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Study 1.47
December 1994

Federal Aid in Wildlife Restoration
Research Final Report
1 July 1993 - 30 September 1994

Management Strategies for Increasing Human Harvest of Moose Populations in Game Management Unit 13

by
J. Ward Testa

Alaska Department of Fish and Game
Division of Wildlife Conservation
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SUMMARY

Results in this first year of study provide evidence of continued high predation on calves in conjunction with poorer nutritional status and lowered productivity for adults in comparison to other Alaskan populations and previous work in the area. Adult survival in late winter and spring was high with little evidence of heavy wolf predation in the area, though wolves are present. Forty-two percent of fetus or neonate calf losses occurred, probably from nutritional causes, before the calf was detected in telemetry surveys, with the remaining 58% disappearing from May 27 to June 15. Only one additional calf was lost prior to September 30. Predation by grizzly bears on moose calves was observed, and the temporal pattern of mortality among observed calves was consistent with Ballard's (1992) findings in which grizzly bear predation was the primary cause of mortality. Even while calf predation continues to be high, the low twinning and calving rates suggest the population is sensitive to nutritional factors, possibly caused by density-dependent competition for forage, especially in severe winters. The results of this study will be incorporated into a larger project described in more detail in the Appendix.

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BACKGROUND

Game Management Unit 13 (GMU 13A), in Southcentral Alaska, is accessible to population centers in the region (e.g., Anchorage, Palmer, Wasilla), as well as home to traditionally consumptive users in the Copper River Basin. The Alaska Department of Fish and Game and the State's Board of Game have set human consumptive use as the priority for management in GMU 13. It is the objective of the Department to maximize human harvest in the unit without endangering the healthy status of predator populations. Effective monitoring of moose and predator populations and study of their interactions are essential to that objective. Several information needs were identified in the proposal for this work:

1. Are there methods for improving population trend and recruitment data?
2. What factors limit population growth in GMU 13A?
3. Do harvest strategies need to be assessed with regard to maximizing human harvest?

OBJECTIVES

Because a principle investigator for this project was not hired until December 1993, these information needs could not be addressed immediately. Rather, objectives dependent on autumn research were postponed and incorporated in a 5-year research plan to begin in July 1994 (see Appendix). This project focused on objectives consistent with those originally proposed and prepare for subsequent work described in the Appendix. The objectives are listed.

1. To identify an appropriate spatial scale for conducting population research, such that the essential interactions of moose with their predators and supporting forage communities would be represented and migration would not overwhelm intrinsic rates of mortality and natality.

2. To estimate mortality and reproductive rates and compare these with rates reported by Ballard et al. (1992) for evidence that underlying ecological factors (predation and nutritional constraints) have changed.

Because of the late start, results presented here are preliminary. More detailed presentation will be made in subsequent reports for the project described in the Appendix.

STUDY AREA

A study area was selected that is important to users of the resource, logistically accessible, and likely to encompass the important dynamics of interacting populations of moose, predators, and forage plants. This is an area in the eastern Talkeetna mountains and adjacent flats surrounding several streams that drain north into the Susitna River: Goose Creek, Black and Oshetna Rivers, Sanona Creek, and Tyone Creek and River (approximately 62°25'N, 147°30'W).

METHODS

Adult female moose were darted from a helicopter on March 7-8 and March 21-22, 1994, with 4 mg of Carfentinil and 166 mg Xylazine (Wildlife Pharmaceuticals). Blood and measurements (total body length, chest girth, and hind foot length) were taken from each, and a subjective condition assessment was made on a scale of 1-10 following Franzmann (1977). All were equipped with radiotransmitters and visual collars, then injected with 400 mg of Naltrexone to reverse the effects of Carfentinil. The reversal agent for Xylazine was not administered because of the small dose. Pregnancy was determined by assay for pregnancy-specific protein b (PSPB) (Wood et al. 1986, Rowell et al. 1989), at the laboratory of R.G. Sasser, University of Idaho.

Radiocollared moose were relocated by a PA-18, "Supercub" or a Robertson-22 helicopter (June 2). Virtually all locations were made by following the radio signal until very close, then circling and visually sighting the collared moose. Location was determined as the plane passed over the collared moose by storing the location as a "waypoint" in a Global Positioning System (GPS) receiver (Trimble Pathfinder+). Telemetry flights were made bimonthly until mid-May. Thereafter, flights were conducted every other day or daily, as weather permitted, during the calving season to detect new calves and monitor calf survival. Supercub flights were made on May 6, 13 and 16, every 2 days from May 19-31 and June 17-28, and daily from June 2-15. Weather postponed a flight on May 27 and caused cancellation of the flight on June 5.

Calving and twinning rates were determined from visual sightings of radiocollared moose with calves between May 13 and June 30. These rates were compared to pregnancy rate in March for those same animals. We surveyed cows with calves in the study area on June 1, 1994 by helicopter to corroborate the twinning rate estimated from collared cows. Calving rate was not estimated from these surveys due to population segregation and sightability biases occurring in spring (Gasaway et al. 1985).

We estimated mean date of parturition from the sample of collared cows seen with calves. The date of parturition of each was assumed to be midway between the first sighting with calf and the previous sighting, except in the case of the first calf observed for the season. The previous flight was a week earlier, but the calf appeared from its size and mobility to be less than a day old. Its age was assumed to be 12 hrs.

Calf survival was estimated from the apparent survival of calves accompanying radiocollared cow moose. A calf was assumed to have died in the interval between the last sighting and when its mother was next seen alone. This assumption will tend to bias the timing of mortality, but this bias is minimal when sightability of calves is high, as it was in this study (>90%). The proportion of calves surviving was evaluated as a function of age and by date.

Differences between various categories of moose (e.g., pregnant and nonpregnant) were tested by t-tests and chi-square tests, as appropriate. Tables for chi-square tests were pooled to bring expected values within the cells to at least 4.0.

RESULTS

Forty moose were captured and released with radiocollars; one other moose died during handling. Body size, condition indices, packed cell volume and hemoglobin content are summarized in Table 1. Moose were collared within an area of approximately 100 km^2 along the Oshetna and Black Rivers. Expansion from this area was expected and occurred mostly in May and June. Apart from the movements of 3 moose, most of the radiocollared animals remained within the Oshetna and Black River drainages, and the area west of Tyone Creek through the calving period (approximately 1500 km^2). Only one moose (no.40) moved permanently from this area, crossing the Susitna River just before May 6 and calving on May 31, 70km from where she was captured in March.

Thirty-five of 40 radiocollared moose were pregnant at the time of handling, as was the moose that died during handling, a pregnancy rate of 88%. Of the 35 pregnant moose seen through June, only 25 were seen with calves (63%). Mean date of parturition was May 23 (s.d.= 6.22, range May 13-June 4). Median parturition date was May 22. Among pregnant females, there were no significant differences in body measurements or blood parameters between those that were never seen with calves and those that were. However, the index to body condition was significantly lower ($P = 0.01$) for pregnant females that were never seen with calves (Table 2). Twinning rate was comparable between collared females that had calves (3 of 25, or 12%) and uncollared females surveyed on June 2 (4 of 52, or 8%). The pooled twinning rate using both these data sources was 9%, one of the lowest recorded in North America (Gasaway et al. 1992).

There were no natural adult fatalities during the study period. One female was killed in the permit hunt on the Oshetna River on September 3, 1994. At the time of captures and telemetry flights, no wolves were seen in the study area. Wolves were known to be present, but subjective impressions of pilots in the area (J. Lee, H. MacMahon, M. Meekin) were that pack size was small (<10). Grizzly bears were commonly seen during the calving period, often on moose calf kills and once on a larger cache that may have been an adult caribou. One bear was observed immediately after catching a moose calf belonging to moose no.13. The calf was still moving when dropped by the bear, and fresh blood was obvious on both bear and calf. Excluding the losses that occurred before a female was seen with a calf, calf mortality did not begin until May 27, and mortality was fairly uniform from May 27 to June 15 (Fig. 1). One calf disappeared in the latter half of August, 1994. Mean age of calves at death was 12.6 days for those lost prior to July (range 2-40). This pattern of mortality, combined with the frequent observations of grizzly bears during this period, indicates mortality of moose calves is comparable to that observed by Ballard et al. (1981) and most likely from the same causes, predation by grizzly bears, the most important (Ballard et al. 1981).

DISCUSSION

The deployment of radio collars was made at a fairly small scale in order to identify a minimum scale for this population study. That is, the study area should be able to enclose the home ranges of a large number of moose and the predators with which they interact. Because most of the moose collared in this study remained within a few 10's of kilometers of where they were captured, the boundaries of the study area thus far are logistically advantageous for continued study. Additional study animals will be collared in November, 1994, from the area east and south of the main concentration of radiocollared moose, in order to add moose from areas of lower moose density and expand the scale so that additional wolf home ranges are likely to be included (Ballard et al. 1987).

Notwithstanding the continued high losses to predation, moose densities may be high enough for range deterioration. The observed twinning rate of 9% is one of the lowest reported for moose in North America (Gasaway et al. 1992). Had pregnancy not been determined from PSPB assay, the apparent calving rate (63%) would also be considered unusually low (Gasaway et al. 1992). These losses may have occurred as abortions late in gestation, as stillborn calves, or from abandonment immediately after birth. These are all possible results of nutritional stress, a hypothesis supported by the poorer condition of females that lost calves. The late onset of mortality and steady losses after May 27 among calves of all ages is not consistent with heavy predation immediately after birth.

CONCLUSION

Results in this first year of study provide evidence of continued high predation on calves in conjunction with poorer nutritional status and lowered productivity for adults in comparison to other Alaskan populations and previous work in the area. Adult survival in late winter and spring was high and there was little evidence of heavy wolf predation in the area, though wolves are present. Forty-two percent of fetus or neonate calf losses occurred before the calf was detected in telemetry surveys, probably from nutritional causes, with the remaining 58% disappearing from May 27 to June 15. Only one additional calf was lost prior to September 30. Predation by grizzly bears on moose calves was observed, and the temporal pattern of mortality among observed calves was consistent with Ballard's et al. (1992) findings that grizzly bear predation was the primary cause of mortality.

Even while calf predation continues to be high, the low twinning and calving rates suggest the population is sensitive to nutritional factors, such as might be caused by density-dependent competition for forage, especially in severe winters. The results of this study will be incorporated into a larger project described in the Appendix, and subsequently reported on in more detail.

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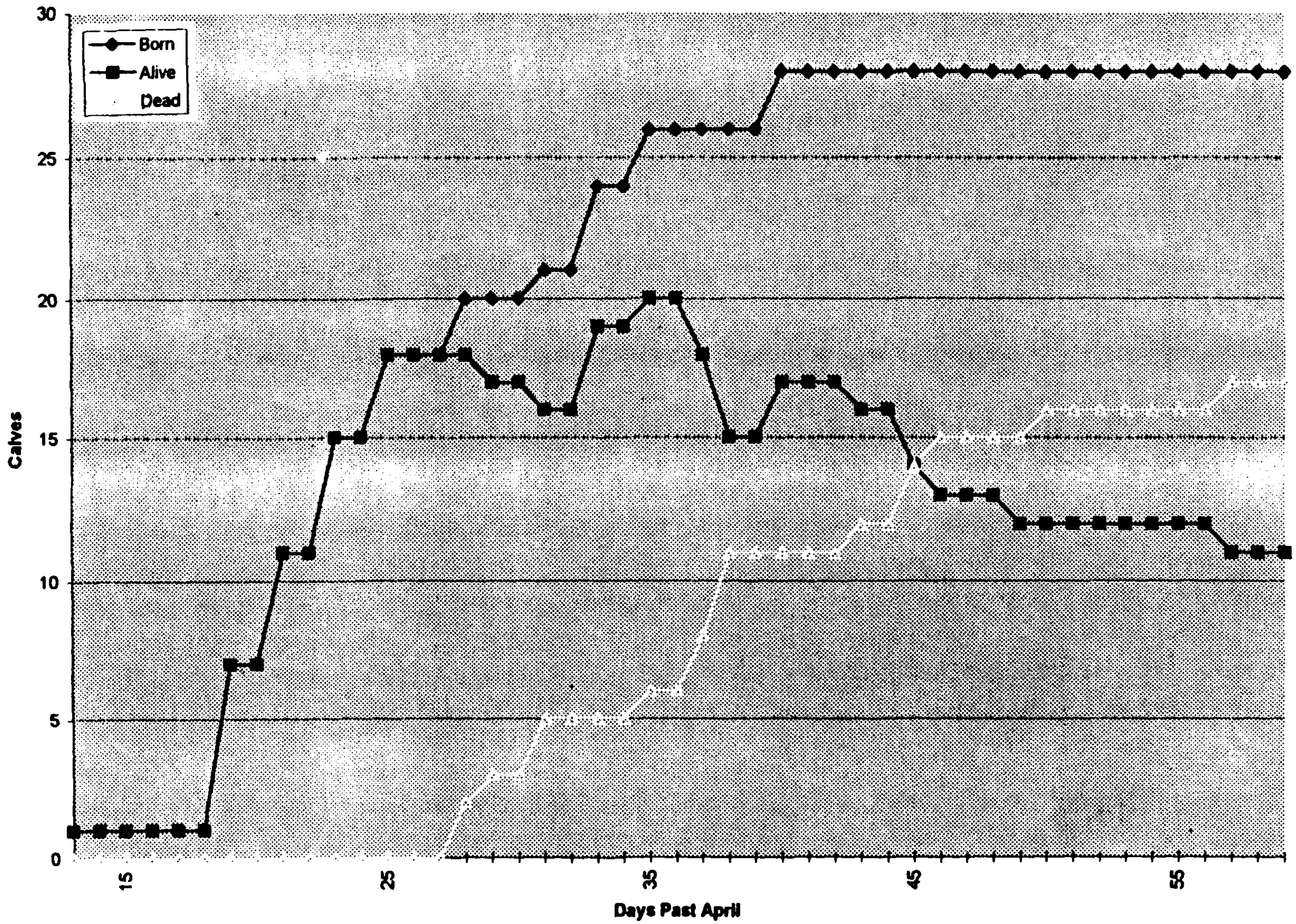

Figure 1. Cumulative totals by date from May 1 of calves born, calves alive, and dead calves in study area based on visual sightings of radiocollared female moose.

Table 1. Summary of body measurements, blood packed cell volume and hemoglobin content, and body condition indices on scale of 110 (Franzmann 1977).

	Mean	S.D.	Range
total length	297.1	8.9	276-315
chest girth	205.9	12.2	180-230
hind foot length	80.2	3.8	70-89
packed cell volume	43.4	1.4	36-51
Hemoglobin	17.0	1.4	14-19.5
condition index	6.2	1.1	4-8

Table 2. Contingency table for moose that were pregnant in March, 1994 and subsequently were seen with a calf or were never seen with a calf. Body condition scores were pooled to avoid low expected values in individual cells. Chi-square value = 6.17 (P = 0.01)

Body Condition	With Calf	
	No	Yes
< 7	9	11
> = 7	1	14

APPENDIX

Wildlife Research Study Plan

Project No. W-24-3
Study No. 1.49
Study Duration -
From: 1 Oct., 1994
To: 30 June, 1999

WILDLIFE RESEARCH STUDY PLAN
Alaska Department of Fish and Game
Division of Wildlife Conservation
J. Ward Testa

STUDY TITLE: Population dynamics of moose and predators in Game Management Unit 13

A. THE PROBLEM/NEED:

1. Statement

Wildlife management policies in Alaska address the needs of diverse constituencies. Game Management Unit 13 (GMU 13), in Southcentral Alaska, is accessible to population centers in the region (e.g., Anchorage, Palmer, Wasilla), as well as home to traditionally consumptive users in the Copper River Basin. The Alaska Department of Fish and Game, and the state's Board of Game have set human consumptive use as the priority for moose management in GMU 13. It is the objective of the Department to maximize human harvest in the unit without endangering the healthy status of predator populations. Effective monitoring of moose and predator populations and study of their interactions are essential to that objective.

2. Background

Few ecological controversies are interwoven with public resource controversy like those of predator-prey dynamics in Alaska. Moose are a central element in these controversies. As a resource, they have nutritional and economic importance to human communities. Ecologically, moose are an important primary consumer with the potential to alter plant community structure and productivity (Moen et al. 1990, Molvar et al. 1993, Peterson 1977: 138). The ecological controversy is over the role of predators in limiting or regulating moose numbers below levels allowed by available forage. Reviews of predator-moose interactions cite many circumstances where reduction in wolf numbers has been associated with high densities of moose, while high wolf densities are often associated with low moose numbers (Bergerud and Snider 1988, Boutin 1992, Gasaway et al. 1992, Messier 1991, Van Ballenberge 1987). Experimental removal of wolves has increased moose recruitment in some cases (e.g., MacGregor 1987, Gasaway et al.

1992), but not in others (Ballard and Larsen 1987, Boutin 1992). Where moose calf mortality has been directly studied, either black or brown bears have had more impact than have wolves (Ballard and Miller 1990, Osborne et al. 1991, Franzman and Schwartz 1986).

These predator-prey relationships are complicated by the influence of weather. Years of heavy snow may have strong impact on moose populations through direct mortality (Peterson 1977, Modaferri pers. comm), increased vulnerability to predation by wolves (Coady 1974, Peterson 1977), or by indirectly influencing growth and reproduction of young animals in subsequent years (Mech et al. 1987).

The diversity of contradicting studies emphasizes an important point: none of these relationships is known to act with certainty; their relative importance must be ascertained by careful study of the particular moose population, their predators, and their environment. Furthermore, because we are dealing with long-lived animals in an environment with varying predator populations, climatic and vegetation characteristics, the mechanisms controlling moose populations in a single area may change.

Moose in the Nelchina Basin, GMU 13, are an important resource for residents in Southcentral Alaska. Hunters have historically taken between 553 and 1,814 moose annually over the last 30 years. Moose also are one of the most conspicuous of the large wildlife that attract tourists to the Denali, Glen, and Richardson highway systems.

The Nelchina moose population has undergone substantial numerical fluctuations in the last 4 decades. Following federal predator control and significant forest fires, moose reached high numbers in the early-to-mid 1960s, declined for some years while predators and human harvest increased, and then began a steady increase in the mid 1970s (Ballard et al. 1991). The most recent increase began while the populations of wolves and brown bears were believed to have decreased, either due to increased harvest or (in the case of wolves) direct control on parts of GMU 13; winters were mostly average-to-mild during that time (Ballard et al. 1991). Extensive studies of predators and moose in GMU 13 were conducted by Ballard and colleagues from the mid 1970s to mid 1980s. Mortality of moose calves was believed to be of primary importance in the population dynamics of moose, and most of this mortality was caused by brown bear predation. Recently, moose numbers again have declined, concurrent with several years of deep snow and evidence of an increase in numbers of wolves. The compounding of these two factors, as well as uncertainty about the present status and impact of the brown bear population, makes the cause or causes of the most recent decline difficult to identify.

The direction of this research program is toward determining whether the factors affecting the moose population in GMU 13 are changing, which factors are still important, and whether such factors can be manipulated or monitored more effectively to achieve desired management goals. These are long-term issues and require that we establish a foundation for long-term research while still addressing short-term goals recognized for the region.

B. OBJECTIVES:

The purpose of this research plan is to begin a long-term program that will (1) more accurately track the dynamics of the moose population, (2) immediately determine which causal variables (e.g., weather, predation, habitat, hunting) are driving population changes, and (3) help identify possible management strategies to anticipate or halt moose population declines and increase human harvests. This study plan is intended to serve as a core program to address several questions about dynamics of a high-profile moose population. Other projects will be added as the data suggest what forces are at work to cause changes in the moose population. In addition, it is my hope that an active, long-term research program, relevant to the state's immediate interests, will provide results useful to managers nationally, and attract professional collaborators to conduct research on moose and predator populations.

The wealth of data on moose in GMU 13 provides valuable reference points to interpret new estimates of population size, productivity, and mortality in the present study. This is particularly so, because estimates of population parameters have been accompanied by studies on the causes of mortality and on snow conditions (Ballard et al. 1987, 1991). Therefore, the initial focus of this research is detecting changes that have occurred in important population parameters that may indicate a change in the underlying causal variables; potential causes would then be investigated in detail. The individual projects proposed here start with assessment of historical data from GMU 13 and comparison of current population parameters with earlier estimates. This is followed by several projects to provide data on present moose numbers, moose mortality and productivity which will be compared with past data from GMU 13 and with other northern moose populations. As the most likely factors affecting the moose population emerge, supporting projects to address those factors will be proposed.

In outline, this research will address the following hypotheses regarding the past and current relationships of moose to their environment, including predators.

H1. Indices of moose productivity and browsing impact are indicative of a population near K-carrying capacity.

Direct measures of range/vegetation quality and abundance are not likely to be feasible. However, a number of indices to moose productivity, nutritional status, and browsing impact have been used in the past and can provide measures of the status of moose in GMU 13. Pregnancy rates of moose are not likely to vary much unless conditions are severe, but moose twinning rate in Alaska varies substantially (0-90% of parturient females that have twins - Gasaway et al. 1992) and such variation has been related to the nutritional quality of the habitat (Franzmann and Schwartz 1985, Boer

1992). It is also an important population parameter affecting population growth and potential yield to hunters. Age of first reproduction similarly affects population growth, and is related to the body weight of young females independent of the mother's weight (Saether and Heim 1993). Direct measures of moose body condition are also useful indicators, if they are carefully collected at standardized seasons (Franzmann and Ballard 1993). Moose handled in this study will be assessed by standard body dimensions, blood packed cell volume and Hemoglobin concentration (Franzman et al. 1987), body fat (Stephenson et al. 1993), haptoglobin levels (Duffy et al. 1994), and possibly urea/creatinine ratios (DelGuidice et al. 1989). The impact of moose on vegetation will be assessed by measuring the proportion of annual growth of willow species browsed by moose during the winter, and by measuring the relationship between twig diameter and nutritional content for the most important browse species. Comparable data have been collected in other parts of interior Alaska (Gasaway et al. 1992, T. Osborne and K. Kielland, pers. comm.)

H2. Weather conditions, particularly snow depth and length of snow-free season, are significantly related to moose productivity, population growth and/or vulnerability to predation.

Weather influences energetic demands and survival of ungulates, but relating relevant weather variables to moose population dynamics can be difficult. Coady (1974) reviewed evidence that snow depths exceeding 90cm impede movements by adult moose, decrease their foraging range, and increase energy demands. Increased vulnerability of ungulates to predation by wolves is also associated with snow depth (Peterson 1977, Huggard 1993). Ballard et al. (1991) found a significant relationship between calf moose survival and a snow depth index in GMU 13; the most recent decline in the moose population there occurred during successive years of deep snow (Schwartz, ADFG memo, 1992; K. Schneider, ADFG memo, 1993). These relationships will be investigated by use of snow course data already being collected in GMU 13, by augmenting the present collection sites with new sites across elevational transects in the study area, possibly by satellite imagery, and by comparing snow characteristics at sites of moose fatalities to those at index or random sites.

H3. Bear numbers and/or moose losses to bear predation indicate no change from previous studies.

Bear predation on moose, especially calf moose in the first 60 days of life, is often the largest source of mortality affecting moose population dynamics in GMU 13 (Ballard et al. 1981, Ballard et al. 1991), as well as in some other parts of Alaska (Osborne et al. 1991, Schwartz and Franzmann 1991). The background of past moose mortality studies in the unit, and the expectation that bear predation on calves will be heaviest in the first 30 days following parturition (Ballard et al. 1981, 1991, Boertje et al. 1988) indicate that a change in the seasonal pattern of calf mortality and evidence for changing bear numbers should be sought before altering the view that bear predation on calves in the area is heavy.

H4. Wolf predation is low enough to allow the moose population to increase.

Management indices to moose numbers are not markedly different from those measured during the early 1980s when various censuses in the western part of GMU 13 indicated densities of 500-900 moose/1000km2 (Ballard et al. 1991). Estimates of wolf numbers for GMU 13 have roughly doubled since the 1980s (Tobey and Gardner 1991, Tobey, pers. commun.) and may approach 10 wolves/1000km2, though this change may not be uniform throughout GMU 13. Moose/wolf ratios therefore seem to be above that at which wolves limit other moose populations (Gasaway et al. 1992). It is also beyond the ratio of moose/wolves where regulating effects of wolf predation are indicated by theoretical models (Messier 1994, Dale et al. 1994), though heavy bear predation may influence that conclusion. Additional predation on neonate moose may be masked by ongoing bear predation after calving, but increased wolf predation should make itself known in increased winter mortality rates of moose, especially of calves and older animals (Peterson 1977, Ballard et al. 1987). In addition to gathering new data on age-specific mortality rates of moose, models that incorporate both important predators and the influence of alternate prey (caribou) should be explored.

To address these hypotheses, the proposed research will include the following jobs as part of a 5-year core program:

1. Analyses of trend-count data and population modeling
2. Snow-course measurements
3. Censuses, trend-counts and composition surveys: possible refinements
4. Moose captures: condition and reproductive status
5. Moose mortality: temporal patterns and causes
6. Age of first reproduction: radio-collars for yearlings
7. Surveys of winter browsing impact
8. Wolf density estimates
9. Experimental technology for censusing bears

10. Preparation of annual reports and publications

C. EXPECTED RESULTS AND BENEFITS

The objectives of this study are clearly related to management goals in GMU 13. Results will clarify the underlying factors causing the most recent decline of moose there, and improve monitoring of future changes. Of particular importance is the foundation being laid for more detailed studies of those factors most affecting moose population dynamics.

D. JOBS

1. Analyses of trend-count data and population modeling

Fifteen traditional count areas (CA's) have been established in GMU-13 and provide annual estimates of the sex and age composition of the moose population, as well as indices to population size. Problems arise in interpretation of these trend-count data because they are indices only and are not directly comparable to population censuses. Little is known about their inherent variability because they are not replicated within years. Nevertheless, these trend and composition counts comprise the heart of the long-term database on moose in GMU 13 and are essential to understanding moose population dynamics there. They exhibit remarkably clear trends since the 1960s in spite of substantial variation within individual count areas. Improved analyses of past trend-count data is therefore of high priority, and substantial time must be allowed for the principle investigator to explore possible analyses and model the dynamics of moose and their predators.

Models of predator-prey interactions are essential to test our conceptualization of these interactions and uncover gaps or uncertainties in available data. The modeling approach of Messier (1994) and Dale et al. (1994), incorporating functional and numeric responses of predators to varying prey populations, are traditional ecological approaches applied to wolves and both caribou and moose as prey. I view these as good theoretical frameworks for understanding predator prey interactions both in terms of short-term predictions of population trends when predator and prey numbers are known, and for long-term expectations of population stability. Such models for moose in GMU 13 need to be expanded to include the interaction of moose and vegetation, bears and moose, and the utility of prey- dependent vs ratio-dependent (moose/predator or vegetation biomass/moose) functional responses (e.g., Akçakaya 1992).

This job will be an ongoing task of exploratory data analyses and modeling with the following subdivisions:

a. Compilation of an efficient and accessible computer database of trend-count data by year and count area;

b. Exploration of statistical models to control for CA effects and detect yearly trends. These are most likely to be robust linear models similar to ANOVA or Median Polish analysis (E.F. Becker, ADFG memo of 5/4/93), and regression;

c. Snow course data as covariates to explain variation in recruitment and rates of population growth or decline (see next page);

d. Population and ecosystem modeling. (e.g., incorporation of predator population estimates, modeling of short-term effects of predation or harvest strategies, long-term dynamics of 3-trophic level models).

2. Snow-course Measurements

Snow depths that exceed certain thresholds can affect the behavior and energetic expenditures of moose during winter (Coady 1974), as well as their vulnerability to predation (Peterson 1977: 145, 154, 158). Measurements of snow characteristics at established sites around GMU 13 have already proven valuable. Snow depth index values exceeding 28in were correlated with elevated moose mortality (Ballard et al. 1991). Snow depth as a contributing factor in moose losses to predation, and to time-lagged effects on mortality, are areas of current scientific controversy (e.g., Mech et al. 1987, Messier 1991). The ongoing collection of snow course data in GMU 13 is a valuable asset to the proposed research. I plan to augment that information with data specific to the moose study area and causes of moose mortality there, and to explore remote sensing methods for measuring area-wide snow depths. The following aspects will be addressed:

a. Continued collection of snow depth and density at traditional sites (currently collected by personnel of Alaska Department of Fish and Game (ADFG) and the U.S. Soil Conservation Service);

b. Addition of snow-course sites in GMU 13A to include a range of elevations and habitats. Monthly survey of sites will contribute to the main database being maintained and analyzed by Jay Ver Hoef, ADFG, Fairbanks. Spatial statistical analyses will be explored with Ver Hoef to estimate average snow depths in the study area;

c. Snow depths associated with fatalities (See next page);

d. Satellite imagery for snow depth, snow-free season, and green-up.

3. Censuses, Trend-Counts and Composition Surveys

One area of disagreement among management biologists is the relative utility of count-index data and their relationship to actual moose numbers. Fifteen count areas are established in GMU 13 to estimate trends in numbers and changes in age-sex composition in the unit. The effects of moose movements on these unit counts, and the significance of differences between units and between years are not well understood. They are potentially important in the interpretation of observed changes (e.g., is 40 moose/hr a significant decline from 45 moose/hr?). Innovations that can assist in interpretation of these data, such as methods to provide variance estimates for point indices, concurrent moose censuses by mark-recapture or Gasaway surveys, and costs and benefits of replicate index counts (Link et al. 1994) must also be explored. With the study area encompassing Count Area 14 (CA-14) and possibly CA-13, this project will focus on the relationship of trend-count data to population density, and on ways to improve the collection and interpretation of index count data. I propose that population censuses be conducted in alternate years over the next 5 years in an area encompassing one or more of the established count areas (CA-14 and possibly CA-13). The intention is to provide for comparison of index counts to actual censuses over years when population change may occur. This establishes a measure of variation in sightability during index counts and an objective comparison of the effectiveness of both methods in detecting any trend over the next 5 years. The study would be designed to provide a density estimate of the particular count area or areas, as well as of the larger area surrounding it that is to be the main study area (pending results of moose telemetry study). Population censuses also provide essential data for modeling the population dynamics and improving estimates of allowable harvest. The presence of nearly 100 radio-collared moose in the survey areas may also allow validation, or correction, of sightability estimates. Methods for collecting and analyzing count-index data as a time series, and as spatial data, will be explored for opportunities to model variation and ascribe confidence intervals to individual index counts without replication. In summary, the following projects are planned in this job:

a. Gasaway-style censuses in alternate years from 1994-1998. These will be conducted in collaboration with Earl Becker and Jay Ver Hoef, employing refinements in stratification methods to improve precision;

b. Replicate count-index surveys using traditional counting methods, before and after censuses, augmented with radio-collar locations to estimate sightability;

c. Exploration of statistical improvements in index-count analyses using time-series and spatial models.

4. Radio-collaring of adult moose: condition and reproductive status

Study of adult and calf mortality is underway, but it is extremely important that sample sizes be high in order to detect real changes in reproductive and mortality rates with a high degree of statistical certainty. I want to maintain 80-100 collared adult female moose in the study population for the next 5 years. Regular additions of yearlings every spring will be necessary to build up a known-age sample and ensure that the age structure of collared animals is similar to that in the population at large (see job 6). Handling of adult moose will be done in mid November in order to assess rump fat (Stephenson et al. 1993) and twinning rates via ultrasound prior to winter. Ultrasound diagnosis of pregnancy and litter size in moose has not been performed in the wild, but is a well-established veterinary technique recently applied to ungulates (e.g., Lenz et al. 1993). Greg Adams (Department of Veterinary Anatomy, University of Saskatchewan) will conduct a workshop on the method prior to field captures of moose and perform the field diagnoses. Pregnancy will also be assessed with pregnancy-specific protein b (PSPB; G. Sasser, University of Idaho). Condition of animals will be assessed subjectively by the scoring system of Franzmann (1977) and by blood parameters that may be indicative of condition (e.g., packed cell volume, hemoglobin content, haptoglobin) (Franzmann and Ballard 1993, Duffy et al. 1993). Serum samples for a statewide disease survey will be archived with R. Zarnke at ADFG-Fairbanks.

a. Post-rut collaring of 40 more adult cows in GMU 13A

b. Pregnancy and twinning rates via ultrasound and PSPB

c. Rump fat via ultrasound

d. Condition indicators: subjective scoring, packed-cell volume, hemoglobin, haptoglobin and possibly cortisol

e. Blood archive for disease survey

5. Moose mortality and reproduction

Hypotheses about what limits moose population growth hinge critically on rates of reproduction and on the amount and causes of mortality. Examination of fatalities as they occur is also essential to determine actual causes of mortality. Assuming that moose capture operations are accomplished under Job 4, the frequent monitoring of telemetered moose, coupled with additional spring surveys during the calving season should provide adequate estimates of mortality and reproductive rates of moose in the study area. Population parameters will be estimated as follows:
a. Adult survival via bimonthly aerial surveys and Kaplan Meier procedures (Pollock et al. 1989)

b. Causes of adult mortality by surface investigation of fatalities and site characteristics such as snow depth slope, etc.

c. Age and condition of fatalities from both prior handling (condition indices, blood parameters, etc., see Job 4) and carcass evidence (marrow fat, teeth wear and cementum annuli, etc.)

d. Calving and twinning rates from daily radio-tracking during the calving season and from independent aerial surveys for twinning rate among parturient cows.

e. Mortality rates of calves from frequent visual sightings of calves accompanying radio-collared cows and application of mark-resighting methods (Lebreton et al. 1992); resightings daily from May 15 to June 1, every 2 to 3 days during June and bimonthly thereafter.

6. Yearling collars

Mortality and reproductive rates in moose vary with age, and these age-specific rates may be important indicators of population status (see H1). It is important that radio-collared moose, on which estimates of reproduction and survival depend, be representative of the population at large, and important that those ages be known. For these reasons additional yearling moose will be collared each year in the spring to supplement the radio-collared population and to begin building the known-age sample that will provide age-specific estimates of mortality and reproduction. As much as possible, these will be female yearlings accompanying radio-collared cows, so that effects of maternal age and condition on calf condition and survival may also be studied.

7. Surveys of winter-browsing impact

While moose twinning and calving rates and moose body condition are indices to the nutritional status of the population, they may lag behind changes in vegetation quality that occur effects of browsing. Therefore, it is important to make a direct assessment of the impact of moose on their forage base in the study area. The approach taken in this study will be to sample riparian habitats for Salix sp. in late winter to estimate the proportion of that year's growth browsed by moose. This will be done by sampling browse species along transects perpendicular to streams in the area, measuring the diameter of twigs at their base (beginning of last year's growth) and at the point of browse. Unbrowsed twigs will be used to determine nutritional value of key species as a function of twig diameter via analyses of crude protein, in vitro dry matter digestibility, and tannin content. This is similar to methods used in previous assessments in interior Alaska (Gasaway et al. 1992; T. Osborne and K. Keiland, pers.commun.).

8. Wolf density estimates

Clearly, if wolf predation is suspected a significant factor affecting moose population dynamics, estimates of wolf abundance are essential and should be conducted at least annually. Ideally, estimates prior to the overwinter period are the most relevant to winter predation on moose, but are difficult to obtain due to unfavorable weather. With the possibility of wolf harvest, both legal and illegal, during the winter and because wolf movements may cause some variability in density estimates, a second census in late winter is desirable for within-season comparison/replication. The area censused will be large enough to encompass the moose study population, plus a buffer so that wolf packs adjacent to the main study area will also be included. If moose mortality rates and wolf numbers suggest wolf predation is important, then additional work will be initiated on rates and impact of predation using radio-collared wolves in later years.

9. Bear Densities

Given the obvious importance of bear predation in GMU 13 in the past (Ballard and Miller 1990, Ballard et al. 1991), bear abundance is an extremely important factor, and new methods should be sought to estimate bear abundance. Mark-recapture procedures to obtain adequate precision for this are too expensive, but new technologies are being developed that might be cost effective and noninvasive. In particular, high-resolution infrared video is a potentially useful approach being tested, most commonly on deer in other states (J. MacAninch, Minnesota Department of Natural Resources). In combination with computer enhancement of the infrared signature, this approach has potential to discriminate between several species and effectively census animals over a large area. Here in Alaska, we have opportunities to test the technology in environments that maximize the thermal differences between targets and their background; we also have good opportunities for validating the counts obtained (e.g., at the Moose Research Center with known numbers of moose and caribou). Trials may be possible in spring 1995. Funding to contribute to or expand those trials is being sought separately, but personnel time is reserved to investigate the application of this technique in GMU 13, particularly for bears.

10. Preparation of Annual Reports and publications

Annual reports are due in August, 1994 (and in March after 1995. Results warranting consideration by international colleagues will be presented at the regular meetings of moose biologists. These will be held in New Brunswick in 1995, in Alberta in 1996, and in Alaska in 1997.

E. SCHEDULE AND COSTS

Job 1. Count area trend analyses and modeling
COST (N/A)

EFFORT (person-months/year)

	FISCAL YEAR				
	1995	1996	1997	1998	1999
Biologist	4.0	4.0	4.0	4.0	4.0
Technician	1.0	0.5	0.5	0.5	0.5

Job 2. Snow-course survey expansion
COST (in thousands of dollars)

	FISCAL YEAR				
Item	1995	1996	1997	1998	1999
materials	0.5				
air taxi	2.0	1.0	1.0	1.1	1.1
Total	2.5	1.0	1.0	1.1	1.1

EFFORT (person-months/year)

	FISCAL YEAR				
Item	1995	1996	1997	1998	1999
Biologist	0.7				
Technician	0.5	0.2	0.2	0.2	0.2

Job 3. Enhancing trend and composition data
COST (in thousands of dollars)

	FISCAL YEAR				
Item	1995	1996	1997	1998	1999
moose census	9.0		9.1		9.2
CA surveys	3.5	3.6	3.7	3.8	3.9
supporting telemetry	0.5	0.5	0.5	0.6	0.6
Total	13.0	4.1	13.3	4.4	13.7

EFFORT (person-months/year)

	FISCAL YEAR				
Item	1995	1996	1997	1998	1999
Biologist	0.5	0.2	0.5	0.2	0.5
Biometrician	1.0		1.0		1.0
Technician	1.0		1.0		1.0

Job 4: Radio-collaring adult moose

COST (in thousands of dollars)

Item	1995	1996	1997	1998	1999
		FISCAL YEAR			
collars	10.0			10.3	10.3
drugs	4.0			4.2	4.3
spotters	4.0			4.1	4.1
fuel	1.5			1.2	1.3
H-500	14.0			14.5	14.6
travel	2.0			2.0	2.0
lab tests	0.8			0.9	0.9
Total	36.3			37.2	37.5

EFFORT (person-months/year)

Item	1995	1996	1997	1998	1999
		FISCAL YEAR			
Biologist	2.2			1.0	1.0
Technician	1.0			2.0	2.0

Job 5: Radio-tracking/survival/reproduction

COST (in thousands of dollars)

Item	1995	1996	1997	1998	1999
		FISCAL YEAR			
26 adult surveys	26.0	26.2	26.4	26.6	26.8
25 calf surveys	25.0	25.2	25.4	25.6	25.8
travel	2.0	2.0	2.1	2.1	2.1
Total	53.0	53.4	53.9	54.3	54.7

EFFORT (person-months/year)

Item	1995	1996	1997	1998	1999
		FISCAL YEAR			
Biologist	3.0	3.0	3.0	3.0	3.0
Technician	3.0	3.0	3.0	3.0	3.0

Job 6: Yearling radiocollars

COST (in thousands of dollars)

Item	1995	1996	1997	1998	1999
		FISCAL YEAR			
collars	4.5	4.5	4.6	4.6	4.7
drugs	2.4	2.4	2.5	2.5	2.5
helicopter	6.5	6.5	6.6	6.6	6.7
spotter	2.0	2.0	2.1	2.1	2.2

fuel	0.5	0.5	0.6	0.6	0.6
Total	15.9	15.9	16.4	16.4	16.7

EFFORT (person-months/year)

		FISCAL YEAR			
Item	1995	1996	1997	1998	1999
Biologist	0.5	0.5	0.5	0.5	0.5
Technician	1.0	1.0	1.0	1.0	1.0

<u>Job 7: Surveys of winter browsing impact</u>

COST (in thousands of dollars)

		FISCAL YEAR			
Item	1995	1996	1997	1998	1999
UAF subcontract	1.5	8.0	8.1	8.2	8.3

EFFORT (person-months/year)

Biologist	1.0	1.0	1.0	1.0	1.0

<u>Job 8: Wolf density estimates</u>

COST (in thousands of dollars)

		FISCAL YEAR			
Item	1995	1996	1997	1998	1999
fall survey	2.4	2.5	2.6	2.7	2.7
spring survey	2.3	2.4	2.5	2.6	2.7
total	2.3	4.8	5.0	5.2	5.4

EFFORT (person-months/year)

		FISCAL YEAR			
Item	1995	1996	1997	1998	1999
Biologist	0.5	0.5	0.5	0.5	0.5
Biometrician	0.5	0.5	0.5	0.5	0.5

<u>Job 9: Experimental techniques for estimating bear density</u>

COST (N/A): separate funding, if available

EFFORT (person-months/year)

		FISCAL YEAR			
Item	1995	1996	1997	1998	1999
Biologist	1.0				

Job 10: Reporting
COST (in thousands of dollars)

	FISCAL YEAR				
Item	1995	1996	1997	1998	1999
Travel/meetings	2.0	2.0	0.5	2.0	2.0
page/publ.	0.0	0.5	0.5	0.6	0.6
total	2.0	2.5	1.0	2.6	2.6

EFFORT (person-months/year)

	FISCAL YEAR				
Item	1995	1996	1997	1998	1999
Biologist	2.0	2.0	2.0	2.0	2.0
Biometrician					1.0

TOTAL
COSTS (in thousands of dollars)

	FISCAL YEAR				
Item	1995	1996	1997	1998	1999
Total	136.4	89.7	98.7	129.4	139.9

TOTAL EFFORT (person-months/year)

	FISCAL YEAR				
Item	1995	1996	1997	1998	1999
Biologist	14.4	10.2	11.5	12.2	12.5
Biometrician	1.5	0.5	1.5	0.5	2.5
Technician	7.5	4.7	5.7	6.7	7.7

F. GEOGRAPHIC LOCATION

The site for this study is in Game Management Unit 13A, encompassing the eastern foothills of the Talkeetna Mountains and adjoining parts of Lake Louise Flats. The exact boundaries will be determined by the movements of radio-collared moose but will probably include drainages of the Oshetna River, Goose Creek, Tyone Creek, and possibly the upper Nelchina River.

G. RELATED FEDERAL STUDIES

(none)

H. REPORTING SCHEDULE

Annual progress reports will be due in Headquarters on March31 each year of the study beginning in 1996.

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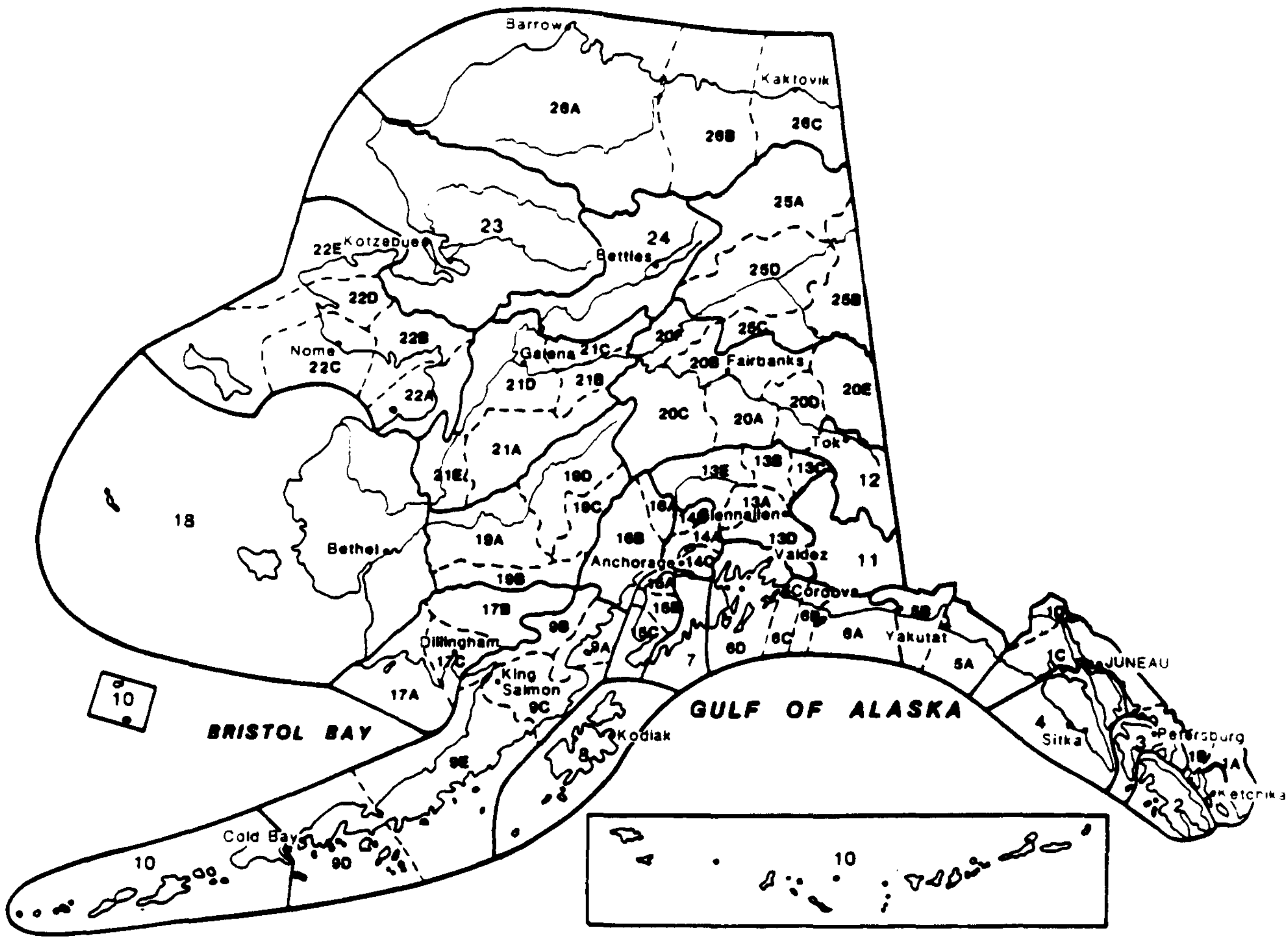
Alaska's Game Management Units



Federal Aid in Wildlife Restoration

The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sales of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program then allots the funds back to states through a formula based on each state's geographic area and the number of paid hunting license holders in the state. Alaska receives 5% of the revenues collected each year, the maximum allowed. The Alaska Department of Fish and Game uses the funds to help restore, conserve, manage, and enhance wild birds and mammals for the public benefit. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes necessary to be reponsible hunters. Seventy-five percent of the funds for this project are from Federal Aid.