios at conception indicate a definite male superiority in numbers, under certain favorable conditions, but sex selective mortality factors tend to reduce this superiority even during the prenatal period. Robinette, et. al. (1957), working with mule deer, presented a review of the literature on sex differential mortality as well as considerable quantitative data on mule deer sex ratios, both pre- and postnatal. The literature and data presented show that there are exceptions to the general belief that males outnumber females at birth. This is especially apparent when dealing with local populations. Some factors which may influence the initial male:female ratio are as follows: age structure of the population, average age and past reproductive history of the females, the plane of nutrition before and after conception, and the severity of winter during the gestation period. Although these factors can affect the male:female ratio at birth, there seems to be no way to predict which sex will be favored; generally, however, the male suffers the greatest mortality.

Robinette, et. al. (op. cit.) indicate that postnatal sex selective mortality factors in mule deer apparently affect males at a greater rate during the early months, but that females die at a greater rate during the first winter. This is reversed during the second winter. During this period the mortality loss rate for males is roughly twice that of females.

The present data on the sex ratio of moose fetuses are limited, but information from 63 fetuses indicates a sex ratio of 103 males per 100 females. The sex ratio of 14 sets of twin fetuses was 16 males to 12 females or 133 males per 100 females. The sex composition of the 14 sets of twins was as follows: males, 5 sets; mixed, one male and one female, 6 sets; and females, 3 sets.

The sex ratio of 129 moose calves, varying in age from one to ten months, was 64 males to 65 females or 98 males per 100 females. This is essentially a 1:1 ratio, as was found in the prenatal specimens, with only a slight indication of excessive male mortality.

The sex ratio of animals older than calves is distorted by hunting. The influence of hunting on the sex ratios of the moose populations is illustrated by dividing the study area into three local areas which are subjected to varying degrees of hunting pressure. The criteria for separating these areas are based on aerial sex and age counts, observations on winter migrations and upon known accessibility to hunting. The areas are as follows: Area I, the Matanuska Valley, Mile Posts 150-175 along the Alaska Railroad; Area II, the Willow area, Mile Posts 176-200 along the Alaska Railroad; and Area III, the Kashwitna-Talkeetna area, Mile Posts 201-250 on the Alaska Railroad. These areas represent moose populations subjected to intense, heavy, and practically no hunting pressure, respectively.

The moose represented in Table No.14, above Age Class Calf, were killed by trains during the winters of 1955-56 and 1956-57. The eight age classes above Age Class I have been combined into four age categories in an attempt to compensate for the aging technic difficulties (see Age Distribution). Although the samples from each local area are small, the effect of hunting on the male segment of the moose populations in Areas I and II is very apparent. The bull:cow ratio in Areas I and II are 21 and 38 bulls per 100 cows, respectively. The assumption that sex ratios obtained from examination of train killed moose are representative of the existing moose populations is supported by the sex ratio data obtained from aerial sex and age counts made on approximately the same local moose populations (see Sex and Age Composition in the Lower Susitna Valley). The sex ratios obtained by the two sampling technics are similar. The overall bull:cow ratio as indicated by the railroad kill is 57 bulls per 100 cows. The same ratio obtained from aerial composition counts is 44 bulls per 100 cows. The two samples are not directly comparable, however, because most of the railroad sample came from Area III which is not hunted, whereas, over half of the aerial sample represents a heavily hunted area. Nevertheless, trains appear to sample proportionately the moose populations inhabiting the areas adjacent to the right-of-way.

The sex ratio in Area III, which supports very little hunting, is 84 bulls per 100 cows, approaching a 1:1 ratio, but showing a definite indication of excessive male mortality. The sex ratio of the three oldest age classes, 46 bulls per 100 cows, suggests that sex selective mortality factors affect males. However, even relatively light hunting would distort the sex ratio; particularly that of the older age categories.

The sex ratio of the yearling class, which indicates a surplus of males, is confusing. The only logical explanation is that trains select yearling males or, more plausible, that the sample is not representative of the age class in question.

Sex ratios of moose appear to be essentially 1:1 with only a slight indication of male superiority in numbers during the fetal stage and a corresponding slight indication of excessive male mortality during the first year of life. The sex ratios beyond Age Class Calf are distorted by hunting, but in Area III where hunting is limited by accessibility natural mortality apparently affects males at a greater rate.

Age Distribution. Data on the age of 240 moose, Age Class I-IX, were obtained from animals killed by trains between Mile Posts 150 and 250 on the Alaska Railroad. These data are presented in Table Nos. 14and 15.

Age determinations of moose based on comparative wear of the mandibular teeth have been described by Skuncke (1949), Lensink (1955), and Peterson (1955). All three of the aging technics are based on diagnostic characteristics of tooth wear, and jaws evidencing similar wear are placed in the same age class. Apparently, only Skuncke had some known age jaws for comparative purposes. All three of the previously named writers describe nine general age classifications, excluding calves of the year. In all probability only the first three age classes correspond to the chronological age of the animal. In analyzing the material presented here the writer first used a key, based on a combination of diagnostic characteristics of wear, constructed by Lensink (op. cit.). Subsequent cross checking by Lensink revealed that complete agreement was not obtained even on Age Classes II & III when using the key alone. Since comparative wear is difficult to evaluate quantitatively, classification of jaws based on experience and comparison with a set of known age or approximate age jaws seems a more desirable technic. Quimby (1957) working with elk and having known age jaws for comparison concluded that no single characteristic or combination of characteristics of wear satisfactorily separated animals with "full mouths", and while not absolute, the best technic was visual comparison with known age jaws. In his conclusion he further states, ". . . familiarity gained by handling large numbers of jaws seems to provide the best criteria for establishing age classes."

The latter, in combination with a jaw board of approximate age jaws, is the technic employed to classify the jaws discussed in this section of the report. Age Class II and beyond undoubtedly includes more than one year class. The overlap occurs because moose are known to have a maximum life span of at least 21 years (Skuncke, op. cit.). Thus, the seven age classes beyond Class II represent moose from 3 to 20 years of age. In all probability the older age classes represent 3-5 year classes.

Hunting changes the age distribution of the bull population segment and for this reason bulls and cows are considered separately in Table Nos. 14 and 15. Very few bulls survive to Age Classes VIII and IX in the three local areas studied. The reason for the poor survival of bulls in Area I and II is directly attributable to removal by hunting. The mortality factors affecting bull survival in Area III are not known.

The status of the population as reflected by age distribution is best assessed from age determinations of the female segment, because, as has been previously discussed, males are removed by hunting. Again, the lack of accurate aging criteria, especially for year classes, compounds the problems involved in analyzing the significance of the population age structure. The basic problem involved is determining the exact number of year classes represented by a particular age class. However, until known age specimens are available the desired breakdown will not be possible and analysis of population age structure based on the nine recognizable age categories or combinations thereof must be considered as only a general indication of population age structure.

Several interesting population trends are revealed through analysis of the age structure of the 1955-56 railroad killed moose. The data obtained from the 1955-56 kills are used instead of a cumulative total kill for a number of years because of the desirability of analyzing the fate of several important year classes. The 112 cow moose, Age Class I-IX, killed by trains during the winter of 1955-56 are listed in Table No. 16 by age class and percent of total. Analysis of these data reveal that Age Classes I and II comprise only six and five percent, respectively, of the total female population. This suggests poor survival of these age classes. Cross checking with the 1953 and 1954 fall aerial sex and age composition counts made on these same areas reveals that the calf:cow ratios were approximately 44 and 40 calves per 100 cows, respectively. Thus, if the sample of railroad killed animals is representative of the existing female population, great mortality has occurred to these age classes. The unusually severe winter of 1954-55 may have caused heavy mortality of calves and possibly affected yearlings similarly (see Sex and Age Composition in the Lower Susitna Valley). Unfortunately, quantitative evidence of calf survival during severe winters is not available. Limited field observations made during the winter of 1955-56, when total snow accumulation possibly exceeded that of 1954-55, revealed that calf and adult mortality may have been heavy, particularly in Areas II and III. Area I, the Matanuska Valley, did not experience unusual snow accumulations in 1955-56. Cow moose have a long reproductive life span and consequently the apparent poor survival of two successive age classes is not necessarily a serious loss in a well established moose population (see Reproduction).

The age structure of the Railbelt moose populations, as indicated by train killed moose for the years of 1955-56 and 1956-57 has a preponderance of "middle" to old age females. However, the age structure of the cow segment of the three local populations is quite different. In Areas I and II 58 and 51 percent, respectively, of the cows are of Age Class V or older, whereas in Area III only 38 percent of the cows are represented in the older age classes. The percentages of females in the oldest age category, Age Classes VIII and IX, from the three areas are as follows: Area I, 25 percent; Area II, 19 percent; and Area III, 11 percent. These data indicate that the age structure of the population in Area III is considerably younger than that of Area I. The most obvious differences between the two areas which might affect population age structure are climatological. Area I, the Matanuska Valley, is subjected to frequent strong winds throughout the winter. The winds tend to reduce the snow cover thereby allowing moose easier travel to browse areas and also making more browse available to the moose. The average temperatures in the Matanuska Valley are considerably warmer than those of Area III. Area III lies within a deep snow belt; frequently 40 or more inches of snow cover the ground and consequently also cover the low shrubs, thereby reducing the amount of available winter browse. Theoretically the more favorable climate of Area I should allow for a greater survival of calves and for better survival of the oldest age class individuals. The harsh winters of Area III could cause great mortality of calves and old animals.

The data obtained from the railroad killed moose indicate that the two populations are possibly responding to the effects of climate as illustrated in the preceding discussion. Area I has a very dense population of moose, with a considerable number of old females. Area III has considerably fewer moose per square mile but has an overall younger population.

Other factors may be affecting the age structure of these populations. The numbers of moose in Area III may be increasing, although there are no data to indicate a substantial increase in moose numbers in this area. Area I populations possibly are decreasing, hence an unbalanced old population; however, the annual calf:cow ratios indicate that production is excellent and last fall's hunting season revealed that survival of bull calves to 16 months was very good.

Table No. 14. Sex and age ratios of three local moose populations (as obtained from railroad kills the winters of 1955-56 and 1956-57).

Age Classes & Area	♂	♀	Total Sample	♂:100 ♀	Percent of Males in Each Local Population	Percent of Females in Each Local Population	Percent of Total Sample
Fetuses	37	36	73	103			
Calves	64	65	129	98			
Class I							
150-175	2	1	3	200	40	5	
176-200	2	2	4	100	10	3	
201-250	9	6	15	150	15	8	
Combined	13	9	22	144	15	6	9
Class II & III							
150-175	2	3	5	66	40	12	
176-200	5	7	12	71	23	12	
201-250	11	18	29	61	18	25	
Combined	18	28	46	64	21	18	19
Class IV & V							
150-175	1	6	7	16	20	25	
176-200	10	20	30	50	45	34	
201-250	23	20	43	115	38	28	
Combined	34	46	80	74	39	30	33
Class VI & VII							
150-175	0	8	8	0	0	33	
176-200	4	18	22	22	18	31	
201-250	12	19	31	63	20	27	
Combined	16	45	61	35	18	29	25
Class VIII & IX							
150-175	0	6	6	0	0	25	
176-200	1	11	12	9	5	19	
201-250	5	8	13	62	8	11	
Combined	6	25	31	24	7	16	13
Combined Totals							
150-175	5	24	29	21			
176-200	22	58	80	38			
201-250	60	71	131	84			
Total	87	153	240	57			

Table No.15. Sex and age composition of Railbelt and Matanuska Valley moose populations by age class (as obtained from railroad killed moose during the winters of 1955-56 and 1956-57).

Area and	1955-56		1956-57		Combined		
Age Class	♂	♀	♂	♀	♂	♀	♂:100 ♀
<u>150-175</u>							
I	1	1	1	0	2	1	
II	0	0	0	1	0	1	
III	1	2	1	0	2	2	
IV	0	2	0	2	0	4	
V	1	1	0	1	1	2	
VI	0	4	0	1	0	5	
VII	0	2	0	1	0	3	
VIII	0	1	0	0	0	1	
IX	0	5	0	0	0	5	
Totals	3	18	2	7	5	24	21
<u>176-200</u>							
I	1	2	1	0	2	2	
II	0	2	0	0	0	2	
III	3	3	2	2	5	5	
IV	3	8	3	3	6	11	
V	3	6	1	3	4	9	
VI	2	6	1	0	3	6	
VII	0	8	1	4	1	12	
VIII	1	4	0	1	1	5	
IX	0	6	0	0	0	6	
Totals	13	45	9	13	22	58	38
<u>201-250</u>							
I	8	4	1	2	9	6	
II	1	3	3	3	4	6	
III	4	4	3	8	7	12	
IV	5	4	7	4	12	8	
V	9	9	2	3	11	12	
VI	6	10	5	1	11	11	
VII	1	8	0	0	1	8	
VIII	3	5	0	0	3	5	
IX	2	2	0	1	2	3	
Totals	39	49	21	22	60	71	84

Table No.16. Age of 112 cow moose killed by trains the winter of 1955-56 between Mile Posts 150-250 on the Alaska Railroad.

Age Class	Number of Moose	Percent of Total
I	7	6
II	5	5
III	9	8
IV	14	13
V	16	14
VI	20	18
VII	18	15
VIII	10	9
IX	13	12
Total	112	100

Weights and Measurements

Peterson (1955) summarized the available weights and measurements of the four subspecies of North American moose. The Alaskan subspecies, Alces alces gigas, is represented in his data by five specimens (bulls collected for museum groups taken from the Kenai Peninsula). No weights are recorded for the Alaskan specimens.

Eighty-three moose, of Age Class Calf or above, were weighed or measured in conjunction with current moose management studies of the Railbelt and Matanuska Valley moose populations in south central Alaska (Table No.17).

The weights are in pounds and are self explanatory. The measurements are in millimeters and definition is necessary. The definitions are as follows:

Girth--This measurement was taken as a circumference of the body back of the forelegs--around the deepest part of the chest.

Hind Foot--This measurement was taken from the heel of the calcaneum to the tip of the hoof.

Total Length--This measurement was taken from the tip of the nose to the tip of the tail, excluding hair, following the body contours.

Ear--This measurement was taken from the notch to the tip of the ear, excluding hair.

Height at Shoulder--This measurement was taken from the vertebral spine of the scapula to the bottom of the hoof.

Pelvis--This measurement was taken from the crest of the ilium to the tuberosity of the ischium.

Body--This measurement was taken from the metacromium process of the scapula to the atlas.

Neck--This measurement was taken from the metacromium process of the scapula to the atlas.

Tail--This measurement was taken from the tip of the tail, excluding hair, to the first sacral vertebra. On moose this measurement is very difficult to take accurately.

Table No.17. Weights and measurements of moose.

Date	Age	Measurements[1] Girth	H. F.	T. L.	E.	Ht. Sh.	Pelvis	Body	Neck	T.	Weights[2] Body	Total	Sex	Accession No.
5/29/57	Calf	655	445	1140	135	835						40	♀	968
6/2/57	Calf	660	465	1090	140	795	220	600	240	45		48	♂	969
6/5/57	Calf	600	420	880	125	770	175	500		40		31	♀	970
6/6/57	Calf	630	440	1105	140	850	200	570		45		45	♂	971
6/13/57	Calf	810	510	1190	160	960	245	680	270	60		78	♀	501
6/15/57	Calf	610	444	842	130	864						39	?	974
6/18/57	Calf	720	460	1180	140	850	210					58	♂	973
6/18/57	Calf	680	430	1040	140	840	190					53	♀	972
6/24/57	Calf	680	472	1052	153	942	185					62	♂	975
6/30/57	Calf		489	1155		927				51		54	♂	504
7/11/56	Calf		533	1295	171					114		102	♂	
7/18/57	Calf		552	1220		1092				76		110	♀	507
(Kalgin Island Moose[3]														
(														
(6/18/57	Calf	680	430	1040	140	840	190					53	♀	972
(6/30/57	Calf	711	451	1079		863							♀	972
(8/11/57	Calf	914	533	1549		1041							♀	972
(														
(6/18/57	Calf	720	460	1180	140	850	210					58	♂	973
(6/30/57	Calf	737	457	1117		914							♂	973
(8/11/57	Calf	990	558	1625		1117							♂	973
11/15-20/57	Calf	1499	673	2108	229	1397	381	1321	267			425	♀	944
11/23/57	Calf		673			1359		1066			210	310	♂	779
11/23/57	Calf		711		229	1499					270		♂	820
12/20/56	Calf										285	450	♂	340

Table No. 17(Continued).

		Measurements									Weights			Accession
Date	Age	Girth	H. F.	T. L.	E.	Ht. Sh.	Pelvis	Body	Neck	T.	Body	Total	Sex	No.
1/2/57	Calf		622	1626		1257							♀	352
1/4/57	Calf		635											
1/8/58	Calf	1321	660	1930	216	1435	394	991		108	210	325	♂	964
1/16/57	Calf	1575	610	1981	254	1422	381	1219	406		275	425	♀	328
1/21/58	Calf	1626	718	1981	222	1511	445	1422	470		265	425	♂	984
1/26/57	Calf		635								205		♂	339
1/26/57	Calf	1473	635	1549	229	1321			330			300	♀	327
1/26/57	Calf	1473	660									202[4]	♀	334
1/26/58	Calf	1549	699	2007	210	1397	406	1321	394			385	♀	987
1/29/58	Calf	1473	692	2159	215	1505	413	1232	406				♂	994
1/31/57	Calf	1524	711		203						223		♂	418
2/3/58	Calf	1372	718	2184	222	1397	419	1346			240	395	♂	
2/4/57	Calf	1524	686			1549					225	375	♂	375
2/4/57	Calf	1422	686			1473					235		♂	366
2/4/57	Calf	1397	610			1473					205		♀	223.4
2/11/57	Calf		673								208		♀	2/11
2/13/57	Calf	1461	686	1880	216	1575			356		268	415	♀	379
2/14/57	Calf				216	1448					240		♀	389
2/16/57	Calf	1270	648	1575	191	1397	318	1092	368		140	230	♀	380
2/23/57	Calf	1524	660	1676		1461			318		205	310	♀	397
2/26/57	Calf	1321	673	1930	216	1422	343		305		200	315	♂	403
3/2/57	Calf	1422	673	1803	216	1499			356		235	385	♀	405
3/11/57	Calf	1321	660	1854	216	1372			356		195	295	♂	426
8/31/57	I			2159	241	1549					485		♀	543
9/2/57	I	1981	749	2438	254	1651	533	1575	495			630	♀	536
3/19/57	I	1829	813	2642	254	1753	533		508		457	669	♀	428

Table No. 17(Continued).

Date	Age	Measurements Girth	H. F.	T. L.	E.	Ht. Sh.	Pelvis	Body	Neck	T.	Weights Body	Total	Sex	Accession No.
9/2/57	II		800			1715					590		♀	513
10/31/57	II	2134	813	2515		1880							♀	677
3/4/57	II	1930	762	2134	254	1803					540	770	♀	415
8/24/57	II-III		749		248	1676						843	♀	559
11/26/57	III-IV	1880	775		254	1753		1524	406		690	840	♀	
8/22/57	III-IV	1905	787	2591	248	1727	533	1727	584	102	545	840	♀	528
1/8/57	IV-V		813									870	♀	420
2/4/57	IV-V	1905	838			1854					665		♀	373
2/13/57	IV-V	1905	787	2438	260	1880	508		610		540	828	♀	378
4/9/57	IV-V		800		248	1829					510	695	♀	450
3/14/57	V		762	2489	254	1854			457		570		♀	430
8/25/57	V-VI	2032	800	2642	267	1854	584	1753	559		700	995	♀	521
9/2/57	VI	2337	787	2692	254	1803			508			925	♀	531
3/9/57	VI	1930	787	2337	241	1880			495		580		♀	417
4/2/57	VI	1880	787	2718	254	1905	559	1753	584		514	800	♀	448
9/16/57	VI-VII	2286	806	2845	273	1880		1702	660		670	955	♀	586
6/9/57	VI-VII	1803	800	2692	241	1803	483		584	89	540	760	♀	500
11/3/57	VIII-IX	2083	826	2616		1854							♀	676
2/22/57	IX		762								500		♀	398
4/10/57	IX		787		260	1727					411	579	♀	451
12/19/57	Adult	2108	806	2794	248								♀	Tags 99-100
1/17/57	Unknown		762									908	♀	344
8/21/57	I		775	2083	248	1536		1080		152			♂	629
8/22/57	I	1727	737	2464	254								♂	821
9/8/57	I	1524	762	1600							450		♂	822
2/7/57	I		749			1753						652	♂	391
3/31/57	I	1626	800	2743	254	1753		1549	559				♂	444

Table No. 17(Continued).

Date	Age	Measurements: Girth	H. F.	T. L.	E.	Ht. Sh.	Pelvis	Body	Neck	T.	Weights: Body	Total	Sex	Accession No.
8/20/57	II		800	2642	254	1638							♂	630
12/18/57	III		813			1778					809[5]		♂	938
2/4/57	III										545		♂	369
9/20/57	IV		826	2819	267	1981				127			♂	587
2/16/57	IV-V		813								580		♂	402
1/31/57	VI	2235	838			2134					780	1085	♂	360
2/14/57	VI		826		254	2083					730		♂	387
1/8/58	VIII	2261	838	2870	254	1930		1778	559		870	1140	♂	965
11/2/57	Unkn.	1930	787	2629	273	1880					540		♂	790
2/7/57	Unkn.	1702	762			1803					460	645	♂	208.5

[1] Measurements in millimeters.
[2] Weights in pounds.
[3] These courtesy of Charles Parsons.
[4] Starved.
[5] With antlers.

Although the present data are too few to be conclusive, it seems that very few mature bulls exceed 1200-1400 pounds in total weight even in their pre-rut prime. Total weights of four bulls, and hog dressed weights of six bulls, Age Class I and above are presently available (Table No. 17). The weights of the mature bulls, Age Class III and above, are all from the winter months, a period when bulls are very thin and possibly weigh 10 to 15 percent less than during their pre-rut prime in the early fall (Skuncke 1949). The heaviest of these individuals weighed a total of 1140 pounds. Skeletal measurements indicated that this was a very large moose.

The maximum total weight of 17 females Age Class I and above was 995 pounds. The average total weight of 10 females Age Class II and above which were collected during the fall and winter months was 877 pounds. Cow moose do not lose weight during the breeding season in late September and early October and consequently they enter the winter in prime condition. They do, however, utilize their fat deposits gradually during the winter and by spring have lost considerable weight. The average total weight of four females above Age Class II which were collected in late spring and early summer, was 708 pounds; roughly 20 percent less than the average of the 10 individuals collected during the fall and winter. The amount of weight lost by individual female moose is dependent upon a number of factors including the severity of the winter and the quantity and quality of available winter browse. The few weights recorded here are not necessarily typical of all areas. Certainly, a greater number of individuals representing all seasonal periods and contrasting climatological and range conditions are needed before conclusions are drawn concerning average winter weight losses.

Growth

Moose calves grow rapidly during their first five or six months of life and may weigh 10 or more times their birth weight by the end of this period. Calves, which in this area are born from mid-May to early June, weigh approximately 25 to 35 pounds at birth (Kellum 1941; Skuncke 1949) and by mid-November they may weigh as much as 400-450 pounds.

The average of 10 calves weighed during late May and June (nine were weighed in June) was 50 pounds; two calves weighed in mid-July averaged slightly over 100 pounds apiece; three calves weighed in mid-November averaged 385 pounds apiece.

The growth of moose from conception through the first year of life is illustrated in Figure No. 10. This graph was constructed from the total length measurements of 95 moose embryos, fetuses, and calves. In this and in the subsequent figures in this section of the report the individual measurements are represented by a point and the averages for the indicated periods by a circle. The curve was fitted to the averages by visual inspection. This is a generalized and tentative curve, as are those given in subsequent figures, and it is not meant to represent any biological law of growth, nor to picture detailed variations in the growth pattern.

The range of total lengths is quite great, particularly in those taken during the winter months when the moose were 6-10 months old. This may well reflect individual differences in rate of growth. The rate of individual growth may be affected by a number of factors of which the more obvious are: differences in the rate of development between the sexes, between twins and singletons, individual differences, i.e., genetic, and variations in local environmental conditions. At present data illustrating these factors are very meager. Skuncke (op. cit.) reports that males exceed females in total growth at the end of six months. There is some indication that moose vary in size from one area of Alaska to another. Again, weights and measurements representing the various areas are too few to be significant.

Growth from the early fetal stages through the first five or six months of life is continuous although at a progressively decreasing rate. With the onset of winter conditions in late November, growth apparently halts.

The growth of moose from birth through approximately 22 months is illustrated in Figure Nos. 11 and 12. Figure No. 11 is based upon total weights of 40 moose. The curve was fitted to these averages by visual inspection. Figure No. 12 represents hind foot measurements of 49 moose. This curve was fitted to the biweekly averages by visual inspection.

The data represented by Figure Nos. 11 and 12 indicate that moose calves grow only during the summer and early fall. Apparently their winter forage, largely willow, birch, and aspen twigs, provides only a maintenance diet. It has been demonstrated that many grasses, legumes, and some trees lose much of their food value at maturity. This, combined with the change from a lush summer diet of leaves, shrubs, and aquatic vegetation and milk, plus the increased difficulty of obtaining food with the advent of snow, perhaps, causes a cessation of growth. However, the physiological processes responsible for the cessation of growth and the stimuli governing them are not, at present, completely understood. This writer believes that in moose, one of the principal factors is the low nutritional plane of the winter diet.

Another period of relatively rapid growth commences in the spring of the moose's second year and by September or October, at 16 to 17 months of age, approximately 90 percent of the total skeletal growth is completed. It is interesting to note in Figure No. 13 that the second period of growth apparently ends in September or October, concurrent with the rut, whereas calves probably grow until November.

Total weight, however, continues to increase for a number of years but apparently at a much reduced rate. Skuncke (op. cit.) indicates that in Sweden moose grow in total weight, until at least seven years of age and that bulls probably grow in total weight until ten years of age. He further states that females do not grow much after the first three or four years. The weights and measurements of the Alaskan subspecies listed in Table No. 17 and illustrated in Figure No. 13 indicate that females grow very little in either total weight or skeletal measurements beyond Age Class III.

Figure No.10. Growth of moose from conception to 10 months post partum as illustrated by total length measurements of 95 embryos, fetuses, and calves.

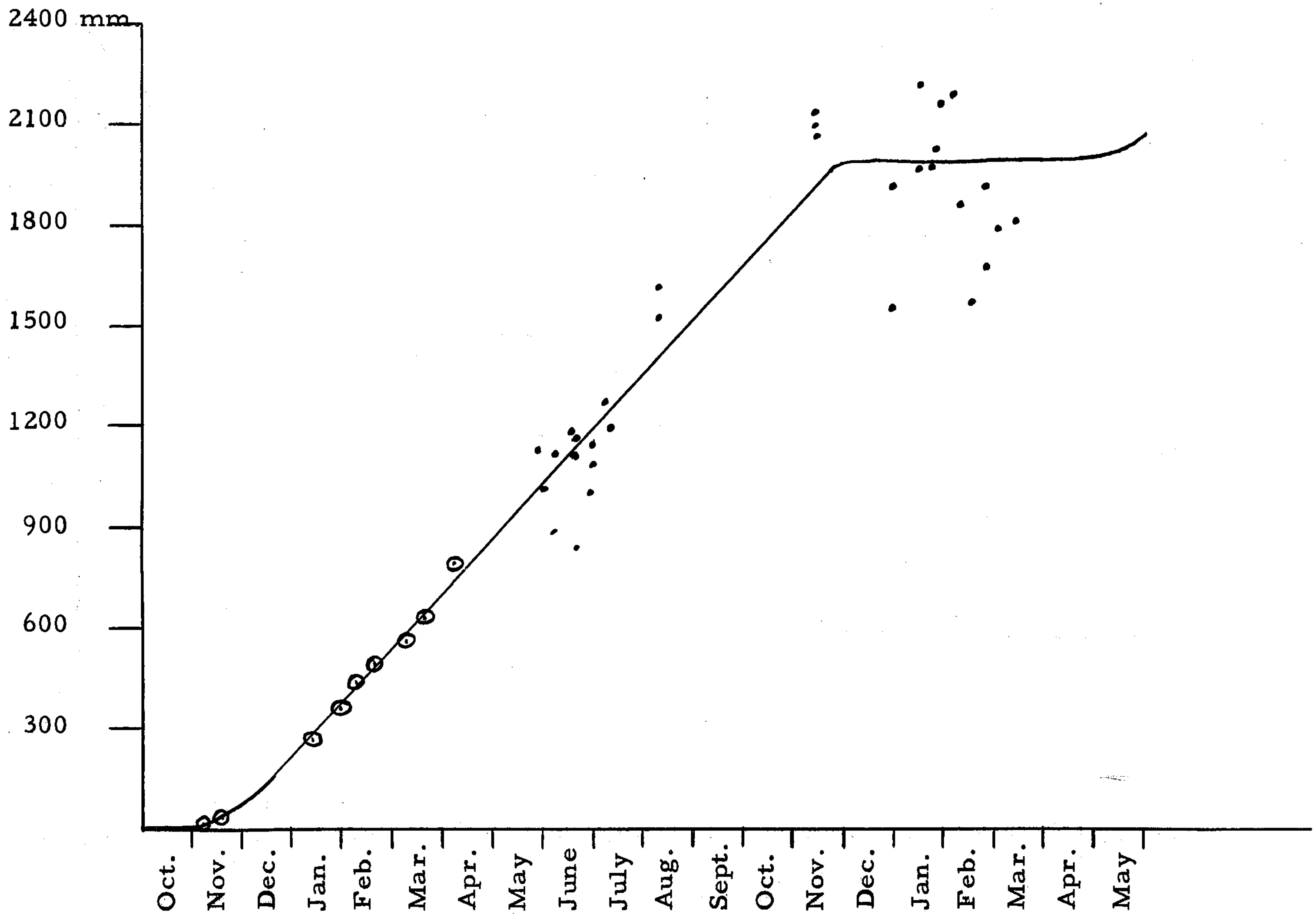


Figure No. 11. Growth of moose from 1 to 22 months as illustrated by total weights of 40 individuals.

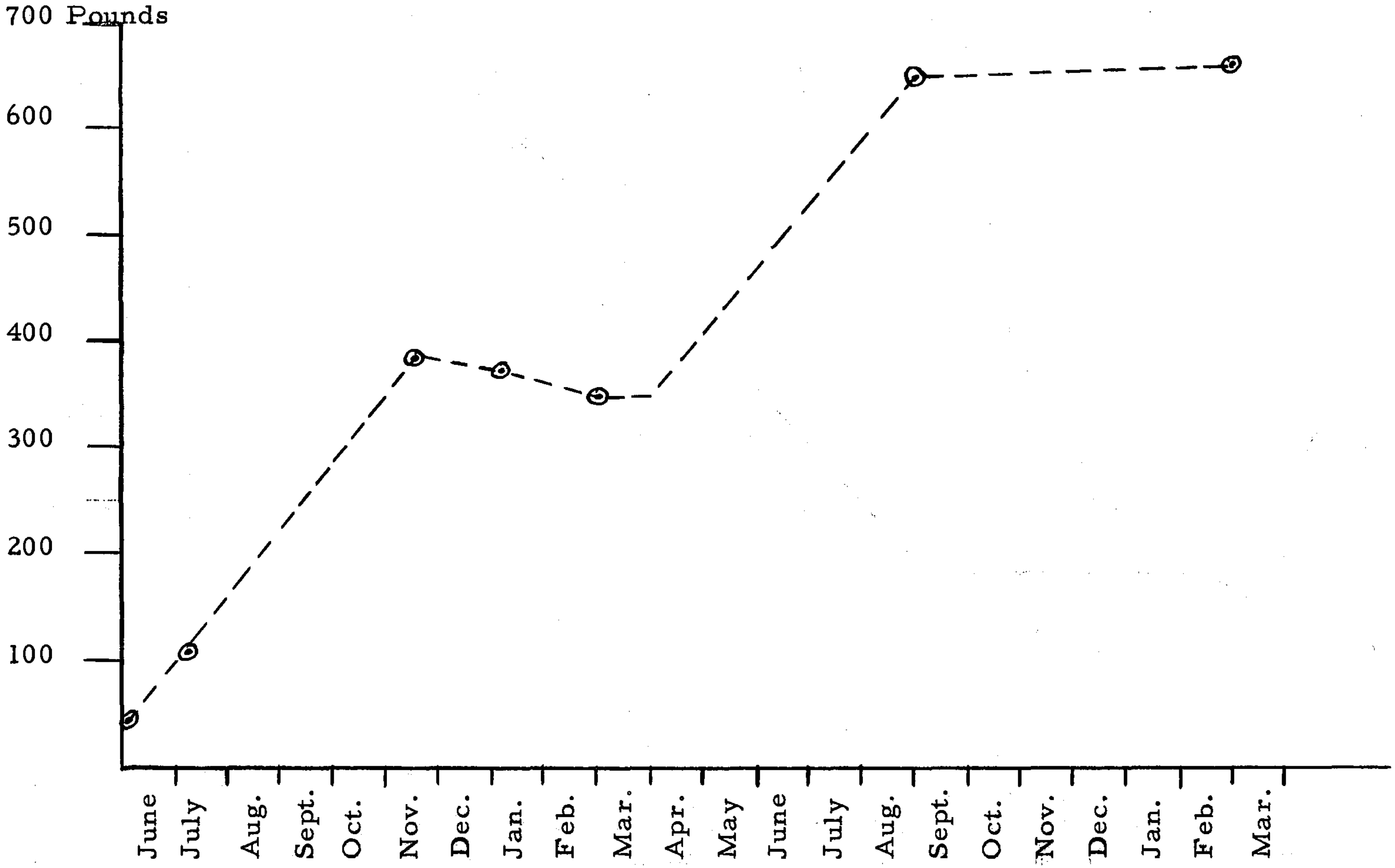


Figure No.12. Growth of moose from 1 to 22 months as illustrated by hind foot measurements of 44 individuals.

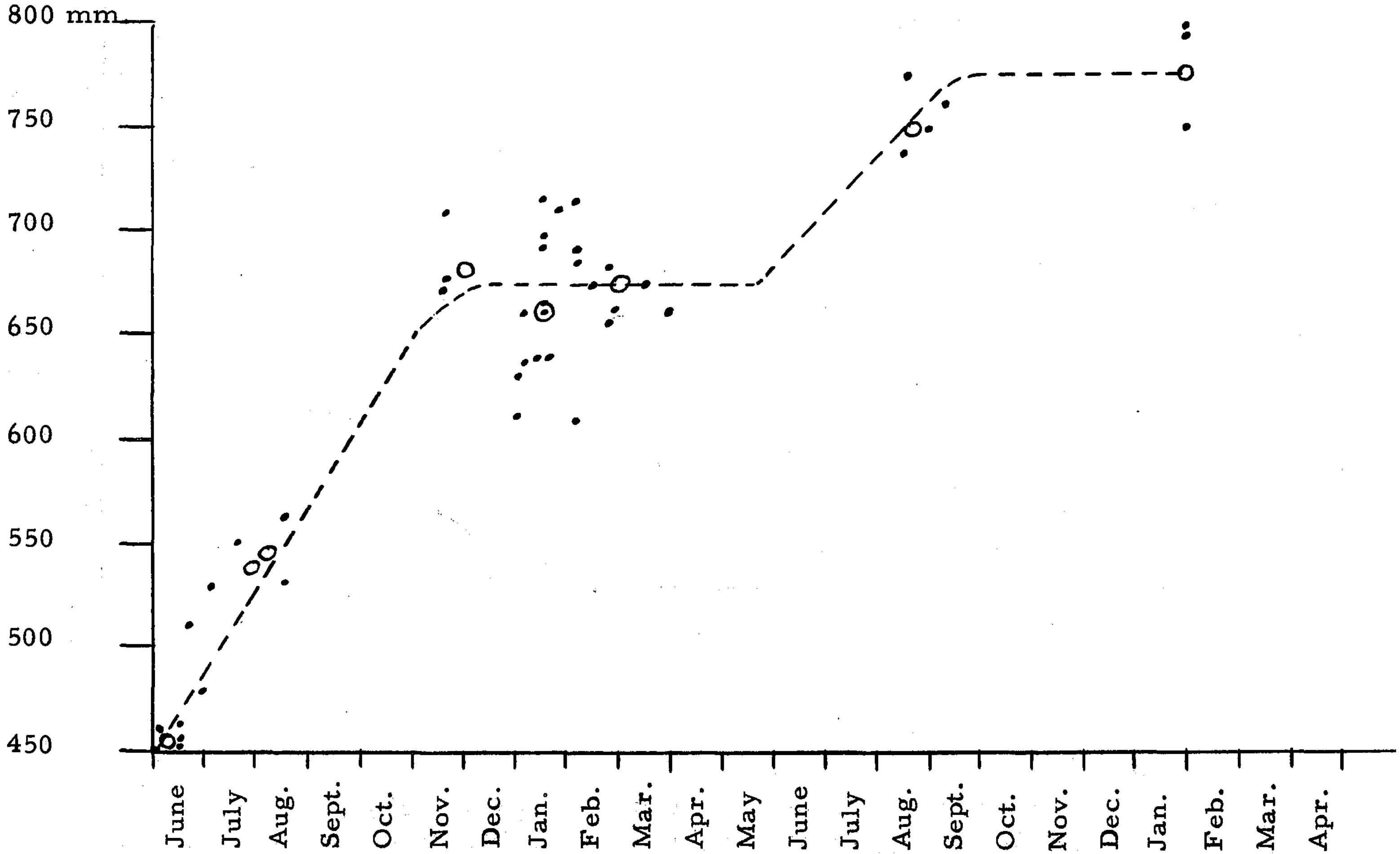
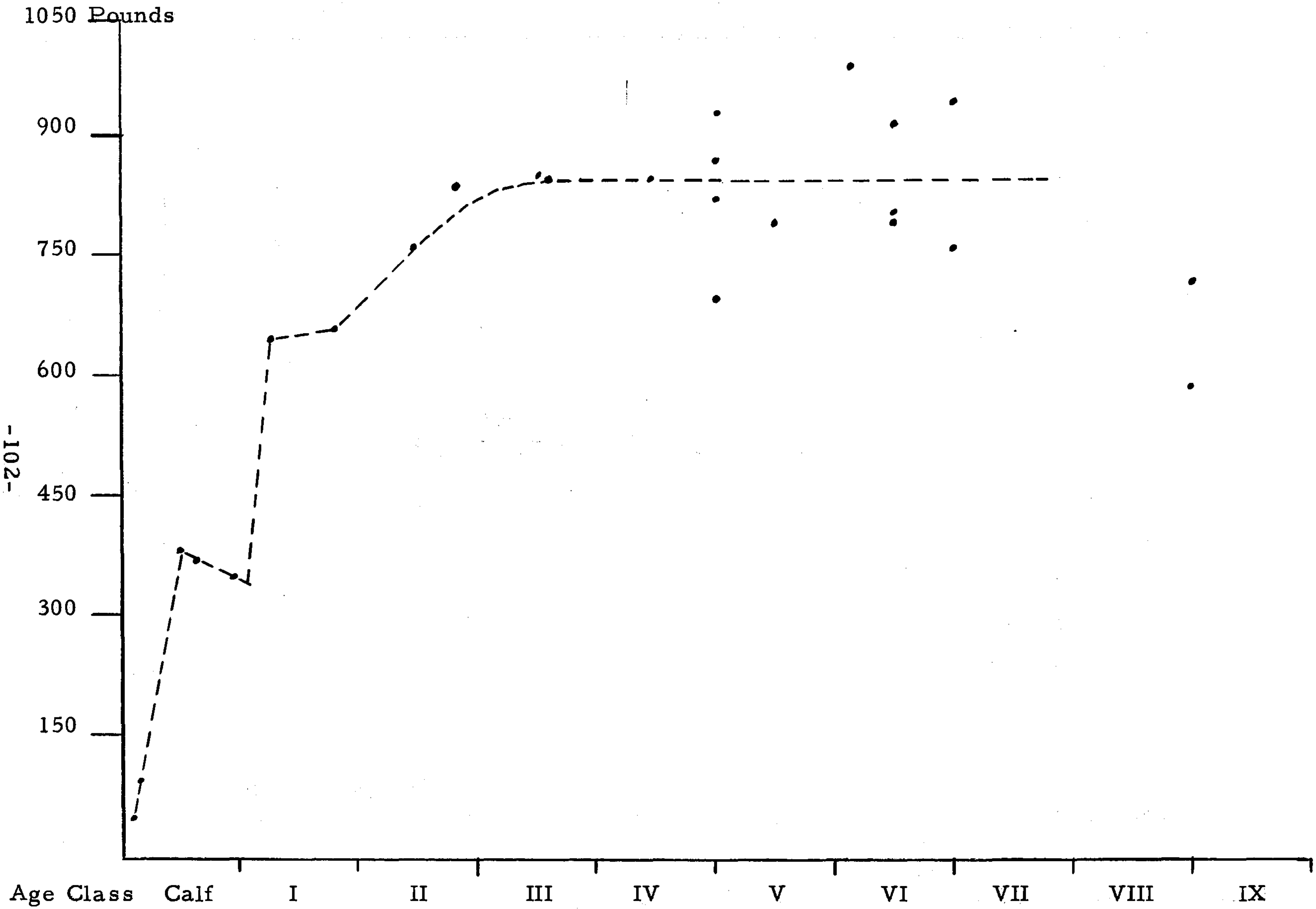


Figure No.13. Growth of moose from birth to maturity as illustrated by total weight. (Beyond Age Class II only weights of females are shown)



Notes on the Incidence of Echinococcus granulosus in Moose

One hundred and twenty-four sets of moose lungs have been collected and examined for the presence of hydatid cysts, Echinococcus granulosus larvae. The lungs were collected in conjunction with studies of the moose-railroad conflict, checking station operations, and routine examination of highway and other accidental kills. The collection of these data was greatly facilitated by cooperation of the management of the Alaska Railroad, railroad section personnel of the Willow, Caswell, Sunshine and Talkeetna sections, and local Fish and Wildlife Service game management agents.

The presence or absence of the tapeworm cyst was determined by visual inspection, palpation, and finally by sectioning the lungs into slices approximately one-half inch thick. Hydatid larvae do not always localize in the lungs of the host, but examination of 86 moose livers and hearts, the lungs of which were also checked and 17 were infected, have given negative results.

The life cycle of this parasite has been reviewed by R. L. Rausch (1952). The cycle usually involves ungulates as the intermediate host, and canines as the final host. The larval form, the hydatid cyst, is found in the intermediate host; usually moose and caribou in this portion of Alaska. The adult tapeworm is found in the final host, in Alaska, usually wolves or dogs. Coyotes are possible final hosts, although according to R. L. Rausch (viva voce) no instances of Echinococcus infected coyotes from the study area are known.

In compiling the data a natural geographic feature was used to separate the two areas portrayed in Figure No.14 and the data tabulated in Table Nos.18 and 19. All moose collected north of Knik Arm were considered in the Railbelt-Matanuska Valley populations and all moose south of Knik Arm are considered in the Anchorage-Upper Kenai populations. In all probability there is very little, if any, interchange between these two areas as Knik Arm and the adjoining mountains constitute a formidable natural barrier.

Analysis of these data reveal interesting information relative to the incidence, distribution and possible final hosts in the Lower Susitna Valley and Anchorage areas.

The incidence of E. granulosus in a moose population seems dependent upon the availability of the parasite and the length of time the individual host species has been exposed to it, i. e., the age of

Figure No. 14. The Railbelt-Matanuska Valley moose populations (Area I) and the Anchorage-Upper Kenai moose populations (Area II).

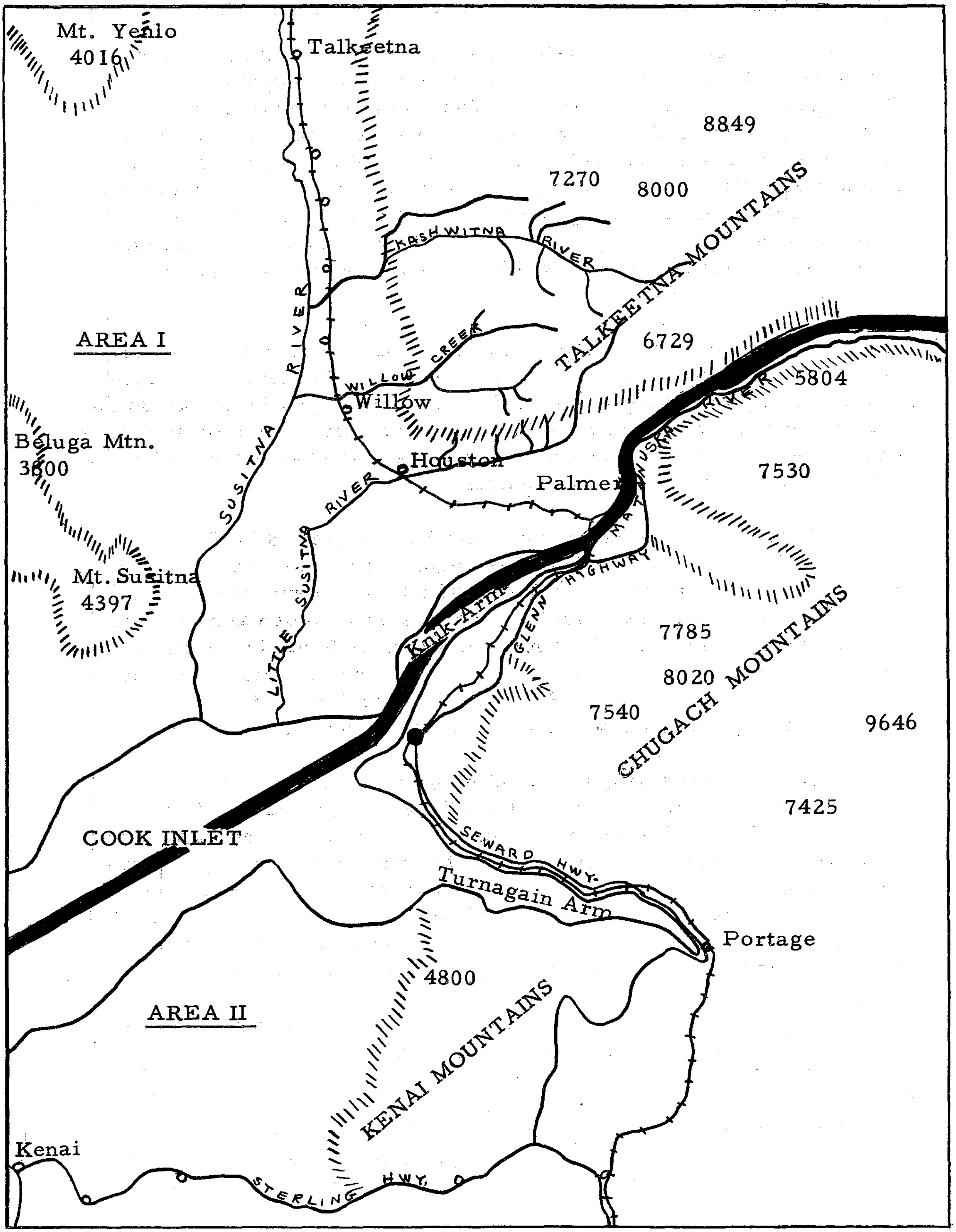


Table No.18. Incidence of <u>Echinococcus granulosus</u> in the Railbelt Moose Populations.

Age Groups	No. Lungs	No. Infected	Percent Infected	Percent of Sample
Calf	23	0	0	22.8
I	13	2	15.3	12.8
II & III	13	2	15.3	12.8
I, II & III	26	4	15.3	25.8
IV, V & VI	29	8	27.5	28.7
VII, VIII & IX	16	10	62.5	15.8
Unknown	7	2	28.5	6.9
Totals	101	24	23.7	100.
Excluding Calves	78	24	30.7	

Table No.19. Incidence of <u>Echinococcus granulosus</u> in the Anchorage-Upper Kenai Moose Populations

Age Groups	No. Lungs	No. Infected	Percent Infected	Percent of Sample
Calf	3	0	0	13.
I	3	0	0	13.1
II & III	4	0	0	17.4
I, II & III	7	0	0	30.5
IV, V & VI	5	1	20	21.7
VII, VIII & IX	8	0	0	34.8
Totals	23	1	4	100.
Excluding Calves	20	1	5	

the individual. In the Railbelt-Matanuska Valley populations the incidence of hydatid disease ranges from 15 percent in the age category composed of Age Classes I, II and III (1, 2, 3, and possibly some 4 year old individuals) to 63 percent in the age category composed of Age Class VII, VIII and IX individuals. The latter probably includes moose from 7 1/2 to 20 years of age (Skuncke 1949). Hydatid cysts were not found in calves of the year. Excluding calves, 24 or 30.7 percent of 78 individuals examined were infected.

E. granulosus is not common in moose populations located in the areas south of the Knik Arm. Only one instance of infection was observed in the 23 sets of lungs examined by this writer.

The reasons for the differential rate of infection between the two areas are not fully understood at present. Possibly, the final host is not present in the Anchorage-Upper Kenai areas or if present, is not sufficiently abundant to insure infection of the ungulate group. In fact, the final host group is not definitely known for either study area. Wolves are absent or very rare in both areas, coyotes are present in both areas but are not abundant and the mature tapeworm has not been identified from a coyote. Dogs are very numerous in both areas and are allowed to roam freely by most owners. Again quantitative evidence on the incidence of E. granulosus in dogs of these areas is not available. In view of their abundance and distribution dogs seem the logical final hosts in the study areas.

Several authorities have discussed the possible pathogenic effects of hydatid disease on the ungulate host (Cowan, 1944, and R. L. Rausch, 1952).

During this study the general physical condition of each animal examined was recorded and the incidence of pregnancy was also noted. In no instance was the physical condition of infected animals visibly different from noninfected animals and the pregnancy rates of infected and noninfected animals were identical; 90 percent of all females Age Class II and above were pregnant. At present, this writer has observed no instances where hydatid disease appeared, upon gross examination, to be significantly detrimental to the vitality of the ungulate host.

RECOMMENDATIONS

1. The moose kill reporting system and collection of moose heads should be continued. The reporting and collecting should continue throughout the year, not just during the winter period.

2. Daylight train operation and slow orders in critical kill areas should be implemented whenever economically feasible. Aerial counts made of the moose inhabiting the area along the right-of-way reveal these critical and potentially critical areas.

3. Trails and feed yards should be constructed in areas with histories of critical kill.

4. Moose guards warrant further testing.

5. The study of seasonal moose movements should be continued.

6. This project has defined the current moose problem and yielded several temporary moose saving expedients. Continued study, on a cooperative basis, should provide further understanding of seasonal moose movements and the feasibility of altering them to the benefit of the railroad and the moose.

7. Collection of biological data relative to the reproduction, health and age of the study populations should be continued.

LITERATURE CITED

Armstrong, R. A. 1950. Fetal development of the Northern White-Tailed Deer (Odocoileus virginianus borealis Miller). The American Midland Naturalist, 43(3):650-666.

Chatelain, E. F. 1951. Winter range problems of moose in the Susitna Valley. Proceedings Alaska Science Conference, 2:343-347.

________________ 1952. Distribution and abundance of moose in Alaska. Proceedings Alaska Science Conference, 3:134-136.

Cheatum, E. L. 1946. Breeding season of White-Tailed Deer in New York. Journal of Wildlife Management, 10(3):249-263.

________________ 1949. The use of corpora lutea for determining ovulation incidence and variations in fertility of the White-Tailed Deer. Cornell Veterinarian, 39(3):282-291.

Golley, F. B. 1957. An appraisal of ovarian analyses in determining reproductive performance of Black-Tailed Deer. Journal of Wildlife Management, 21(1):62-65.

Kellum, F. 1941. Cusino's captive moose. Michigan Conservation, Michigan Department of Conservation, 10(7):4-5.

Lensink, C. J. 1955. Tentative method for aging moose. Federal Aid in Wildlife Restoration, 10(2).

Lönnburg, Einor. 1923. Sveriges Jaktbara Djur. Svenska Jordbrakets Gok, Albert Bonnier, Stockholm, Häft. 1, pp. 1-65.

Peterson, R. L. 1955. North American Moose. University of Toronto Press, Toronto, Canada, pp. 1-280.

Quimby, D. C. and J. E. Gaub. 1957. Mandibular dentition as an age indicator in Rocky Mountain Elk. Journal of Wildlife Management, 21(4):435-450.

Rausch, R. L. 1952. Hydatid disease in Boreal regions. Journal of the Arctic Institute of North America, 5(3):157-174.

Ritcey, R. W. and R. Y. Edwards. 1957. Letter of June 19 to Robert F. Scott.

Robinette, L. W., J. S. Gashwiler, J. B. Low, and D. A. Jones. 1957. Differential mortality by sex and age among mule deer. Journal of Wildlife Management, 21(1):1-16.

Skuncke, F. 1949. Algen, studier, jakt och vård. P. A. Norstedt and Söners, Förlag, Stockholm, pp. 1-400.

Winters, L. M. and G. Feuffel. 1936. Studies on the physiology of reproduction in the sheep. University of Minnesota Agricultural Experiment Station Technical Bulletin 118, 20 pp.

_______________, W. W. Green, and R. E. Comstock. 1942. Prenatal development of the bovine. University of Minnesota Agricultural Experiment Station Technical Bulletin 151, 44 pp.

VIVA VOCE REFERENCES

Buckley, J. L. 1957. Leader, Cooperative Wildlife Research Unit, College, Alaska.

Rausch, R. L. 1958. Chief, Zoonotic Disease Section, Arctic Health Research Center, United States Public Health Service, Anchorage, Alaska.

Watson, G. W. 1957. Fish and Wildlife Administrator, Branch of River Basins Studies, Fish and Wildlife Service, Anchorage, Alaska.

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Date: January 31, 1958

JOB NO. 5: Food Habits of Railbelt Moose

PERIOD COVERED: January 1, 1957, to March 31, 1957

ABSTRACT

Rumen content samples from 122 moose killed by trains between Mile Posts 172 and 231 on the Alaska Railroad during the winters of 1955-56 and 1956-57 were analyzed. Only the gross particles, an average of 5 percent of each sample, were considered. This analysis revealed the following: (1) seventeen food items were identified; (2) willow, birch and aspen comprised 97 percent of the identifiable food material; (3) moose ate more willow during 1956-57, possibly due to lesser snow accumulations; and (4) until some technique for identifying the small food particles, which comprise about 95 percent of an average rumen content sample, is devised the validity of the present technique is questionable.

OBJECTIVES

To determine relative occurrence of the various browse species in samples of moose stomach contents taken along the railbelt.

TECHNIQUES USED

Research investigations began with a review of available literature concerning stomach content analysis of browsing animals. Few entirely satisfactory methods were discovered and conspicuous among the methods reviewed was the absence of a technique for evaluating the proportion of food items which are unidentifiable with the unaided eye. Probably Dusi (1946) has come closest to devising a workable microtechnique for food habits studies. This technique involves the use of plant tissue slides and photographs for comparison with fecal pellet. Therefore, when the stomach sample investigations began, an attempt was made to develop a similar technique.

In order to properly prepare the plant tissues for slide mounting they were first fixed, then macerated in a solution of chromic acid and nitric acid as described by Dusi (op. cit.). Following the maceration process, the plant material was centrifuged in distilled water until clear and acid free. Next, the various plant tissue samples were placed in a solution of Mayer's Haemalum for approximately five to ten minutes. The Haemalum stain was not too successful, but examination of prepared slides showed some distinct cell detail which was encouraging, in that generic separation appeared possible. Further experimentation with one percent aqueous safranine proved worthwhile as slides prepared with this dye were clearer and showed more detail than the previous stain. Before mounting on slides the stained tissues were dehydrated with Tertiary Butyl alcohol. Canada Balsam mixed with Tertiary Butyl alcohol was used as a mounting medium.

Permanent slides of reference plants were made with which stomach samples or pellets were to be compared. Considerable difficulty was encountered in differentiating plant cells of the two genera in the willow family. Separation of these genera was thought possible by fiber length, but statistical analysis of the various fibers showed too great an overlap to use this measurement criteria for identification. Some attention was given to the organization of slope of pits on the plant vessel walls, but again this criterion was not distinct enough in any of the closely related plants to assure positive identification. Thus, since use of the proposed technique could only be realized through extended research, which at the time was not feasible, only the particles identifiable macroscopically were used.

The identification of the gross particles was accomplished (in the case of the dry samples, 1955-56) through hydration of the samples by boiling until the stomach contents had reached a saturation point. The next step was to wash the material through a wire mesh screen. A one-quarter inch mesh screen was found to be the most satisfactory for retaining identifiable food items. These remaining coarse constituents were examined with the unaided eye or a 6X binocular microscope.

Identifiable materials were segregated by species and measured volumetrically by the water displacement method. This was accomplished by removing the food items from the containers in which they were segregated and placing them on absorbent paper towels to dry, then transferring them to a graduated cylinder. Readings of the identifiable material were taken to the nearest .1 milliliter. All other materials were measured to the nearest milliliter. With the exception of hydration, the frozen samples (1956-57) were subjected to the same process as the dry preserved samples.

During the course of the investigations several problems arose, presenting obstacles still needing resolution. Perhaps the greatest problem encountered in analysis of the stomach samples was the condition of the samples. The first series (1955-56) was dried and hydration by boiling was necessary in order to restore the food items into more readily recognized particles. This condition was not encountered in the 1956-57 group, as these samples were preserved by freezing. Consequently, plant tissues from this group were identified more accurately and with greater ease.

In addition to being thoroughly dried, some samples in the 1955-56 series had been subjected to considerable damage by wood and bark eating insects. Identification of heavily damaged samples was only possible by microscopic examination; fortunately, only 14 out of 73 samples needed this treatment. If possible, samples should be preserved in formaldehyde or frozen if proper storage facilities are available.

Another problem, although not as acute, was the lack of a complete reference collection of moose browse items. However, this lack was met by comparing food items with herbarium specimens at the University of Alaska. For future analysis work, a collection of known food items should be gathered and identified.

When the reference plants were subjected to acid treatments there appeared to be a differential breakdown of tissues. In the same sense these tissues appear to break down similarly in moose digestive juices; that is, birch appeared to be the hardiest while willow, and especially aspen, tended to be less resistant to mechanical and chemical actions. Consequently, the effects of such factors might introduce a bias in analyses based on only the readily identifiable food particles.

FINDINGS

This report presents the results of an analysis of 122 moose rumen content samples collected along the Alaska Railroad during the winters of 1955-56 and 1956-57. The samples were collected by Robert A. Rausch, Dustin L. Sloan and railroad employees, between Mile Posts 172 and 231 on the Alaska Railroad.

Seventeen different food items were identified from the 122 samples analyzed. These food items included, in order of total identifiable volume, the species as follows: willow (Salix spp.), birch (Betula spp.). aspen and cottonwood (Populus spp.)[1/], high-bush cranberry (Viburnum sp.), alder (Alnus sp.), grasses (Graminae), Labrador tea (Ledum spp.), hemlock or water parsnip (Umbelleriferae), spruce (Picea spp.), bog blueberry (Vaccinium uliginosum), moss (unknown), red alderberry (Sambucus racemosa), low-bush cranberry (Vaccinium vitis-idaea), fungi (unknown), currant (Ribes spp.), horsetail (Equisetum spp.),

1/ The term aspen as used in this report refers to all species of Populus that occur in the railbelt area.

dwarf dogwood (Cornus sp.), wild rose (Rosa acicularis).

The three most important browse species, willow, birch and aspen, comprised about 97 percent of the total identifiable volume for both years' samples. The average percentage occurrence of willow, birch and aspen in 1955-56 was 49, 37 and 10 percent, respectively (Table No. 1). In 1956-57 the average percentage of occurrence for the same species was 65, 24 and 8 percent, respectively (Table No. 2). The average percent occurrence for the three important species in 1955-56 and 1956-57 are very similar to the findings of Spencer (1953) which were based on the analysis of 96 moose stomach content samples collected from railroad killed moose between Mile Posts 172 and 228 on the Alaska Railroad. The average percentage occurrence in Spencer's samples were as follows: willow, 53 percent; birch, 37 percent; and aspen, 12 percent.

The utilization of willow and birch differs considerably between the winters of 1955-56 and 1956-57 whereas consumption of aspen and browse species of lesser importance remained relatively constant. Apparently, moose ate more willow during the winter of 1956-57. Snow cover was the major variable between the two years. In 1955-56 snow cover was considerably greater than in the following winter. Frequently 60 or more inches of snow covered the ground during the winter of 1955-56, whereas 30 to 40 inches was about the maximum accumulation of snow during the following winter. Snow cover affects browse utilization in several ways. Deep snow materially restricts travel by moose (thereby forcing them to remain in one area until all browse is exhausted), covers low shrubs, and permits moose to utilize browse that they would not be able to reach during winters of normal snowfall.

The relative importance of the effects of deep snow is not known; perhaps the most important single factor is the restriction of the moose's mobility. Previous browse studies indicate that moose prefer willow (Spencer 1953, Rausch 1956), but when climatological conditions restrict the amount of favored species available to them, moose exist on browse that would be eaten in lesser quantities under more favorable conditions. The relative amounts of each potential browse species available, as revealed by a browse reconnaissance of the study area in 1955-56, are illustrated by percent of total in Figure 1. The relative utilization as revealed by analysis of the rumen content of samples collected in 1955-56 and 1956-57 are also illustrated in Figure 1. Willow comprised about 30 percent of the woody vegetation above snowline but constituted about 60 percent of identifiable food in the rumen content samples.

Table No. 1. Average species composition of moose stomach samples collected--winter of 1955-56.

Species	Average* Percent	Percentage Range	Frequency
Willow	49.2	0-100	96.2
Birch	37.1	0-100	94.9
Aspen	10.7	0-100	50.0
Alder	1.8	0-28	11.5
Currant	Tr.**	0-6	10.0
Elder	Tr.	0-6	5.1
Spruce	Tr.	0-36	2.5
Horsetail	Tr.	0-Tr.	1.3
Moss	Tr.	0-17	1.3

* of identifiable material.

** Tr. = less than .5 of 1 percent.

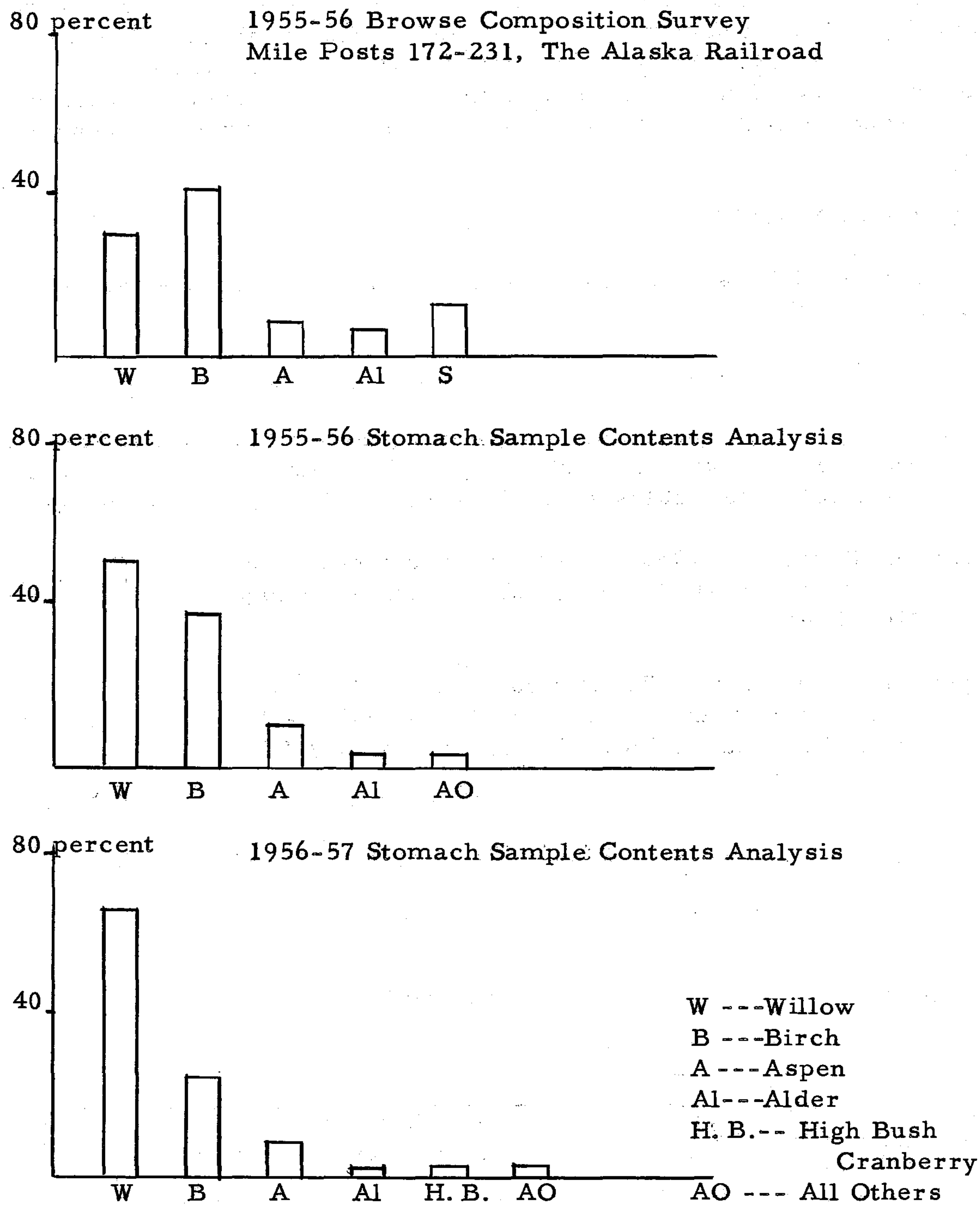
Table No. 2. Average species composition of moose stomach samples collected--winter of 1956-57.

Species	Average* Percent	Percentage Range	Frequency
Willow	65	30-95	100
Birch	24	4-70	100
Aspen	8	0-42	44.8
High Bush Cranberry	1 +	0-32	20.4
Alder	1 -	0-13	14.2
Labrador Tea	Tr.**	0-16	10.2
Low Bush Cranberry	Tr.	0-3	8.1
Elder	Tr.	0-3	4.0
Currant	Tr.	0-10	2
Dogwood	Tr.	0-Tr.	2
Wild Rose	Tr.	0-6	2
Spruce	Tr.	0-Tr.	2
Grass	Tr.	0-Tr.	2
Fungus	Tr.	0-3	2
Water Parsnip	Tr.	0-Tr.	2
Bog Blueberry	Tr.	0-8	2

* of identifiable material.

** Tr. = less than .5 of 1 percent.

Figure No. 1. Comparison of available browse and stomach contents sample analysis.



Although the results of this study are in general agreement with other similar studies of moose browse utilization and do not differ markedly from field observations on browse utilization, a system for identifying a greater portion of each sample, to determine the validity of the present technique, is needed. An average of about 5 percent of each of the 122 samples was identifiable. The problems of devising a technique for identifying the small food particles, roughly 95 percent of each sample, were discussed in the section on Techniques Used.

RECOMMENDATIONS

A method for analyzing a greater percent of an average sample should be devised.

LITERATURE CITED

Dusi, Julian L. 1946. A method for the determination of the food habits of the cottontail rabbit by use of the plant microtechniques and fecal pellet analysis. M.S. Thesis, Ohio State University.

Rausch, Robert A. 1956. Moose management studies. Quarterly Progress Report, Federal Aid in Wildlife Restoration, 11(2):1-43.

Spencer, D. L. and E. F. Chatelain. 1953. Progress in the management of the moose of South Central Alaska. Transactions North American Wildlife Conference, 18:539-552.

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Date: January 31, 1958

JOB NO. 5: Sampling of Kill by Hunters

PERIOD COVERED: August 20, 1957, to December 31, 1957

ABSTRACT

The 1957 moose hunting season can be summarized as follows:

1. Twelve percent of 2,075 hunters checked were successful.

2. Two hundred ninety-five moose were checked; interviews with guides and outfitters revealed 300 additional hunter kills for a total known kill of approximately 600.

3. Fifty-five percent of the moose checked were yearlings.

4. Ninety percent of the moose checked in the Matanuska Valley were yearlings.

5. Yearlings, due to habitat preference, may be more susceptible to hunters.

OBJECTIVES

To obtain data relative to the magnitude and composition of the kill by hunters and to collect biological specimens and data.

TECHNIQUES USED

Data on the moose kill in south central Alaska, excluding the Kenai Peninsula, were obtained from hunter checking stations, game management agents' reports, and interviews with guides and outfitters. Two hunter checking stations were operated, one on the Glenn Highway at Palmer and the other on the Denali Highway near Paxson.

FINDINGS

During the 1957 hunting season 295 moose were checked at hunter checking stations or by Fish and Wildlife Service field personnel. Breakdown by checking agency reveals the following totals: (1) Palmer checking station, 190 moose; (2) Denali checking station, 59 moose; and (3) field personnel, 46 moose.

The number of moose hunters, length of average hunting trip, and percent of successful hunters are summarized in Table No. 1.

Table No. 1. Summary of checking station data--1957.

Station	Species	Total Hunters	Total Man Days	Man Days/Hunter	Successful Hunters	Percent Successful	Kill	Man Days/Kill
Denali 8/20-9/4	Moose	980	2336	2.4	59	6	59	39.6
Palmer* 8/20-9/4	Moose	1095	2737	2.5	190	17	190	14.4
Total		2075	5173	2.4	249	12	249	20.7

*Operated on weekends throughout season.

Moose hunting during August and early September apparently was most successful in the Matanuska Valley and along the Glenn Highway where 17 percent of the hunters were successful; only six percent of those hunting on the Denali highway were successful. However, reports from guides and hunters indicate greatly increased hunter success in the Denali area during the last ten days of the first season. Additional information on the hunter take in the Lake Louise and Denali Highway area was obtained from interviews with guides and outfitters. The interviews, conducted by R. O. Skoog, revealed that approximately 150 moose were taken from each of the former areas.

The total known kill is approximately 600 moose; however, a few of the moose reported by the guides and outfitters undoubtedly were checked at hunter checking stations. The distribution of the known kill is as follows: Denali Highway, 200 moose; Lake Louise area, 150; Glenn Highway system, 130; and the Matanuska Valley, 120.

Although the present data does not provide a means for accurately estimating the total hunter kill, this writer believes that the 600 known kills does not exceed 50 percent of the total hunter kill.

Age Composition of Hunter Killed Moose

Age data from 142 hunter killed moose were obtained. The age compositions for the various areas are represented in Tables 2 and 3.

Table No. 2. Age class of hunter killed moose (by percent).

Area	Age Class I	II	III	IV	V	VI	VII	VIII	IX	Total Moose
Matanuska Valley	87.5	7	4.1	1.4	--	--	--	--	--	72
Willow	53	13.5	6.7	6.7	6.7	6.7	6.7	--	--	15
Matanuska Valley-Willow Combined	82	8	4.5	2.2	1.1	1.1	1.1	--	--	87
Glenn Highway	57	24	9.6	4.7	0	4.7	--	--	--	21
Denali Highway	17	22	28	17	11	--	5	--	--	18
Other Areas	25	25	25	6.5	12	--	6.5	--	--	16
Total All Areas	63.3	14.1	10.5	5	3.5	1.5	2.1	--	--	142
Total All Areas Except Matanuska Valley	38	21.1	18.3	8.4	7	3	4.2	--	--	71

Table No. 3. Ratio of yearling bulls per 100 older bulls.

Area	Yearling Bulls: 100 Older Bulls	Total Animals
Matanuska Valley	630	73
Willow	88	17
Matanuska Valley-Willow Combined	373	90
Glenn Highway	50	36
All other Areas	31	17
Total All Areas	125	162
Total All Areas Except Matanuska Valley	43	90

The sample of hunter kills obtained at hunter checking stations represents the take by roadside and ground vehicle hunters. Very few airplane hunter killed moose are checked. The age composition data reveals that continued heavy hunting pressure greatly affects the age composition of the bull population segment. In the Matanuska Valley approximately 90 percent of the hunter killed bulls were yearlings (Table No. 2). The ratio of yearling bulls per 100 older bulls also reflects the effects of hunting pressure, but in areas where intense hunting is relatively recent this ratio indicates that yearling males possibly are more susceptible to hunters (Table No. 3). Yearling males tend to remain at low elevations during the fall whereas many of the older males are usually at or near timberline. This differential habitat preference may cause an over representation of yearlings in the hunter take.

Biological specimens collected at hunter checking stations are reported on in other sections of this report.

RECOMMENDATIONS

A system of sampling that provides a basis for estimating the annual hunter harvest of moose should be continued.

Prepared by:

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Approved by:

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Supervisor of Game Restoration

Date: January 31, 1958

Job No. 6 -- Herd Composition in Interior Alaska

PERIOD COVERED: October 31, 1957 to December 1, 1957

ABSTRACT

Aerial composition counts were made in three specific areas subject to hunting: the Tanana Valley, Fortymile, and the lower Koyukuk Valley. Six hundred nine moose were counted in 19.8 hours for an average of 30.7 moose sighted per hour. The sex and age data are summarized as follows:

Tanana Valley: The calf:cow ratio decreased from 47:100 in 1956 to 42:100 in 1957. Survival of bull calves to yearlings indicated 35 per cent mortality. The bull:cow ratio of 68:100 indicated light hunting pressure.

Fortymile: The calf cow: ratio decreased from 53:100 in 1956 to 46:100 in 1957. Survival of bull calves to yearlings indicated 20 per cent mortality. The bull:cow ratio of 91:100 indicates light hunting pressure; however, it is believed that a disproportionate sampling of bulls may have occurred.

Koyukuk: The calf:cow ratio was 67:100 indicating a high level of productivity. Data from 1956 were not available to determine calf survival. The young bull:bull calf ratio of 48:100, however, suggested higher mortality than in other areas; perhaps due to heavy wolf predation the previous winter. The bull:cow ratio of 80:100 indicated light hunting pressure.

The calf percentage of the total herd continues at 20 and 19 per cent for the Tanana Valley and Fortymile respectively. These ratios have not changed since 1954. In the Koyukuk, there were 28 per cent calves in 1957 as compared to 36 per cent in 1954.

It is apparent that the moose populations in the Tanana and Fortymile are relatively stable and are not being affected adversely by the present hunting pressure. The Koyukuk moose herd also appears to be in healthy condition despite unusually heavy wolf predation during the winter of 1957.

The data for this study are in the Federal Aid files of the Fish and Wildlife Service at Fairbanks.

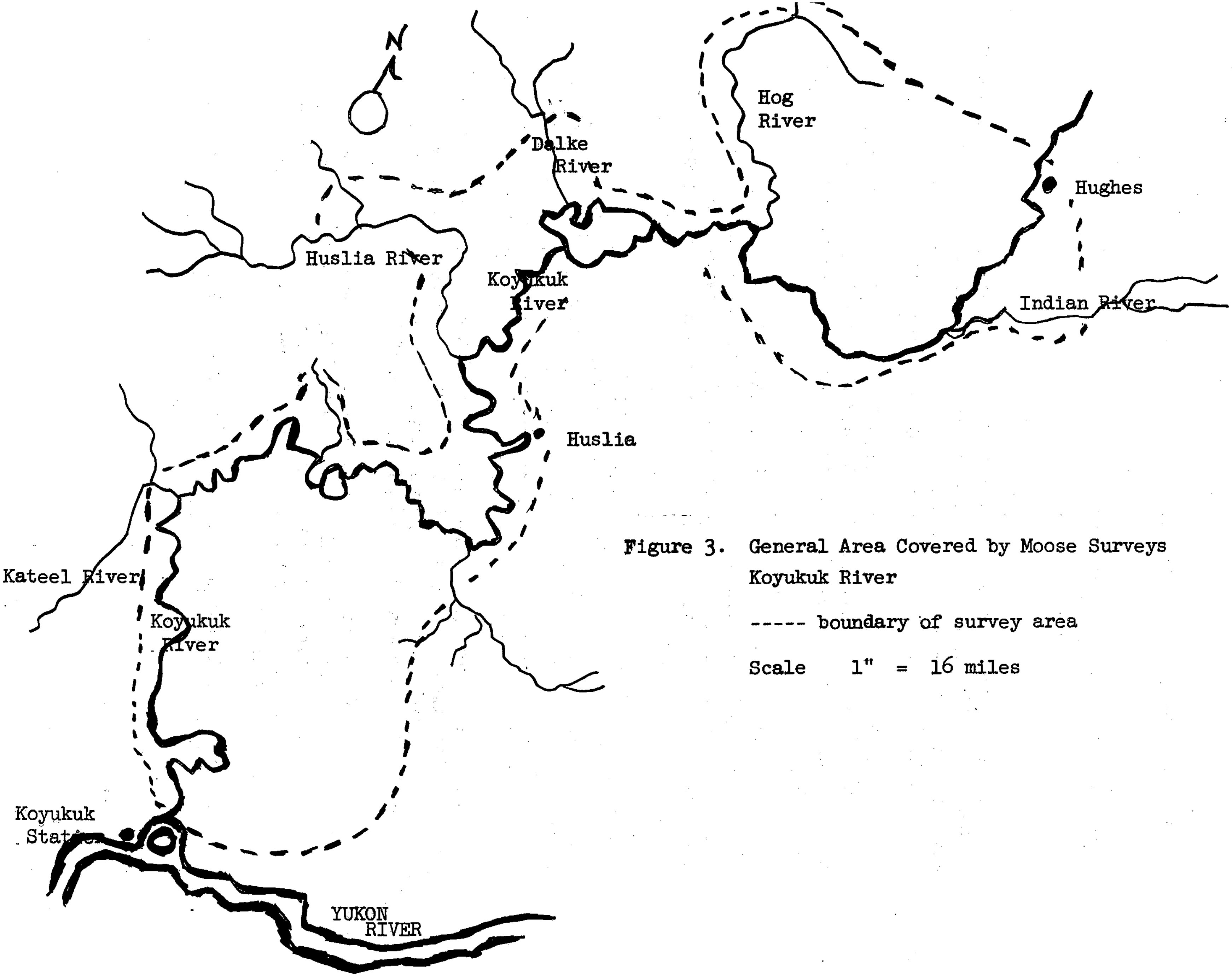

Figure 3. General Area Covered by Moose Surveys
Koyukuk River

----- boundary of survey area

Scale 1" = 16 miles

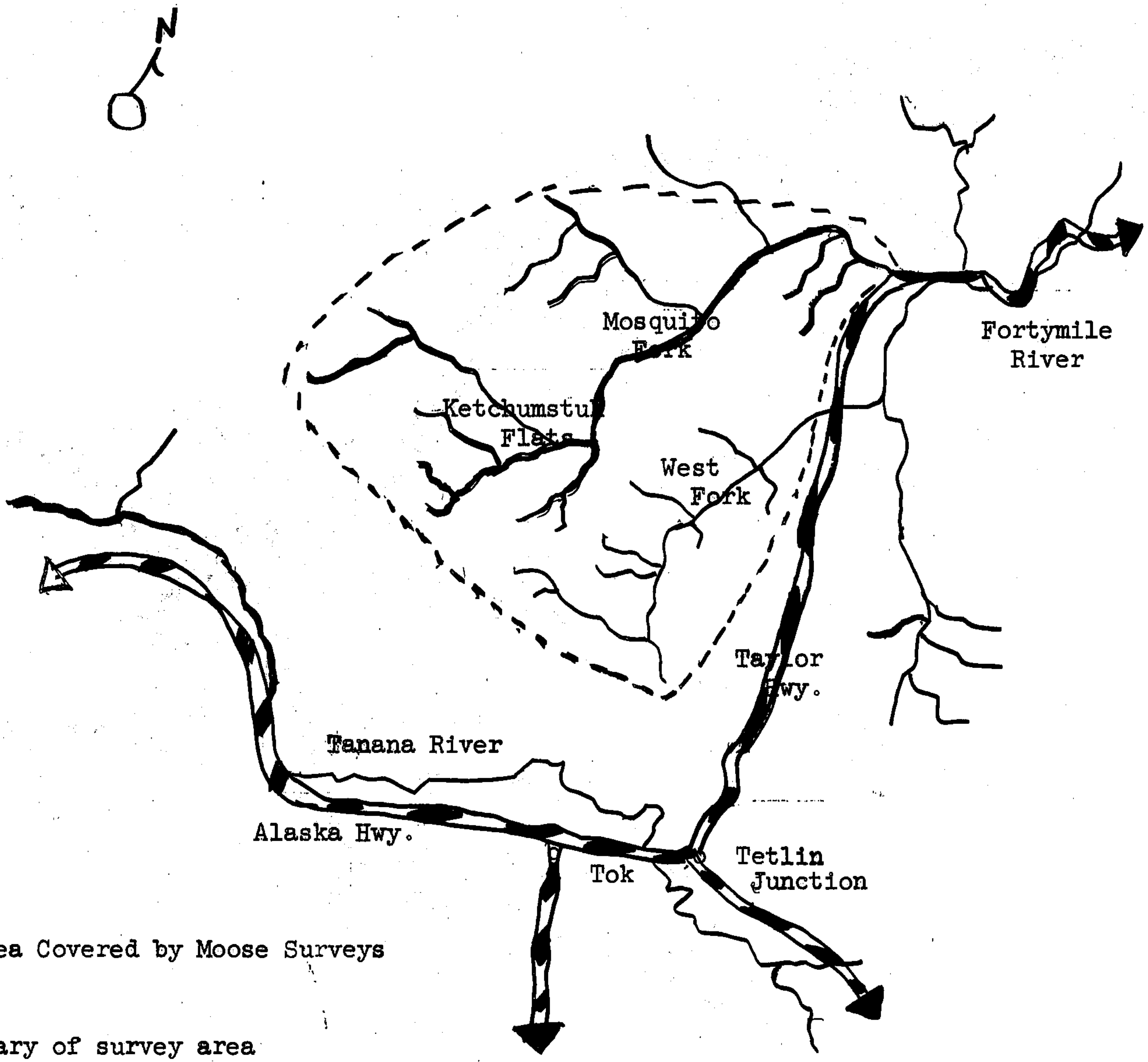

Figure 2. General Area Covered by Moose Surveys
Fortymile

----- bounary of survey area

Scale 1" = 16 miles

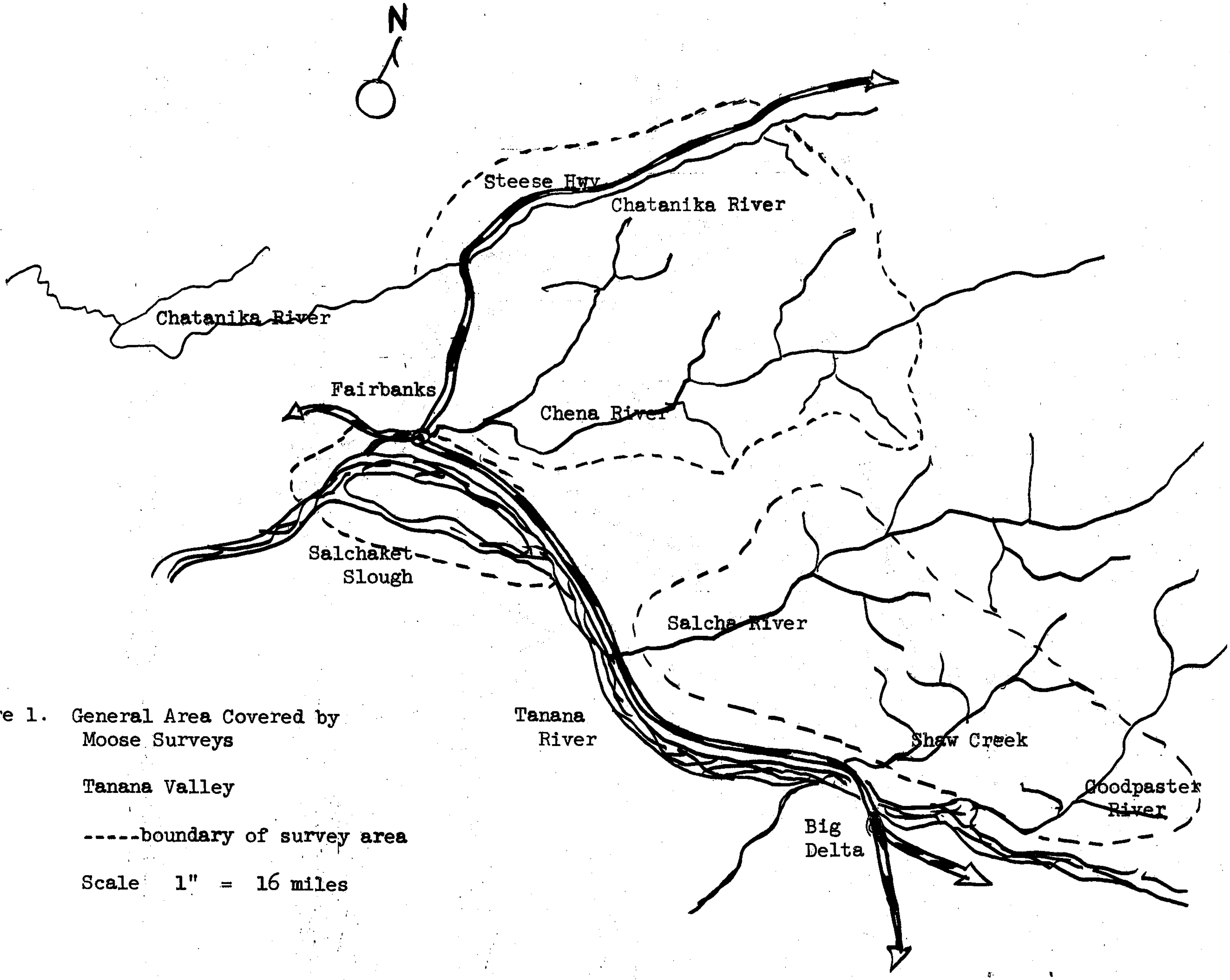

Figure 1. General Area Covered by Moose Surveys

Tanana Valley

-----boundary of survey area

Scale 1" = 16 miles

OBJECTIVES

To determine age and sex composition of local moose populations as an index to productivity and survival in areas subject to significant hunting pressure or wolf predation.

TECHNIQUES USED

During the period from October 31 to December 1, 1957, aerial composition counts were conducted in the Tanana River and tributary valleys near Fairbanks, the Mosquito Fork, Ketchumstuk Flats area of the Fortymile, and the Koyukuk flats between Koyukuk Station and Hughes. Counts were made using a Super-cub in the Tanana area, a Cessna 180 and a Pacer in the Koyukuk area, and a Pacer in the Fortymile area. Flights were made at elevations of 500-700 feet above the ground and moose were tallied in the following categories:

1. Small bulls - spiked, forked or antlers with very small palms considered to be 18 months of age. There is probably some overlap between this class and adults.

2. Adult bulls - antlers medium to large.

3. Cows - all anterless adult moose:

   (a) Without calves

   (b) With one calf

   (c) With two or more calves

4. Calves - moose 4 - 6 months old, smaller than adults.

5. Questionable - moose which could not be identified accurately due to poor visability or flying conditions.

The number of hours actually spent searching for moose was recorded for each area to determine the number of moose seen per flying hour. Sig Olson, John Klingbeil, Jack Frost and Douglas Jones acted as observers while Joe Miner, Stan Fredericksen, Harry Pinkham and Glenn Orton served as pilots during the survey.

The areas covered were essentially limited to those supporting moose populations subject to hunting pressure, wolf predation or both. Except for the area between Salchaket Slough and the Richardson Highway, the Tanana flats and Wood River areas covered in previous years were not included, since hunting pressure in these areas is negligible. The areas surveyed are shown in Figures 1, 2, and 3.

FINDINGS

A summary of all moose tallied is presented in Table 1 by area. Five hundred ninety-two moose were classified as to sex and age, plus 17 additional individuals which were not, for a total sample of six hundred nine individuals. The total flying time for the entire project, including the time spent traveling to and from the survey, was 29.8 hours. The actual time spent counting moose on the areas was 19.8 hours. The total moose seen per hour based on total flying time for the project was 20.4, and 30.7 moose were seen per hour during the time actually spent looking for moose. The number of moose observed per hour for the various areas is as follows:

AREA	NO. MOOSE SEEN PER HOUR
Tanana Valley	24.7
Fortymile	40.0
Koyukuk	34.6
All areas combined	30.7

The number of moose seen per hour is undoubtedly low, since conditions for observation were extremely poor. Snow cover was light; consequently, low brush, grass, stumps, windfalls and rocks projecting through the snow presented constant distractions and hampered the observer's ability to see moose as compared to spotting moose against the relatively even, overall snow cover prevailing in prior years.

Moose were not observed in sufficient numbers to allow statistical analysis of the comparative differences in herd composition at different elevations. No moose were observed above timberline; the majority being located along the tributary creeks and main river bottoms and flats. The herd composition for all areas surveyed is summarized and presented in Table 2.

PRODUCTIVITY

Tanana Valley Area - The calf:cow ratio dropped slightly from 47:100 in 1956 to 42:100 in 1957. This is the third year that this ratio has decreased (53:100 in 1955). Despite this fact, productivity can be considered good. Althouth it is assumed that the cow segment of the herd is the most constant, it is possible that the percentage of yearling cows has increased due to good survival, and the calf:cow ratio consequently would decrease. The calf percentage of the total herd still remains at 20 per cent; the same level maintained since 1954, which would tend to indicate a uniform level of production. The ratio of twin calves per 100 cows dropped to the lowest point in three years (2:100). Outwardly, there appears to be a slight downward trend in productivity over the past three or four years. A more direct comparison between 1956 and 1957 is possible by excluding the Tanana Flats and Wood River counts for both years, using only those counts from the Chena River, Chatanika River, Shaw Creek, and the Goodpaster River. It is evident in Table 2 that the data indicate very little change in the past two years in this area.

Fortymile - The productivity index in this area decreased somewhat from the previous year. Calves per 100 cows dropped from 53:100 in 1956 to 46:100 in 1957, and the percentage of calves dropped from 24 to 19. Despite this fact, productivity in this area still is on par with the Tanana Valley as well as areas south of the Alaska Range. Eight cows with twin calves were observed in the Fortymile as compared to no cows with twins per 100 cows with calves in 1956.

The reduced ratio of calves per 100 cows in 1957 might have been caused by good calf survival from 1956 resulting in a larger number of non-breeding yearling cows. In 1956, 28 cows without calves and 31 cows with calves were tallied (90:100) as compared to 34 cows without calves and 23 with calves (148:100) tallied in 1957.

Koyukuk - The Koyukuk area showed the highest level of productivity of any of the areas surveyed. The calf:cow ratio was 67:100 and the proportion of calves in the total herd was 28 per cent. A further indication of relatively high level of production was the incidence of cows with twin calves (23 cows with twin claves per 100 cows with calves). The only comparable data available from previous years for this area was obtained in 1954. Production was very good at that time as indicated by a calf:cow ratio of 86:100 and a calf percentage of 26. The ratio of cows with twin calves was also very high, 36:100. It is evident that during the past four years, the level of productivity in this area has been very high.

Unusually heavy wolf predation, aggravated by a deep crusted snow condition during the winter and early spring of 1957, was apparently an important mortality factor. During March, the bounty hunter team of Stickman and Huntington counted 175 dead moose believed to be wolf kills in 123 hours of flying time.

TABLE 1

SUMMARY OF MOOSE POPULATION COMPOSITION COUNTS
TANANA VALLEY, FORTYMILE, AND KOYUKUK
NOVEMBER - DECEMBER 1957

AREA	BULLS			COWS				CALVES	UNIDEN-TIFIED	MOOSE	ACTUAL FLYING TIME	MOOSE SEEN PER HOUR
	YOUNG	ADULT	TOTAL	WITHOUT CALF	WITH 1 CALF	WITH 2 CALVES	TOTAL	TOTAL		TOTAL	TOTAL	
TANANA VALLEY												
Chena, Chatánika, Shaw, Salcha Cr., Goodpaster	14	38	52	44	31	1	76	34	6	168	7.8	21.5
Tanana River (Salchaket)	3	15	18	26	15	0	41	15	0	74	2.0	37.0
Above areas combined	17	53	70	70	46	1	117	49	6	242	9.8	24.7
FORTYMILE												
Mosquito Fork, West Fork, Kechumstuk	12	42	54	34	23	2	59	27	1	141	3.5	40.0
KOYUKUK VALLEY												
Hughes to Koyukuk Hog R., Huslia R.	14	56	70	42	35	11	88	58	10	226	6.5	34.6
GRAND TOTAL	43	151	194	146	104	14	264	134	17	609	19.8	30.7

TABLE 2

SEX AND AGE RATIOS - TANANA VALLEY, FORTYMILE AND KOYUKUK - 1957

(Comparison with 1954, 1955, 1956 in Tanana Valley and 1956 in Fortymile)

AREA SAMPLED	YEAR	TOTAL BULLS PER 100 COWS	YOUNG BULLS PER 100 AD. BULLS	CALVES PER 100 COWS	TWIN CALVES PER 100 COWS W/CALVES	CALF % OF TOTAL HERD	YOUNG BULLS % OF TOTAL HERD	YOUNG BULLS PER 100 BULL CALVES	TOTAL NUMBER MOOSE IN SAMPLE
TANANA VALLEY									
Chena, Chatanika, Shaw Cr., Salcha, Goodpaster	1957	68	37	45	3	20	8	82	162
	1956	68	30	43	19	20	8	77	93
Tanana (Salchaket)	1957	44	20	37	0	20	4	40	74
Above areas combined	1957	60	32	42	2	20	7	69	236
	1956	83	25	47	5	20	7	71	405
	1955	123	--	53	13	19	18	186	410
	1954	85	--	47	5	20	13	127	109
FORTYMILE									
Mosquito Fork, Ketchumstuk, West Fork	1957	91	29	46	8	19	8	89	140
	1956	66	30	53	0	24	7	60	129
KOYUKUK RIVER									
Koyukuk R. (Huslia to Hughes, Hog River, Huslia River)	1957	80	25	66	23	28	6	48	216

TABLE 3

YOUNG BULL:BULL CALF RATIOS
(TANANA VALLEY & FORTYMILE)
1956-57

AREA	1956			1957			PERCENT MORTALITY
	TOTAL COWS	TOTAL BULL CALVES	BULL CALF / TOTAL COW	TOTAL COWS	TOTAL YOUNG BULLS	YOUNG BULLS / TOTAL COWS	
TANANA VALLEY							
Chena, Chatanika, Shaw Cr., Salcha, Goodpaster	44	9	21:100	76	14	18:100	14%
Tanana (Salchaket)	95	23	24:100	41	3	7:100	70%
Above areas combined	139	32	23:100	117	17	15:100	35%
FORTYMILE							
Ketchumstuk, Mosquito Fork, West Fork	59	15	25:100	59	12	20:100	20%

The young bull:adult bull ratio in all areas ranges from 25 to 32 per 100 and is indicative of good overall production. It further reflects the light overall hunting pressure exerted on these herds. In general, productivity can be considered good despite a slight downward trend from previous years for all three areas surveyed, and it compares favorably with the Susitna-Matanuska area as well as the Copper River Basin.

SURVIVAL (to 18 months)

Survival of young bulls (to 18 months) can be measured in one of two ways, i.e., the ratio of young bulls to bull calves of the year or the ratio of bull calves to total cows for the past year as compared to the ratio of young bulls to total cows for the current year. The reliability of the former depends primarily on uniform calf production from year to year. The latter assumes that since cows are not hunted and subject principally to natural mortality factors, this segment of the population is probably the most constant and thus probably provides the most reliable index to survival. The ratios of bull calves and young bulls to total cows for 1956 and 1957 respectively, are presented in Table 3.

Tanana Valley - The 1956 counts indicated a bull calf:total cow ratio of 23:100 and the 1957 counts showed a young bull:total cow ratio of 15:100, indicating 35 per cent mortality. Only a moderate loss of young male animals, probably mostly due to hunting is evident.

Fortymile - The bull calf:total cow ratio derived in 1956 was 25:100 and the young bull:total cow ratio similarly derived in 1957 was 20:100, thus showing a 20 per cent mortality. This reflects a relatively high level of survival and the light hunting pressure exerted in this area. The ratio of 89 young bulls per 100 bull calves in 1957 tends to substantiate the above although it is apparent that the latter figures indicate a lesser degree of mortality.

Koyukuk - There are no data available for 1956 from which to derive a bull calf:total cow ratio. Therefore, it is not possible to determine the survival of young males to 18 months on this basis. The young bull: bull calf ratio (48:100) suggests considerably heavier mortality of young bulls than observed in other areas. This cannot be interpreted as an accurate figure, however, since there is no way in which to ascertain whether or not calf production has been constant in this area from year to year. It may, however, reflect the allegedly heavy wolf predation during the previous winter.

If predation resulted in a weak yearling male class, it is logical that the female segment of the yearling class was similarly affected. Conceivably, predation in the Koyukuk area should have taken a proportionately larger toll of the calves, the most vulnerable age class, thereby affecting the yearling class represented the following fall. Yearling females are generally non-breeding and comprise a portion of those cows recorded as "cows without calves". The areas with no serious predation problem should show a little higher ratio of cows without calves compared to areas where heavy predation has occurred. In the Tanana Valley and Fortymile area, the ratio of cows without calves to 100 total cows was 60:100 and 58:100 respectively. In the Koyukuk, the ratio was 48:100. Since the yearling bull:bull calf ratio also indicates the possibility of a higher degree of mortality than elsewhere, it is possible that wolf predation would have materially affected survival of the 1956 calf crop in the Koyukuk area.

EFFECTS OF HUNTING

Tanana Valley - The bull:cow ratio of 68:100 in the tributary stream valleys and ratio of 44:100 in the Tanana flats indicates an overall light to moderate hunting pressure in these areas. The ratio for the entire area is 60:100 and it is believed that the current hunting pressure is in no way detrimental to the moose population at present.

Fortymile - The bull:cow ratio (91:100) in this area is high and does not seem comparable to the ratio obtained in 1956 (66:100). This ratio suggests disproportionate sampling of bulls. Although a questionable ratio has been obtained in the current counts, there is no doubt that hunting pressure is not significant enough to substantially affect the number of bulls in the population.

Koyukuk - Three native villages (Hughes, Huslia and Koyukuk) have ready access to the area. Hunting is restricted principally to those areas along or immediately adjacent to the rivers and streams navigable by river boat. The ratio of bulls to cows is high (80:100).

Hunting in all the areas surveyed is limited, for the most part, to the navigable streams and rivers, roads and the areas immediately adjacent to them. Some moose are taken by aircraft as well, however, this accounts for a comparatively small segment of the kill. Very few moose are taken over a half-mile from a route of travel, which leaves the major portion of these areas unhunted. The road network out of Fairbanks receives heavy pressure during the moose season and there is no doubt that the bull population in local areas is depleted temporarily. The large surrounding untapped reservoirs, however, serve to replenish these areas over a period of time and the general effect of hunting on the population as a whole is insignificant at present. Likewise, the hunting in the Fortymile (Taylor Highway) is nearly all accomplished from the road leaving the area a half-mile or more from the road practically untouched.

There are no moads in the Koyukuk region, thus travel is restricted to river boats and an occasional airplane. It is again obvious that the area effectively hunted is only a small portion of the region as a whole, and hunting in itself is not an important decimating factor at present.

RECOMMENDATIONS

Herd composition counts in the Tanana, Fortymile and Koyukuk areas should be continued.

Prepared by: Approved by:

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ROBERT F. SCOTT
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DATE: January 31, 1958

Job No. 7 Moose Management Studies - Stikine River Valley
Aerial Surveys

PERIOD COVERED: September 15 - December 31, 1957

ABSTRACT

Forty-one moose were killed on the Alaska portion of the Stikine River valley during the 1957 legal season. Age composition determined from jaws collected indicates a healthy population, with a large portion of young animals represented in the kill. Aerial counts made in December showed a good herd increase with the average ratio being 37 calves per 100 adults.

OBJECTIVES

To obtain a total population estimate and herd sex and age composition. To evaluate the hunter harvest.

TECHNIQUES USED

During the legal open season, (Sep. 15 - Oct. 15), jaws were collected from moose killed by hunters and all moose taken were tabulated to record the total harvest. It is believed that an accurate record of the kill was obtained, as Fish and Wildlife Service personnel were present on the river and checked on kills throughout the entire season. Jaws were segrated into age class groupings by examination of tooth replacement and wear.

It was planned to make aerial composition counts in November prior to the shedding of antlers by the bulls, however, unfavorable flying weather and lack of snow cover delayed the counts. On December 17 counts were finally made under relatively good conditions. A new show cover provided excellent contrast for spotting moose and flying conditions were favorable, with the exception of snow squalls in the Limb Island area. A Cessna 180 was used for the counts, piloted by Bill Stedman, with Dave Klein as observer.

The Stikine River penetrates the Coast Range and reaches tide water near the town of Wrangell. Moose occur along the entire river, from interior British Columbia to the delta flats on the Southeast Alaska coast. Generally, the river is closely flanked by rolling hills and mountains, but the lower forty-five miles of the river below the Great Glacier runs through a flat valley three to four miles wide. A relatively stable moose herd exists in this lower valley and there is little exchange of animals with other areas. The greater portion of this area lies within Alaska (30 miles).

There are about 50 square miles of valley bottom along the Alaska portion of the Stikine River. Probably one-half of this is excellent winter moose range, the remainder being intermediate in quality. An estimate based on recent aerial surveys and a partial ground count made

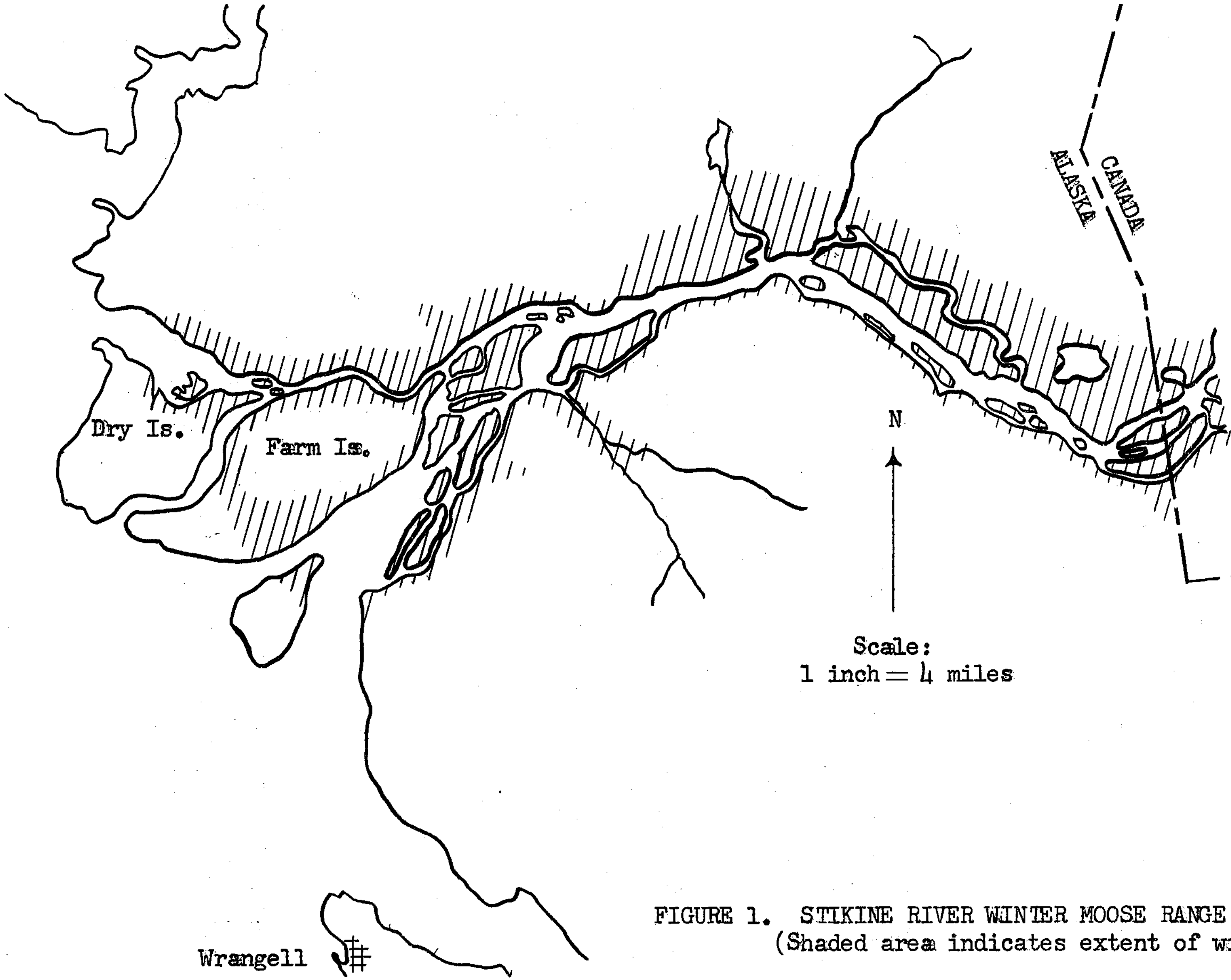

FIGURE 1. STIKINE RIVER WINTER MOOSE RANGE
(Shaded area indicates extent of winter range)

in 1952 by Mammal Control Agent, Lee Ellis, in which 126 moose or their tracks were counted, places the population level of moose at 150-175 on the Alaska side of the International Boundary.

Browse species are more varied and somewhat different than on moose ranges in western Alaska. Dogwood, Cornus stolonifera has the greatest density and may be the most important winter food in this area. Willow and cottonwood are of secondary importance and Viburnum, Elder and mountain ash are also used, but are less numerous. Evidence of heavy browsing is apparent in some areas; however, generally, browse plants appear vigorous and in good condition. Density of browse plants is much greater than in Western Alaska.

The Stikine River moose herd is a valuable asset to Southeast Alaska, offering an opportunity for moose hunting which is not generally available throughout this region.

The Hunter Harvest: This year the total legal harvest of moose on the Stikine River, within Alaska, was 40 bulls. In addition, one cow was shot accidentally when a hunter's bullet passed through a bull and struck the cow standing behind it. Three more moose were also shot in the Muddy River-Thomas Bay area.

This substantial kill, the largest on record for the Stikine River, was brought about through increased hunting pressure under favorable weather conditions over a one month season. Although small boats with outboard motors are the main mode of transport for the hunters, airplanes were used extensively this year for transporting hunters and equipment to and from camps and for reconnaissance flights to survey terrain and locate moose. A summary of the moose kill on the Stikine River from 1952 - 1957 is shown in Table 1, with the length of seasons, number of hunters and hunter success.

TABLE 1. Total Kill and Hunter Success Ratios on the Stikine River, Alaska, in Relation to Length of Season, 1952 - 1957.

Year	Length of Season	Est. No. of Hunters	No. of Moose Taken	Percent Success
1952	Sept. 15 - Oct. 14	300	31	10
1953	Sept. 15 - Sept. 30	100	12	12
1954	Sept. 15 - Oct. 5	125	14	11
1955	Sept. 15 - Oct. 5	150	16	11
1956	Sept. 15 - Oct. 5	125	30	24
1957	Sept. 15 - Oct. 15	160	40	25
	Averages	160	24	16

Restricted travel, due to low water levels, resulted in a reduced moose kill on the British Columbia side of the border in the Iskut and Katete river areas this year. It is believed seven moose were taken from this area. Normally, about 10 - 12 moose are killed each year on the Canadian side of the boundary by Alaska hunters employing the Canadian guide, Walter Simpson.

Bulls killed late in the season, (Oct. 10 - 15), were still in excellent condition. Several hunters taking these late moose reported no offensive flavor to the meat. The rut, which was apparently initiated by this date, was not reflected in deterioration of the physical condition of the bulls. Sexual-physiological changes associated with the rut are minimal in young bulls and their large representation in the kill may account for the high quality of the meat.

The age composition of the kill continues to show a large proportion of young animals, as has been the case in past years. Such an age structure reflects a heavily harvested and healthy population, which is quite likely increasing in numbers. The gradually increasing annual harvest over the past several years is apparently a product of this herd increase. The age class distribution of moose killed in the 1957 harvest is shown in Table 2, as determined from jaws collected from 21 bulls. Although the number of jaws collected was small it represents a random sample of the animals killed.

TABLE 2. Age Class Representation of Hunter-Killed Moose on the Stikine River during 1953-1955 and 1957. (From aged jaws collected).

	1953		1954		1955		1957	
Age Class	%	No. Jaws	%	No. Jaws	%	No. Jaws	%	No. Jaws
I (15-17 months)	18	2	8	1	58	7	57	12
II (2 yrs. 3-5 mos.)	55	6	33	4	8	1	29	6
III (3 yrs. & older)	27	3	58	7	33	4	14	3
Totals		11		12		12		21

Aerial Counts: Complete Coverage of the Alaska portion of the Stikine River Valley is attempted in making the aerial counts, however, the interspersion of spruce timber throughout the valley offers concealing cover for the moose. Consequently, the counts obtained more nearly reflect trends in population size. A summary of the aerial counts is presented in Table 3. The breakdown of calves to adults indicates a favorable increase this year. Ratios varied from 25 calves per 100 adults on the lower river, to 56 calves per 100 adults on the upper river. The average for the whole valley was 37 calves per 100 adults. These ratios compare favorably with the lower Susitna-Matanuska Valley moose herd ratios of 31 calves per 100 adults. Removal of a large portion of bulls by hunting prior to the counts, undoubtedly, contributes to this high calf:adult ratio on the Stikine.

Segration of bulls and cows was not possible. Antler shedding had started, and in addition, the small size of the antlers of moose in this area, the turbulent air conditions usually encountered, and the abundance of vegetative cover, make aerial differentiation of sexes unreliable. Only one large antlered bull was seen; however, antlers on yearling bulls in the dense brush or scattered spruce could easily have been overlooked.

TABLE 3. Aerial Moose Counts Made on the Stikine River, Alaska, December 17, 1957.

Area	Adults	Calves	Unident.	Total	Calves/100 Adults
Lower River (flats to Kakwan Pt.)	27	7	3	37	25
Upper River (Kakwan Pt. to Int. boundary)	16	9		25	56
Totals	43	16	3	62	37

RECOMMENDATIONS

Annual aerial composition counts and the collection of harvest information should be continued to maintain a current knowledge of the welfare of this important moose herd. Effort should be continued to secure counts of bulls under favorable conditions soon after the hunting season. There is a need for additional study to explain variations in calf:adult ratios on the upper and lower rivers.

Prepared by: ____________________ Approved by: ____________________

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Date: December 31, 1957