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Factors Limiting Moose at High Densities in Unit 20A

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RESEARCH PROGRESS REPORT

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STUDY TITLE: Factors Limiting Moose at High Densities in Unit 20A

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SUMMARY

Progress this period included completion of the first year of fieldwork and limited data analysis of factors limiting moose (*Alces alces gigas*) at high densities in Unit 20A. This report includes data collected between 1 March 1996 and 1 March 1997. During early March 1996, we radiocollared 44 adult female moose (> 33 months old) and, during May 1996, we radiocollared 46 newborn moose. During immobilization, we collected data on condition of moose. We regularly radiotracked moose to collect data on movements, productivity, and survival.

The most notable observations were: 1) high calf survival to 365 days (59%) compared with 5 other Alaska-Yukon moose calf mortality studies (19% to 42%), 2) a high adult survival rate (91%), and 3) high pregnancy rates of adult cows (98%, $n = 44$). These data indicate the population is increasing and nutritional status is favorable, despite the study population's high density (7680 moose in 6730 km^2, 1.14 moose/km^2 ± 15% [90% CI]).

No examples exist in Alaska or the Yukon where moose maintained this high density for an extended period in a similarly large area. This moose density is well above the level at which combined wolf (*Canis lupus*) and bear (*Ursus* spp.) predation commonly limit moose density in Alaska and the Yukon (0.04 to 0.42 moose/km^2, Gasaway et al. 1992). Two Alaska Department of Fish and Game (ADF&G) wolf control programs likely helped initiate and continue this increase in moose density to high levels (Boertje et al. 1996). Also, the area has had favorable weather since 1975, except during 1990-1993, and has good moose habitat (Boertje et al. 1996).

We have made no proposals to stabilize this moose population through cow hunting but have initiated a minimal cow hunt and are experimenting with methods for distributing this harvest. ADF&G is actively pursuing prescribed burns in Unit 20A to improve moose habitat, and we will pursue more extensive cow hunts in the near future with the purpose of increasing hunting opportunity if condition and survival of cows remain high. We plan to manage moose yearly, using all available information on condition, survival, and productivity. Primary goals are to sustain a high opportunity to harvest moose and to avoid repeated predator control programs to increase moose numbers. Thus, our priority is to keep the moose density well above levels at which combined wolf and bear predation maintain moose at low densities.

Key words: backfat, moose, moose condition, mortality, predation, pregnancy, survival, twinning.

CONTENTS

BACKGROUND

Moose (*Alces alces gigas*) densities in Unit 20A have been increasing during most years since initiation of an intensive aerial wolf (*Canis lupus*) control program (1976-1982) and moose are at high densities (Boertje et al. 1996, ADF&G unpubl data). A second wolf control program during 1993-1995 probably also helped increase this moose population (Boertje et al. 1996). Also, the area has had favorable weather since 1975, except during 1990-1993, and has good moose habitat (Boertje et al. 1996). Black (*Ursus americanus*) and grizzly bear (*Ursus arctos)* predation in our study area in the 1970s was low compared to wolf predation (Gasaway et al. 1983:30). Grizzly bears and possibly black bears were reduced in a portion of our study area by local harvests during the mid to late 1980s (Hechtel 1991, Reynolds 1994).

The entire Unit 20A moose population was estimated to be about 11,500 moose in 13,000 km^2 of moose habitat (0.87 moose/km^2) during early winter 1996. Moose densities in the central portion of Unit 20A, where we are conducting this study, are much higher (6500 to 8800 moose in 6730 km^2 of moose habitat, 1.14 moose/km^2 ± 15% [90% CI]).

No examples exist in either Alaska or the Yukon where moose have maintained such a high density for long periods of time over a similarly large area (Gasaway et al. 1992), indicating that moose in our study area will decline substantially in the near future from the combined effects of adverse weather, browse limitation, and uncontrolled wolf and bear predation (Gasaway et al. 1992). This was the case between 1965 and 1975 when the Unit 20A moose population decreased from about 1.7 to 0.23 moose/km^2 (Gasaway et al. 1983). Ill-timed harvest of cow moose also contributed to the magnitude of this previous decline.

Maintaining moose in Unit 20A above the level at which predation can strongly limit moose would be a significant wildlife management achievement. For example, elevated consumptive and nonconsumptive uses of moose would be ensured without repeated intensive predator control programs. Gasaway et al. (1992) concluded that moose densities are predictably low (0.04 to 0.42 moose/1000 km^2) where near-natural levels of wolf and bear predation prevailed for long periods in Alaska and the Yukon. Moose densities are higher in these same systems where humans reduced predation.

Since the mid-1970s, Unit 20A has proven to be Alaska's most intensively managed area in terms of ADF&G costs to survey wildlife and reduce predation for promoting increased moose and caribou (*Rangifer tarandus*) numbers. This management focus has broad local support stemming primarily from a strong local tradition of hunting, awareness of the enhanced value of land with abundant wildlife, more hunting restrictions elsewhere in Alaska, and awareness of the area's high densities and harvest of ungulates during the 1960s, following federal predator control in the 1950s. Approximately 3000 hunters used this area annually in the late 1980s.

The 10-year decline of moose in Unit 20A, from about 22,000 in 1965 to about 2800 in 1975, taught us several important lessons (Gasaway et al. 1983). First, Unit 20A probably cannot sustain 1.5 to 1.9 moose/km^2 through severe, deep snowfall winters when browse availability is reduced and energetic costs of obtaining browse are high. Second, wolves strongly impacted the declining moose population, as demonstrated by the wolf control program which coincided with a sustained 15% finite annual increase in the moose population (Boertje et al. 1996). Third, errors were made in managing moose in the late 1960s and early 1970s. Biologists mistakenly believed that wolves killed only moose that would soon die from other causes.

Initially, moose population size was overestimated and the rate of decline was underestimated. Also, biologists erred by underestimating the combined impact of wolf predation and hunting on moose. Ill-timed intense hunting of cow moose was allowed in 1972, 1973, and 1974, in part because of the belief that poor range condition was the major factor limiting yearling recruitment. Biologists patiently awaited a compensatory rebound in yearling recruitment from improved range that would offset the intense harvest. However, it was a futile vigil; yearling moose became increasingly scarce until wolf control began. Severe winters, hunting, and wolf predation combined to cause a substantial decline in moose numbers.

Today, biologists developed proven techniques for estimating moose population size and trend (Gasaway et al. 1986), and radiotelemetry allows biologists to investigate causes and rate of moose mortality and changes in reproduction. Also, the potential effects of wolf and bear predation are better understood.

A current theory on wolf predation in wolf-bear-moose systems predicts that, without periodic wolf control, wolves will increase and combined wolf and bear predation will be sufficiently high to reduce the moose population to a low level (Sinclair 1989, Messier 1994, Hayes 1995). Under an alternative theory, wolves may naturally restrict their density and fail to reduce the moose population. For example, large wolf territory size may restrict wolf density well below the level where wolves alone can reduce the moose population to low densities. Moose may live at elevated densities for a protracted period under this theory.

The most plausible scenario is the moose population will continue to grow until severe weather intervenes; at this time browse limitation and predation may exacerbate the decline to low levels. For example, a moose population living at an overly high density may suffer greater nutritional impacts from adverse weather (Peterson and Page 1983, Messier 1995) and could potentially be accelerated to low levels by intense predation, even when moose:wolf ratios are initially relatively high (Gasaway et al. 1983). Predation can accelerate declines because prey are highly vulnerable and carcasses are underutilized (Peterson and Page 1983). Overly high moose densities vulnerable to browse limitation are, therefore, cause for concern among managers where predation is not controlled.

To examine these potential scenarios, we are studying the reproductive and nutritional vigor of the moose population, snowfall, and the causes and rate of moose mortality in an area where predation is not annually controlled by humans (Boertje et al. 1988, Gasaway et al. 1992:Fig 9). Parameters previously correlated with moose nutritional condition include yearling and adult pregnancy rates, adult backfat depths, adult twinning rates, and chronology of calving (Boer 1992, Gasaway et al. 1992, Schwartz 1992). We will focus our research on calf and yearling survival and yearling reproduction because young age classes are most sensitive to limiting factors, e.g., predation, adverse weather, or food limitation. Companion projects will study dynamics of wolf and grizzly bear populations.

We hope to determine what factors combine to influence the moose population and what management strategies are prudent to keep moose from returning to low densities. For example, current management options include reducing harvest during years of adverse weather and increasing harvest and habitat to reduce the possibility of food limitation.

OBJECTIVES

Review literature on 1) moose biology and ecology at high densities; 2) indices to nutritional status of ungulates; 3) models of ungulate population dynamics; 4) predator prey ratios in relation to population dynamics of moose, caribou, sheep (*Ovis dalli*), wolves, and grizzly bears; 5) predator/prey relationships in multi-prey, multi-predator systems; and 6) population and harvest data on moose, caribou, sheep, wolves, and bears in Unit 20A.

- Estimate and evaluate the usefulness of several reproductive and condition indices for moose in Unit 20A. In March 1997 we plan to collar and weigh 10-month-old calves and determine yearling pregnancy rates and first age of reproduction. As part of a graduate student project, we hope to test the hypotheses that a relationship exists between dam condition and mortality of calves and that a relationship exists between neonatal variables of condition and mortality of calves.

- Determine causes and respective rates of mortality among radiocollared moose of various age classes in Unit 20A.

STUDY AREA

This study is being conducted in the central portion of Unit 20A (6730 km^2) where moose densities are highest. This area is bounded to the north by the Tanana River, to the west by the Tatlanika River, to the south by the Alaska Range, and to the east by the Little Delta River. The study area was described previously by Gasaway et al. (1983) and Boertje et al. (1996).

METHODS

ADULT CAPTURE, CONDITION INDICES, RADIOTELEMETRY, AND MORTALITY

We immobilized 22 adult female moose (> 33 months old) in the Tanana Flats and 22 adult female moose and 1 yearling female in the Alaska Range foothills during 1-4 March 1996. We immobilized these moose with 4.0 to 4.5 mg (1.33 to 1.5 cc) carfentanil citrate (Wildnil®, Wildlife Pharmaceuticals, Fort Collins, Colo) and 150 to 167 mg (1.5 to 1.67 cc) xylazine hydrochloride (Anased®, Lloyd Laboratories, Shenandoah, Ia) administered intramuscularly via a 3 cc projectile syringe fired from an extra long range Palmer Cap-Chur® rifle (Douglasville, Ga). We injected 400 to 450 mg (8 to 9 cc) of naltrexone hydrochloride (Trexonil®, Wildlife Pharmaceuticals) intramuscularly to reverse the effects of the carfentanil citrate. We used 2 R-22 helicopters for capture, allowing simultaneous processing and darting.

When moose were immobilized, we 1) measured neck girth of moose and total length along the dorsal body contour from the hairless patch on the nose to the tip of the tail bone, 2) measured depth of backfat on the rump via ultrasound (Stephenson 1995), 3) extracted a canine tooth to determine age from cementum annuli (Matson's Laboratory, Miltown, Mont), and 4) collected 50 cc of blood from the jugular vein. R Zarnke (ADF&G, Fairbanks) processed blood samples. Serum was analyzed for antibodies (ADF&G, unpubl data), 22 constituents (standard blood-serum profile, Fairbanks Memorial Hospital), the acute phase protein haptoglobin (L Duffy, Univ Alaska Fairbanks), and pregnancy-specific protein B (PSPB, Bio Tracking, Moscow, Id). T Stephenson (ADF&G, Soldotna) determined pregnancy status via ultrasound.

We deployed 45 Advanced Telemetry Systems (ATS, Isanti, Minn) radiocollars (model 2-9D3). Pulse rate of collars doubled when collars remained motionless for 5 hr (motion sensing switch). We radiotracked adults daily in May to find newborn calves and listened to adult signals approximately monthly to monitor mortality rates. We used criteria and techniques described by Adams et al. (1995) and Boertje and Gardner (1996) to evaluate causes of death.

CALF CAPTURE, CONDITION INDICES, RADIOTELEMETRY, AND MORTALITY

We monitored pregnant collared females daily from fixed-wing aircraft (Piper PA-18 Supercub) between 14 May and 3 June 1996. We noted births during early morning fixed-wing flights and captured calves in the afternoon. We captured 46 calves between 14 May and 3 June 1996, 28 from radiocollared cows and 18 from random cows.

We captured newborns using a Jet Ranger 206 helicopter. Cow-calf pairs were commonly in clearings that permitted landing within a few meters of calves, and disturbance from the helicopter was usually sufficient to frighten dams away from the capture crew. If the cow-calf pair was not in or near clearings, the capture crew (with radiocommunication) exited the helicopter in the closest landing area. The helicopter then hovered above the calf in an attempt to frighten the dam away. We monitored all captures from fixed-wing aircraft. Some calves could not be captured without undue risk to the capture crew. If a calf of a radiocollared dam could not be captured, we captured a substitute calf from an uncollared dam in the same area. We released calves in less than 5 minutes (even if data collection was not complete) to minimize separation time. We used latex gloves and individual weighing and restraint bags to minimize transfer of scent. When twins were present, the capture crew captured and restrained both calves but processed only 1 and released both simultaneously.

We determined sex of calves and weighed calves by placing them in a bag and suspending them with a 25 kg Chatillon spring scale. To estimate birthweights, we subtracted 0.6 kg for each day > 1 (Clutton-Brock et al. 1982). We collected 3 cc of blood from the jugular vein. R Zarnke processed blood samples. L Duffy analyzed serum samples for the acute phase protein haptoglobin.

We deployed radiocollars weighing 180 g each (ATS model 8 transmitters, 1.5 hr motion sensing switch) constructed from 2 layers of 10 cm PEG (Franklin Lakes, NJ) elastic bandage (Osborne et al. 1991). The day following capture we visually radiolocated calves to assure the pair rebonded. Following visual confirmation of rebonding, we listened to calf signals to determine survival; flights were daily until 13 June and every other day until 30 June, after which tracking interval gradually increased. We investigated mortality signals immediately using a helicopter. We used criteria and techniques described by Adams et al. (1995) and Boertje and Gardner (1996) to evaluate causes of death.

Eleven calves slipped collars, 8 from collared dams and 3 from uncollared dams; we immediately censored calves of uncollared dams but visually located collared dams to evaluate calf mortality rates. If the calf was not with the collared dam on more than 2 flights, we assumed the calf died.

STATISTICAL ANALYSES

To identify potential relationships between 22 serum constituents (standard blood profile) and backfat depth, we used multiple regression models (α to enter and stay = 0.15). We used linear regression to evaluate whether relationships existed between calving date and cow age or cow backfat depth. We estimated survival rates for calves using Kaplan-Meier staggered-entry design for telemetry studies (Pollock et al. 1989). We used logistic regression to model the influence of the independent variables of cow condition (cow age, maximum backfat depth, and midpoint backfat depth) on the dependent variable calf survival (Adams et al. 1995). We also used logistic regression to model the influence of the independent variables of neonate condition (birthweight, birth date, sibling status, and sex) on the dependent variable calf survival. Survival was broken down into the 6 time intervals used for the Kaplan-Meier estimates, α for entry and inclusion into the model was set at 0.10.

RESULTS AND DISCUSSION

ADULT AGE STRUCTURE, REPRODUCTIVE INDICES, AND BACKFAT DEPTHS

Mean age of 44 adult (> 33 months old) female moose was 6.86 yr (s = 0.70). We will provide a histogram of adult moose ages in the next progress report.

Given the high density of our study population and data summarized by Gasaway et al. (1992:Table 5), we predicted adult pregnancy rates of about 76% to 84% or lower. In contrast, 43 (98%) of 44 adult females were pregnant. This rate is higher than most populations reported to be below K carrying capacity (Gasaway et al. 1992:6), indicating the population is on a higher plane of nutrition than predicted from density alone.

The observed adult twinning rate (31%) falls within the range (23% to 90%) reported for moose of similar ages from populations below K carrying capacity (Gasaway et al. 1992:Table 5). Twinning occurred in 11 of 35 births of radiocollared adult females ≥ 36 months old, similar to the 32% twinning rate observed in the study area during 1977 and 1978 using identical methods (Gasaway et al. 1983:18). However, during 1977 and 1978 the prehunt Unit 20A moose population was numbered only 3600 to 4400, compared with 12,300 in 1996 (Boertje et al. 1996, ADF&G unpubl data).

This twinning rate is higher than previously reported for Unit 20A using standard spring surveys. Standard spring surveys are biased low because 24-month-old females are included, yet these females rarely twin and are abundant in the population (Boertje et al. 1996, ADF&G unpubl data). Standard spring twinning surveys in our area in 1996 indicated a twinning rate of 18% (n = 40 random females observed with calves ≥ 24 months old), which is probably not significantly different from the above adult twinning rate of 31%. We hope to gather data on twinning and birth rates of known 24-month-olds during spring 1998.

Mean maximum depth of backfat for adults was 1.57 cm (s = 0.40, n = 43), mean midpoint backfat depth was 0.58 cm (s = 0.26, n = 42). These values are less than Stephenson (1995) reported for moose below K carrying capacity on the Copper River Delta during March 1993 and 1994. However, the Copper River Delta has a much milder climate and longer growing season than Unit 20A. Comparable data from Interior Alaska and the Yukon are lacking at this time.

CALF WEIGHTS

Mean adjusted birthweights of collared twin (13.7 kg, $s = 1.9$, $n = 12$) and single (17.8 kg, $s = 3.2$, $n = 31$) calves were significantly different ($P = 0.0003$, one-way analysis of variance). Whereas, mean adjusted weights of collared male (17.9 kg, $s = 3.9$, $n = 14$) and female (16.1 kg, $s = 3.1$, $n = 24$) calves were not significantly different ($P = 0.128$, one-way analysis of variance).

Data from birthweights probably provide a relative index to winter and spring conditions. Working with captive moose on a high plane of nutrition, Schwartz and Hundertmark (1993) reported mean birthweights of 13.5 kg for twin calves and 16.2 kg for single calves < 24 hours old at the Moose Research Center (MRC) on the Kenai Peninsula, Alaska. They also found no significant difference between male and female calf weights. Calves from Unit 20A are slightly heavier than captive moose calves born at the MRC, which indicates winter forage may not be limiting in Unit 20A. However, comparable data on calf weights from Interior Alaska and the Yukon are lacking at this time, making interpretation speculative.

BLOOD PARAMETERS OF CONDITION

The acute phase protein haptoglobin in serum samples may be helpful in distinguishing stressed from nonstressed mammals (Duffy et al. 1993, Zenteno-Savin et al. 1997). No detectable levels of haptoglobin were present in any of our calf ($n = 43$) or adult ($n = 44$) serum samples.

To identify potential relationships between 22 serum constituents (standard blood profile) and backfat depth, we used multiple regression models. A model using creatinine and AST met all the necessary criteria but accounted for only 33.7% (adjusted R^2) of the variability observed. We conclude, at this time, that standard serum constituents are not useful indicators of backfat reserves in moose. More data are forthcoming.

CALVING DATE AND CORRELATIONS WITH COW BACKFAT DEPTH AND AGE

Births ($n = 35$) of radiocollared cows occurred between 12 May and 27 May in 1996, median date of calving was 19 May, and the greatest number of births ($n = 5$) occurred on 20 May. Historical data from this study area indicate these are typical moose calving dates. Only following severe winters with deep snow has calving in this area been delayed until June (ADF&G unpubl data).

If severe winter weather can delay calving or if poor autumn condition delays conception, we would predict an inverse relationship between calving date and spring fat reserves, i.e., cows calving the earliest each year might have the greatest fat reserves. Indeed, a significant ($P = 0.025$) negative relationship (slope = -0.117) existed between calving date and maximum

March backfat depth. More data are needed to confirm this relationship. No significant ($P > 0.05$) relationship existed between calving date and cow age.

ADULT NATURAL MORTALITY AND HARVEST

During the initial 12 months of this study, predators killed 4 (9%) of 44 radiocollared adult female moose. Wolves killed 1 between late April and mid May 1996, 1 during November 1996, and 1 during early March 1997. A grizzly bear killed 1 during June 1996. Additionally, a trapper killed 1 in a wolf snare during January 1997.

Hunters took a minimal harvest of cows in the study area during autumn 1996, during the first legal cow harvest since 1974. We issued 300 drawing permits; 63 cows were reported harvested. We will continue to experiment with distributing and increasing this harvest as long as cows are in good condition and natural mortality is low. The reported bull harvest totaled 594 for a combined reported harvest rate of 5% of the prehunt population. If we multiply reported harvest by 1.15 to account for unreported harvest and mortally wounded moose that were lost (Boertje et al. 1996), the harvest rate totaled 6%. Boertje et al. (1996) reported a 4% average annual harvest rate in Unit 20A during the previous 20 years.

CALF MORTALITY

We observed the highest annual (365 days) survival rate (59%) among Alaska-Yukon moose calf mortality studies conducted to date. Previously reported annual calf survival rates were 19% (Larsen et al. 1989), 25% (Gasaway et al. 1992), 29% (Osborne et al. 1991), 32% (Ballard et al. 1991), and 42% (Franzmann et al. 1980). Predation was the only known cause of death in our study sample, and predation was by far the major cause of death in all previous studies. We examined 13 death sites and attributed 5 deaths to black bears, 4 to grizzly bears, and 4 to wolves.

We collared 46 calves, but 4 died from capture-induced reasons (trampling by dam following release), and we censored these from the data. One transmitter failed within a few weeks of deployment and 1 failed a few months later. We observed only 1 nonpredation, natural mortality during the 1996-1997 field season, a stillborn calf from a set of twins born to an uncollared cow.

RELATIONSHIP BETWEEN ADULT CONDITION AND CALF MORTALITY

Data collected to date support the hypothesis that no relationship exists between dam condition (age or fat reserves) and mortality of their calves. Neither dam age nor fat reserves entered the logistic regression model during any time interval. More data are forthcoming.

RELATIONSHIP BETWEEN NEONATE CONDITION AND CALF MORTALITY

Preliminary data support the hypothesis that twins have higher mortality rates than singletons, as previously reported by Osborne et al. (1991). Protecting 2 calves from predators is likely more difficult than protecting a single calf. For survival from age 1 to 10 days, only sibling status entered the logistic regression model ($P = 0.065$), with a parameter estimate of 2.12, indicating increased mortality of twin calves. For survival intervals between age 11 and 215 days, no variables entered the model. For survival from age 216 to 315 days, birthweight entered the logistic regression model ($P = 0.023$), with a parameter estimate of -11.755, indicating increased mortality of light birthweight calves. Second-year data are forthcoming.

CONCLUSIONS

Considering the favorable weather conditions during this project's first year, more data are needed to confirm the population's apparent high nutritional status. No strong density-dependent effect on nutrition was observed at this time, despite the population's high density. Data from Isle Royale and Norway indicate that moose tend to overshoot the long-term carrying capacity of their range, unless severe weather and predation intervene (Page 1989, Saether et al. 1996). Boertje et al. (1996) concluded that given the wide variation in snow conditions and effects of predation, the concept of a long-term carrying capacity may be inappropriate in this study area.

During 1996-1997 nutritional status seemed high and mortality was insufficient to stabilize or decrease the moose population. ADF&G is actively pursuing prescribed burns in Unit 20A to improve moose habitat, and we will pursue more extensive cow hunts in the near future to increase hunting opportunity if condition and survival of cows remain high. We plan to manage moose yearly, using all available information on condition, survival, and productivity. A primary goal is to provide maximum sustained opportunity to harvest moose and avoid repeated predator control programs. Thus, our priority is to keep the moose density well above levels at which combined wolf and bear predation maintain moose at low densities (Gasaway et al. 1983, 1992).

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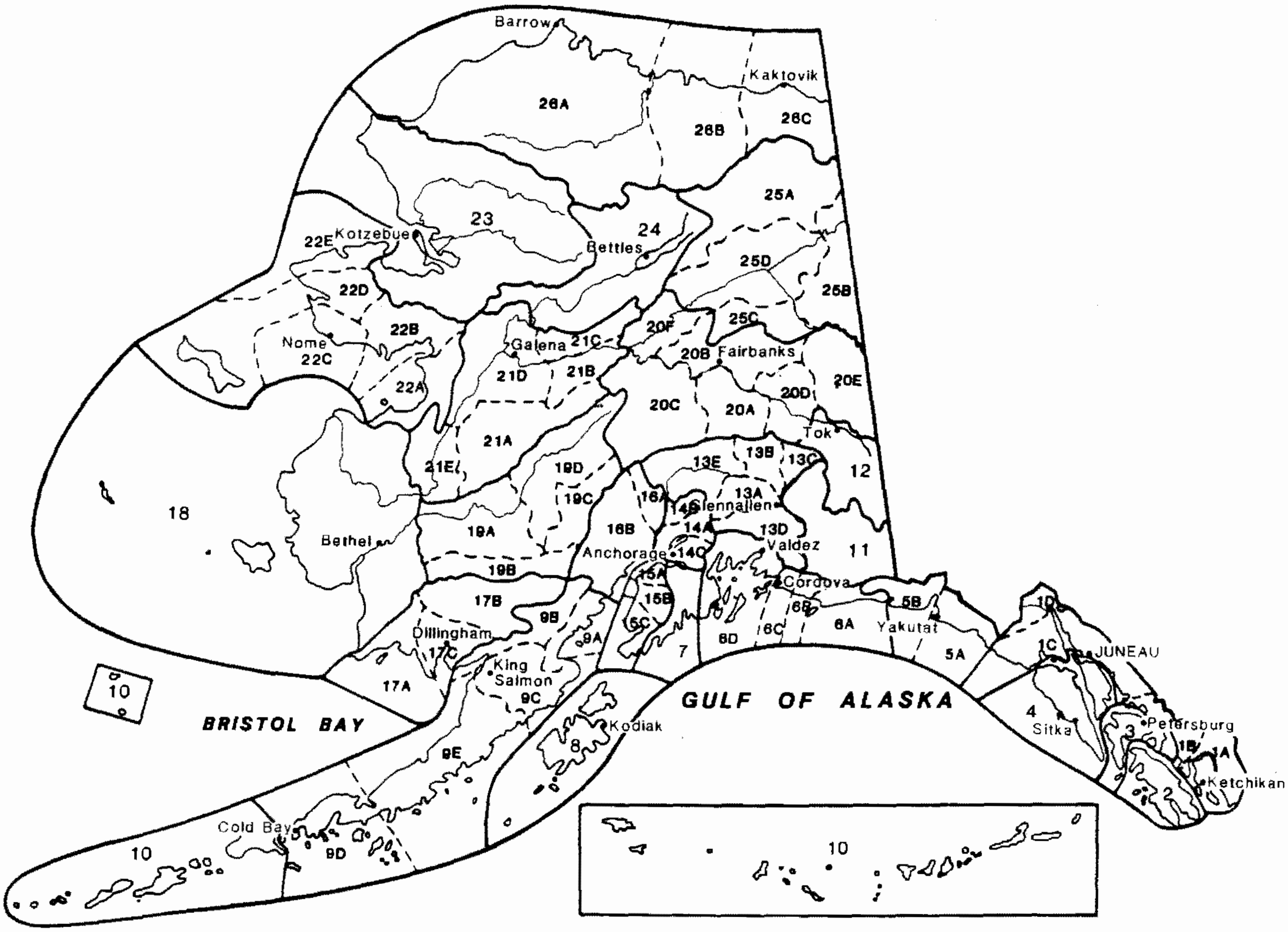
Division of Wildlife Conservation

Alaska's Game Management Units



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 allots funds back to states through a formula based on each state's geographic area and number of paid hunting license holders. Alaska receives a maximum 5% of revenues collected each year. The Alaska Department of Fish and Game uses federal aid funds to help restore, conserve, and manage wild birds and mammals to benefit the public. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes for responsible hunting. Seventy-five percent of the funds for this report are from Federal Aid.

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