Alaska Department of Fish and Game
Division of Wildlife Conservation
August 1993

Testing Socially Acceptable Methods of Managing Caribou Predation—Reducing Predation on Caribou and Moose Neonates by Diversionary Feeding of Predators, Macomb Plateau, 1990–93

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Federal Aid in Wildlife Restoration
Research Final Report
Grants W-23-3, W-23-4, W-23-5, W-24-1
Study 1.40

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FINAL REPORT (RESEARCH)

State: Alaska

Cooperators: Dean Cummings, land and sawmill owner; Alaska Railroad Corporation; U.S. Army-Fort Greely

Project No.: W-23-3, W-23-4, W-23-5, W-24-1

Project Title: Wildlife Research and Management

Study No.: 1.40

Study Title: Testing Socially Acceptable Methods of Managing Predation--Reducing Predation on Caribou and Moose Neonates by Diversionary Feeding of Predators, Macomb Plateau, 1990-93

Period Covered: 1 July 1989-30 June 1993

SUMMARY

The authors initially designed this study to test whether artificial feeding of grizzly bears (*Ursus arctos*), black bears (*Ursus americanus*), and wolves (*Canis lupus*) can reduce predation on newborn moose (*Alces alces*) and/or caribou (*Rangifer tarandus*). If successful, this technique could provide a means to enhance moose or caribou populations without resorting to lethal methods to control predation. The Alaska Department of Fish and Game is obligated to investigate alternatives to lethal predator control because of the high economic, political, and social costs of lethal control. This study was concluded 1 year earlier than scheduled because experimental results indicated that continued study under current environmental conditions would not be cost-effective.

We distributed 26 metric tons of bait from 14 May to 5 June in 1990 and 16 metric tons during the same dates in 1991 in a 1,650-km^2 area on the northern exposure of the eastern Alaska Range, hereafter referred to as the "treated area." Bait consisted largely of train-killed or winter-killed moose unsalvageable for human consumption. During 1992 and 1993 funding was inadequate and we distributed no bait; 1992 served as a control year to document calf survival without treatment.

Bears (mostly grizzly bears) and wolves consumed 79% of the baits by 14 June 1990, as evidenced by disarticulated skeletons and aerial observations of bears and wolves at baits. In 1991, grizzly bear tracks were in evidence at 50% of 30 sites investigated on 3-4 June. Grizzly bears and wolves were common in the treated area.

Treatment apparently resulted in enhanced moose calf survival to November 1990; moose calf survival was the highest recorded (42 calves:100 cows $\geq$2 years old) in the treated area compared with similarly derived 1981-89 pretreatment values (19-38, $\bar{x}$ = 25, SD = 9, n = 8) when winters were less severe. The reduced level of treatment in 1991 did not significantly elevate moose calf survival in the treatment area. Data collected to date suggest that 20 or more metric tons of bait may be necessary to deter predators from preying on newborn moose calves in the 1,650-km^2 treated area.

Other data also suggest the treatment in 1990 increased moose calf survival. For example, elevated 1990 moose calf survival was not widespread. Untreated control moose populations and adjacent, partially treated moose populations experienced low calf survival in 1990 (11-31 calves:100 cows $\geq$2 years old). In contrast, in 1991, one of the untreated control populations experienced higher calf survival than the treated area.

Caribou calf survival was extremely poor following treatment in 1990 and 1991, yet survival was similar to control herds. Caribou calf telemetry studies in the Alaska Range Denali herd indicated that poor environmental conditions favored reduced productivity, increased nonpredation perinatal mortality, and increased predation on adults, which together resulted in population declines in 1990 and 1991 (L. Adams, unpubl. data). Increased wolf numbers also occurred during recent years in Denali National Park, Alaska (T. Meier, National Park Service, pers. commun.). Feeding of predators did not provide a measurable or detectable improvement in Macomb caribou calf survival under these poor environmental conditions.

Further study is recommended when funding levels and environmental conditions are suitable to test this technique in an area where moose are clearly limited by bear predation. A moose calf mortality study should be funded before and during treatment to ascertain if bears are the major predator on moose calves.

We finalized a manuscript during this report period that includes our conclusions. This manuscript was accepted for publication in the *Proceedings of the Second North American Symposium on Wolves* and is entitled "Methods for reducing natural predation on moose in Alaska and the Yukon: an evaluation" (Appendix A). We also prepared a condensed, simplified version of this manuscript for the public (Appendix B).

Key Words: Alaska, baiting, bears, calf survival, calving, caribou, diversionary feeding, feeding, moose, predator-prey relationships, wolves.

CONTENTS

BACKGROUND

Humans manage wildlife populations to influence a desired outcome. For example, humans sometimes desire more ungulates than occur naturally. The elevated numbers of ungulates may be important to help protect habitat from competing land uses and/or to provide for consumptive and/or nonconsumptive uses of wildlife.

Moose (*Alces alces*) populations in much of Alaska and the Yukon are maintained below food-limited densities by predation (Gasaway *et al.* 1992). For example, predation maintains moose populations at chronically low densities where moose are a primary prey of lightly exploited wolf (*Canis lupus*), black bear (*Ursus americanus*), and grizzly bear (*U. arctos*) populations. In areas where wolves and bears were at near-natural densities, the mean density was only 148 moose/1,000 km^2 (n = 20 areas, range = 45-417, SD = 81), compared with a mean of 663 moose/1,000 km^2 (n = 16 areas, range = 169-1,447, SD = 389) in areas where humans maintain wolves and, in some cases, bears below food-limited densities (Gasaway *et al.* 1992).

Apparently moose do not occur at a high-density equilibrium without continued predator management, except where moose are (1) preyed on by only one predator species (Messier and Crete 1985, Crete 1987, Bergerud and Snider 1988, Messier 1988), (2) preyed on by black and grizzly bears (wolves extirpated) with or without alternate ungulate prey (Houston 1968, Bailey 1978, Peterson *et al.* 1984), or (3) minor prey in wolf-bear multiprey systems (Crete 1987, Bergerud and Snider 1988). In Alaska, wolves, moose, and one or both species of bears occupy the same habitats. Caribou (*Rangifer tarandus*) are rarely the primary prey, except in portions of the Brooks Range and arctic coastal plain. Therefore, Alaskan moose populations can be expected to occur at low densities, except where wolf and/or bear populations are strongly manipulated by humans.

To manage for elevated densities of caribou, managers must also counter strong natural processes (Bergerud and Elliot 1986). Although some Alaskan caribou populations have periodically increased with little human intervention (Skoog 1968), caribou population growth is limited at low densities by predation, and increases are temporary (Bergerud 1980, Bergerud and Elliot 1986). Mainland caribou densities (i.e., $\leq$400 caribou/1,000 km^2 in areas where wolves are nearly unexploited) are frequently well below those where food limitation caused a reduction in caribou populations (Bergerud 1980, Skogland 1986).

Reductions in predator populations by the public (e.g., same-day-airborne shooting) and/or the Alaska Department of Fish and Game (ADF&G) have contributed to recent increases in several Alaskan caribou herds (e.g., Nelchina, Delta, and Fortymile) (Gasaway *et al.* 1983, Ballard *et al.* 1987, Boertje *et al.* 1987, Valkenburg and Davis 1988). Recent controversy over these methods highlights the need for socially acceptable alternatives to lethal control if moderate caribou densities are to be maintained.

The Division of Wildlife Conservation is obligated to provide for the long-term conservation of large carnivore populations throughout Alaska as well as to reduce the controversy surrounding management of large carnivores. The division established a framework for citizen involvement in developing a strategic wolf management plan. Evaluating more nonlethal ways to manage predator-prey relationships is integral to this process in areas where the public has requested that ungulate-predator systems be managed for increased human use of ungulates (Boertje *et al.*, in press).

Several alternatives to intense, lethal, government-conducted or public predator control have been proposed for managing predator-prey relationships (Gasaway *et al.* 1992; Boertje *et al.*, in press). This study assesses if, and to what extent, diversionary feeding of predators reduces predation and facilitates management of caribou-moose-predator relationships.

Preliminary evidence indicates that diversionary feeding of predators may increase survival of caribou and/or moose neonates. During May and June 1985, we air-dropped approximately 12-15 tons of train-killed moose and scrap meat to attract grizzly bears for collaring purposes in and near Mosquito Flats, an important moose calving area north of Tok. We observed that grizzly bears, wolves, and black bears consumed much of this meat and that fall moose calf:cow ratios were higher than normal. The 1985 early winter calf:cow ratio was 53:100 (n = 17 cows), compared with a range of 11-15:100 (n = 26-39) during the 3 preceding years and a range of 26-36:100 (n = 25-27) during 1986 and 1987. Also, the 1985 response was not observed in untreated adjacent areas (10-19:100, n = 25-70); however, some of the increase in calf survival may have resulted from immobilization and slow recovery of bears (4-5 days), rather than the introduction of meat.

Other circumstantial evidence also suggests that diversionary feeding for 1 month during and immediately following the calving season may increase caribou and moose calf survival. Most mortalities among caribou and moose populations in central and southern Alaska and the Yukon occur on neonates during the first 2-3 weeks of life.

Predation is the major cause of these mortalities (Franzmann *et al.* 1980; Ballard *et al.* 1981; Boertje *et al.* 1987, 1988; Adams *et al.* 1988; Larsen *et al.* 1989).

The Macomb caribou herd has been small ($\leq$800 caribou, 200 caribou/1,000 km^2) for 2 decades or more, yet management goals for the herd call for increasing the herd to 1,000-1,500 caribou by 1997. The herd's location along the road system makes it ideally suited to this study. Substantial public benefits would be incurred from increased caribou, moose, and wolves in this area. Following intensive wolf removal during winter 1980-81, the herd grew from 500-600 caribou to about 800 during October 1988. Calf mortality has remained high since wolf removal ceased. Causes and chronology of this mortality are probably similar to those recently documented in the Denali caribou herd where grizzly bears and wolves killed about 39% of the collared calves by 1 June during 1984-88 (Adams *et al.* 1988).

OBJECTIVES

Objectives for this study were to:

1. Estimate the change in survival of neonatal moose and density of the moose population resulting from diversionary feeding of wolves and bears on and adjacent to the Macomb Plateau from 1990 to 1993.

2. Estimate the changes in the survival of neonatal caribou and size of the caribou population resulting from diversionary feeding of wolves, bears, golden eagles (*Aquila chrysaetos*), and bald eagles (*Haliaeetus leucocephalus*) on and adjacent to the Macomb Plateau from 1990 to 1993.

STUDY AREA

We distributed food for predators in a 1,650-km^2 portion of the Alaska Range and adjacent lowlands between elevations of 400 m and 1,550 m (Fig. 1). This treated area includes the calving ground of the Macomb caribou herd and portions of the Knob Ridge and Robertson River moose calving grounds. The treated area is centered around 63° 35'N latitude and 144° 30'E longitude (Figs. 1, 2).

We used two moose populations as controls in this study. The Central Creek population is 80 km north of the treated area, and the eastern Subunit 20E population is 120 km east. Caribou herds used as controls include the Denali herd which is 290 km west of the treated area and the Delta herd which is 160 km west. The Macomb, Denali, and Delta herds share the northern slopes of the Alaska Range.

A subarctic, continental climate occurs in the treated and control areas. "Winter" occurs from October through April. Leaves emerged on most shrubs on the Macomb Plateau during 26-27 May 1990 and 15-20 June 1991, and leaves usually fall in late August. Total annual precipitation averages 24 cm at Tok, 60 km east of the plateau (National Oceanic and Atmospheric Administration 1986).

Wolves, black bears, and grizzly bears occur at near-natural densities in the treated and control areas; i.e., predator-prey relationships had not been strongly manipulated by humans during the 8-9 years before this study. One exception is that grizzly bear density has been reduced by harvest in recent years in the Delta herd's range (Reynolds and Boudreau 1992). Moose, caribou, and Dall sheep (*Ovis dalli*) are the major prey in the treated and control areas, except the Central Creek and eastern Subunit 20E areas where there are no sheep. Minor prey in these areas include snowshoe hares (*Lepus americanus*), beavers (*Castor canadensis*), hoary marmots (*Marmota caligata*), and, except in the Central Creek and eastern Subunit 20E control areas, arctic ground squirrels (*Citellus parryii*). Snowshoe hare abundance has been relatively low in these areas since the early 1970s.

METHODS

Carcass Collection and Storage

During winter 1989-90, 26 metric tons of bait were collected. The Alaska Railroad Corporation collected 60 train-killed moose, using a crane or ditcher mounted on a railroad car. These carcasses were stored in the town of Willow until they could be transported to Cummings' Sawmill near Delta Junction (Fig. 1). We collected an additional 30 unsalvageable carcasses near Delta Junction and Fairbanks; most of these carcasses were winter-killed moose calves. About 4% of the bait were spawned red salmon carcasses collected from the Paxson Hatchery; carcasses were frozen and stored in Fairbanks until April. Upon arrival at the sawmill (Jan-Apr 1990), bait was covered with sawdust for cold storage until distribution.

During winter 1990-91, 16 metric tons of bait were collected. Most of this bait consisted of unsalvageable starved or road-killed moose collected in and around Fairbanks by a local volunteer organization, the Moose Mobile. In addition, the Alaska Railroad Corporation collected several unsalvageable train-killed moose. Twenty adult and 43 calf moose carcasses were collected by these two methods. Less than 5% of the bait consisted of outdated, unsalvageable dog food contributed by Kobuk Feed Company of Fairbanks. Carcasses were stored at Cummings' Sawmill under sawdust from April until distribution in May and early June.

Bait Distribution and Use Monitoring

During 1990, bait (n = 87 baits, $\bar{x}$ = 300 kg) was distributed using Army UH-1 helicopters (40 flight hours) on 14 and 15 May (n = 29 baits), 21 and 22 May (n = 25 baits), and 30 May 1990 (n = 33 baits). We baited in a 1,650-km^2 area around Macomb Plateau near calving caribou and moose (Fig. 1). To aid in relocating the carcasses later, we directed the helicopters to each bait site using light fixed-wing aircraft (Bellanca Scout or Piper Super Cub). One bait was deposited at each site (n = 61 sites) and replenished as necessary during successive baiting periods; some sites received up to three baits (Fig. 1).

To monitor 1990 bait use, we made several low passes over bait sites using light fixed-wing aircraft at 4- to 10-day intervals through 14 June. We deemed a bait "largely consumed" when it was over 50% gone. In a large majority of these cases, only hair and scattered bones remained, but in a few cases hides and a low percentage (<20%) of meat remained.

In 1991, we distributed bait (n = 68 baits, $\bar{x}$ = 256 kg) using ADF&G equipment, including a DeHavilland Beaver aircraft, riverboat, and 4x4 pickup truck. Baits were distributed 14-17 May (n = 16), 21-24 May (n = 28), 28-31 May (n = 20), and 5 June (n = 4) in the 1,650-km^2 treated area (Fig. 2). We monitored bait use along the Alaska Highway and Tanana River before distributing new baits. Some sites (n = 43 total) received up to three baits (Fig. 2).

Between 15 and 30 May 1991, we distributed chemical scents throughout the treated area at weekly intervals to distract predators from preying on calves. We used skunk essence and Carman's Canine Call Lure (CCCL) and distributed the scents on rocks (*n* = 67) and cotton-tipped arrows (*n* = 85) along the Alaska Highway and Tanana River. We also placed about 4 cc of CCCL and 10 cc of water in water balloons (*n* = 94) and distributed these across the subalpine portions of the treated area using a DeHavilland Beaver aircraft. In addition, scent was placed adjacent to carcass sites along the Alaska Highway and Tanana River (*n* = 25, Fig. 2).

Monitoring Moose Calf Survival

Between 18 October and 3 December 1990, 1991, and 1992, we flew moose surveys in the Knob Ridge treated area, the upper Robertson River partially treated area, and the Central Creek and eastern Subunit 20E control areas. The Knob Ridge survey area was 181 km^2 and the Central Creek area 161 km^2, and each was flown at 1.5 to 1.9 min/km^2 as prescribed by Gasaway *et al.* (1986). In contrast, the Robertson River (350 km^2) and eastern Subunit 20E (900 km^2) survey areas were much larger and flown less intensively, about 0.8 min/km^2.

Monitoring Caribou Pregnancy and Survival

1990 Methodology:

Using a Piper Super Cub and Bellanca Scout, we examined the 18 adult ($\geq$3 years old) radio-collared Macomb caribou on 14 and 20 May for evidence of pregnancy; i.e., retention of antlers and presence of distended udders. Pregnant collared caribou were radio-tracked after 20 May at 2- to 6-day intervals through 8 June to determine calving distribution and survival of calves. Using a Hughes 500 helicopter, we classified 600 caribou on 14 June and 734 on 9 October. Caribou were classified as either calves, females $\geq$1 year old, or males $\geq$1 year old.

1991 Methodology:

Using a Piper Super Cub, we examined 16 radio-collared Macomb caribou for evidence of pregnancy or newborn calves on 16, 21, and 23 May and 11 June. We also used a Hughes 500 helicopter on 11 June to classify 319 caribou and on 25 September to classify 560 caribou.

1992 Methodology:

Using an R22 helicopter and Bellanca Scout, we classified 455 caribou on 26 September.

RESULTS AND DISCUSSION

Consumption of Bait

Most observations on bait consumption occurred during 1990. Scavengers largely consumed 76 (88%) of the 87 baits by 14 June 1990 (Fig. 3). Approximately 45-50% of the baits were largely consumed within 10 days of distribution, and an additional 30-40% were consumed during the following 10 days. Bears (mostly grizzly bears) and wolves consumed 79% of the baits, as evidenced by disarticulated moose skeletons and observations of bears and wolves at baits. Removal and/or burial of baits occurred at 44% of the 87 drop sites, indicating grizzly or black bear use; however, because bears did not always move or bury baits, they may have consumed >44% of the baits. We estimated that golden and bald eagles consumed about 9% of the baits. During 1991, we observed grizzly bear sign at 15 of 30 sites checked on 3-4 June. Black bears, wolves, and eagles were minor scavengers at several of these sites.

Predator Densities

Grizzly bears and wolves are common in the treated area. In 1990, 13 different grizzly bears $\geq$2 years old were observed in a 1,000-km^2 area on and adjacent to the Macomb Plateau (eight adult bears, four 3-year-olds, and one 2-year-old). This is a high density for grizzly bears in the Alaska Range (Reynolds and Boudreau 1992) and adjacent Fortymile River drainage (Boertje *et al.* 1987).

We estimated 19 wolves ranged within the treated area in fall 1989, 25 in fall 1990, 16 in fall 1991, and 40 in fall 1992. Ten percent of these were single wolves (Mech 1973). The wolves ranged over a 2,000- to 2,500-km^2 area, indicating a high wolf density relative to adjacent areas (Gasaway *et al.* 1992). One pack member was radio-collared in April 1990 to help distinguish packs in the study area; this wolf was shot in March 1991.

Moose Calf Survival

Treatment with 26 metric tons of bait in May and June 1990 resulted in enhanced moose calf survival to November 1990; moose calf survival was the highest recorded (42 calves:100 cows $\geq$2 years old) in the treated area compared with similarly derived 1981-89 pretreatment values (19-38, $\bar{x}$ = 25, SD = 9, n = 8) when winters were less severe (Table 1). In contrast, following treatment with 16 metric tons in May and June 1991, only 32 calves:100 cows $\geq$2 years old survived to November 1991. We conclude that 16 metric tons of bait may have been insufficient to elicit a response in calf survival.

Other data also suggest the 1990 bait treatment increased moose calf survival. For example, elevated 1990 moose calf survival was not widespread (Table 1). Untreated control moose populations and adjacent, partially treated moose populations experienced low calf survival in 1990 (11-31 calves:100 cows $\geq$2 years old). In contrast, in 1991 one untreated control population experienced higher calf survival than the treated area. No trend in density of the treated moose population was apparent during this study.

Caribou Calf Survival

Caribou calf survival declined significantly beginning in 1990 in several Alaska Range herds, including the Macomb herd. Caribou calf survival remained low in 1991 and 1992 (Table 2). Diversionary feeding of predators in 1990 and 1991 failed to improve Macomb caribou calf survival compared with pretreatment years and controls. In 1990, 15 (83%) of 18 collared female caribou $\geq$3 years old were pregnant and 12 calves (80%) survived to 8 June (Fig. 3). These data suggest good survival rates; however, 1990 calf survival in the herd was poor (about 50% survival by 14 June, 32 calves:100 females, n = 600; Boertje *et al.* 1990). In 1991, 10 (83%) of 12 collared female caribou $\geq$3 years old were pregnant, but only 1 of the 10 calves was alive on 12 June. Calf survival in the herd was estimated at 25% on 12 June 1991 (64 calves:100 females $\geq$1 year old born and 16 calves:100 females alive on 12 June, n = 319).

Mortality studies of radio-collared caribou calves in the Alaska Range Denali herd indicate that calf birth weights declined during 1990 and 1991 possibly because of drier summers and/or deeper than average snowfall (L. Adams, unpubl. data). Average age of first reproduction also increased in the Denali herd. These poor conditions for caribou favored increased wolf numbers (T. Meier, U.S. National Park Service, pers. commun.). Initial declines in caribou numbers caused by poor environmental conditions can be exacerbated quickly by elevated wolf numbers and wolf predation. Prolonged accelerated declines in caribou often follow adverse weather because wolf numbers are slow to decline (predator lag), and therefore the same number of wolves are feeding on fewer caribou for several consecutive years. Predation management using diversionary feeding appears incapable of reversing this declining trend in Macomb caribou numbers. The Macomb herd declined from about 850 in fall 1988 to 550 in fall 1992.

CONCLUSIONS

Our evaluation of diversionary feeding as a management tool is summarized in Appendix A. Diversionary feeding appears to hold promise as a tool to reduce bear predation on moose calves, but costs may be prohibitively expensive. Commercial bear food costs may total about $40,000 for annual treatment of a 2,000-km^2 area, and these costs currently prohibit intensive testing of this technique. Collaring moose calves to evaluate the effects of diversionary feeding is currently cost-prohibitive. Under current conditions, diversionary feeding is insufficient to reverse the decline in the Macomb caribou herd.

RECOMMENDATIONS

We recommend further evaluation of diversionary feeding when funding levels and environmental conditions are suitable for testing this technique in an area where moose are clearly limited by bear predation. Investigations of the causes of moose calf mortality using collared calves should precede studies of diversionary feeding, and mortality studies should be conducted simultaneous to diversionary feeding. This study was concluded 1 year earlier than scheduled because experimental results indicated that continued study under current environmental conditions would not be cost-effective.

ACKNOWLEDGMENTS

We are indebted to the following for their contribution to this study. The Alaska Railroad Corporation graciously collected moose carcasses for this study during 1990 and 1991. In addition, a volunteer group in Fairbanks, the Moose Mobile, collected a large majority of the carcasses during 1991. Highway transportation of carcasses was provided by H. Sanders of Delta Junction and D. Lambert of ADF&G. The Cummings family of Delta Junction provided technical support for the unloading, loading, and cold-storing of carcasses. The U.S. Army 72nd Light Infantry Division of Fort Greely provided about 40 hours each of ground and aerial support during 1990 for the transportation of carcasses to the study area and technical support for the development of appropriate slings for carrying the carcasses. Aerial support supplemented Army training exercises. Military pilots R. Pickard and R. Pappa deserve special recognition. Civilian pilots who assisted with the project included J. Musgrove, D. Miller, and R. Warbelow. The 1990 field camp was supervised by E. Lenart and included A. Kennedy, D. Arnet, and R. DeLong. M. Keech and E. Lenart assisted with the distribution of baits and chemical scents during 1991. D. Reed provided statistical and editorial comments. Funding was provided by Federal Aid in Wildlife Restoration Projects and the Alaska Department of Fish and Game.

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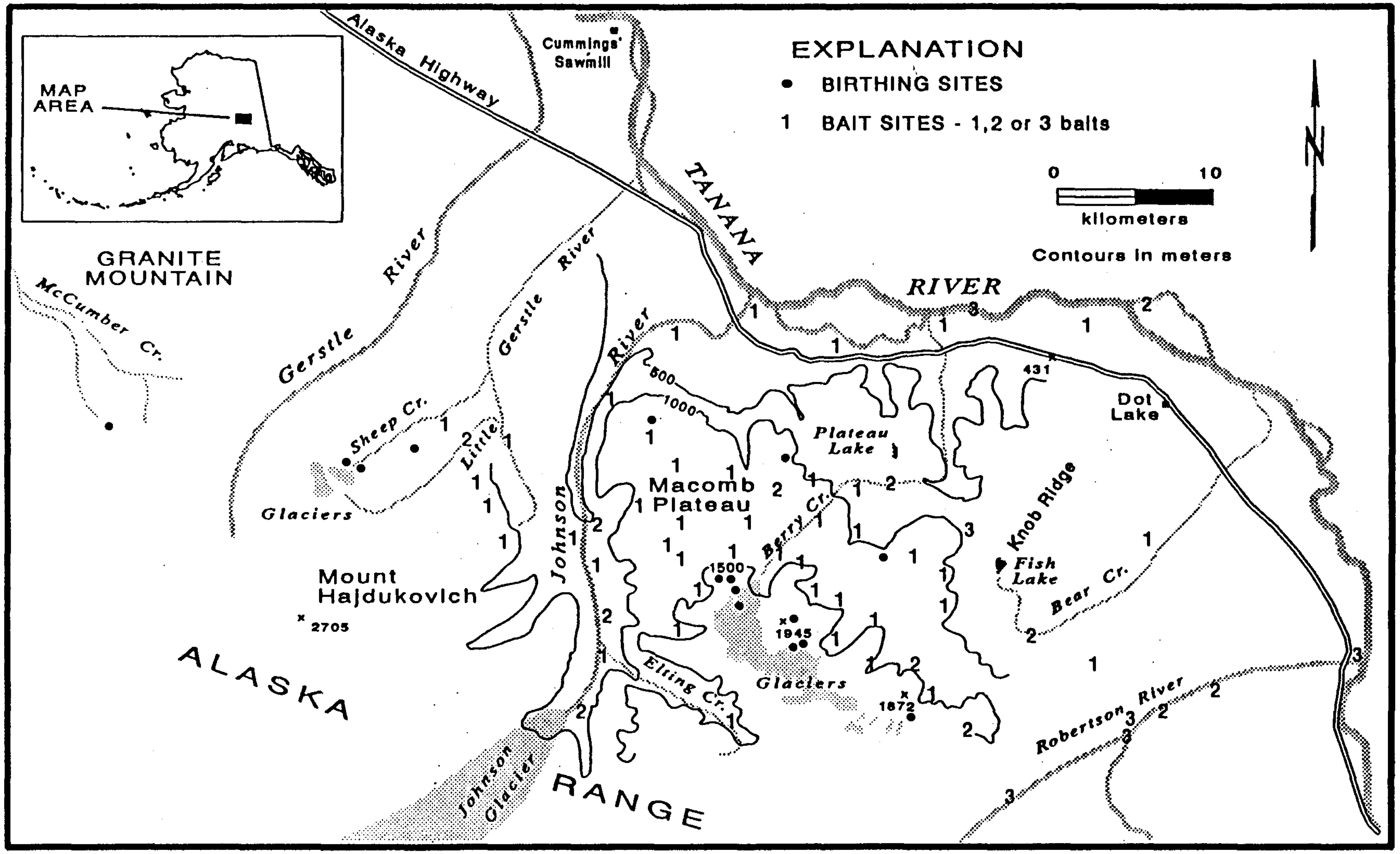

Figure 1. Birthing sites (.) of 15 adult radio-collared Macomb caribou and location of bait sites (1, 2, or 3 baits), eastcentral Alaska, May 1990. Bait sites (n = 61) were replenished up to 3 times at weekly intervals (n = 87 baits, x = 300 kg).

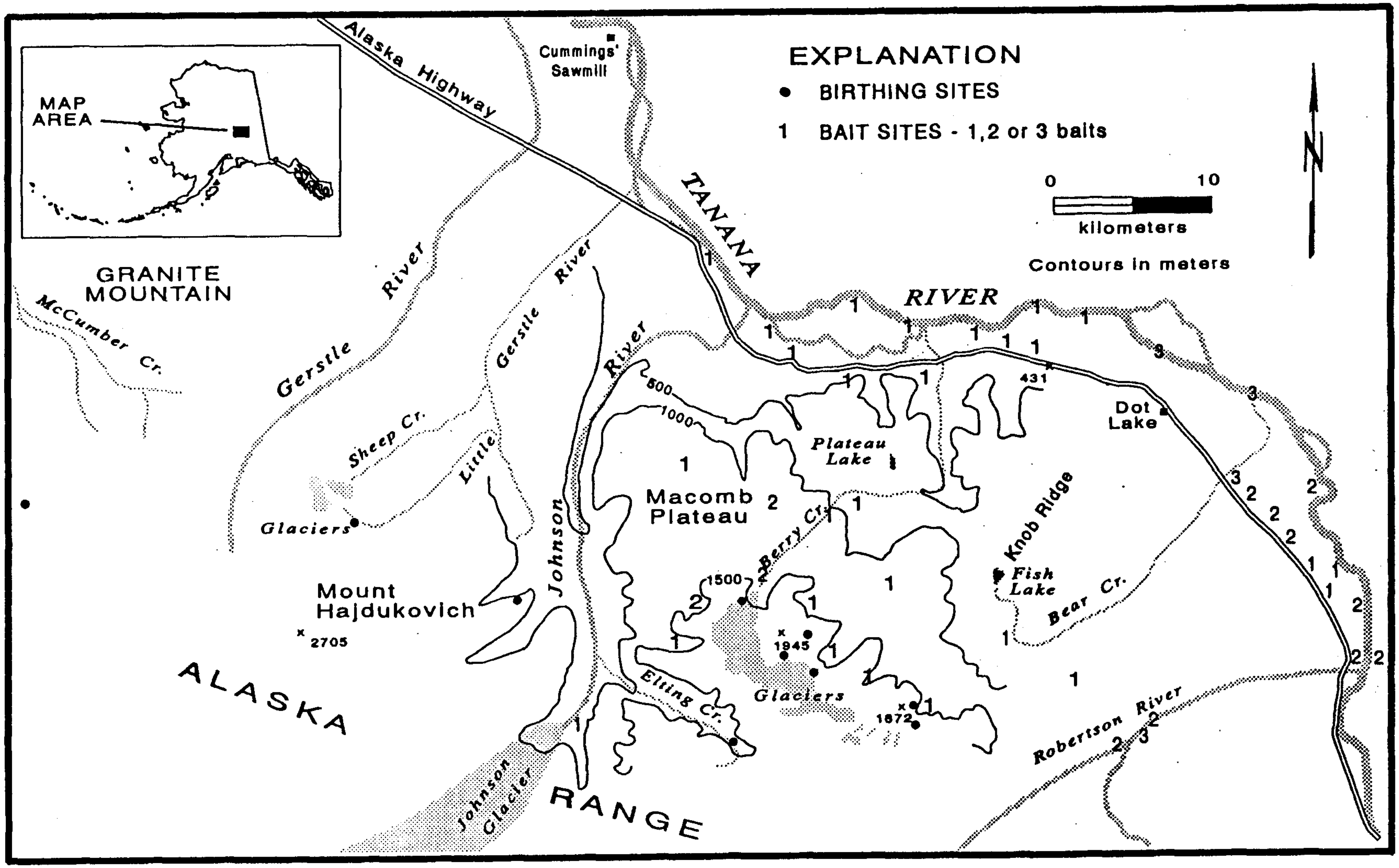

Figure 2. Birthing sites (.) of 10 adult radio-collared Macomb caribou and location of bait sites (1, 2, or 3 baits), eastcentral Alaska, May and June 1991. Bait sites (n = 43) were replenished up to 3 times at weekly intervals (n = 68 baits, x = 256 kg).

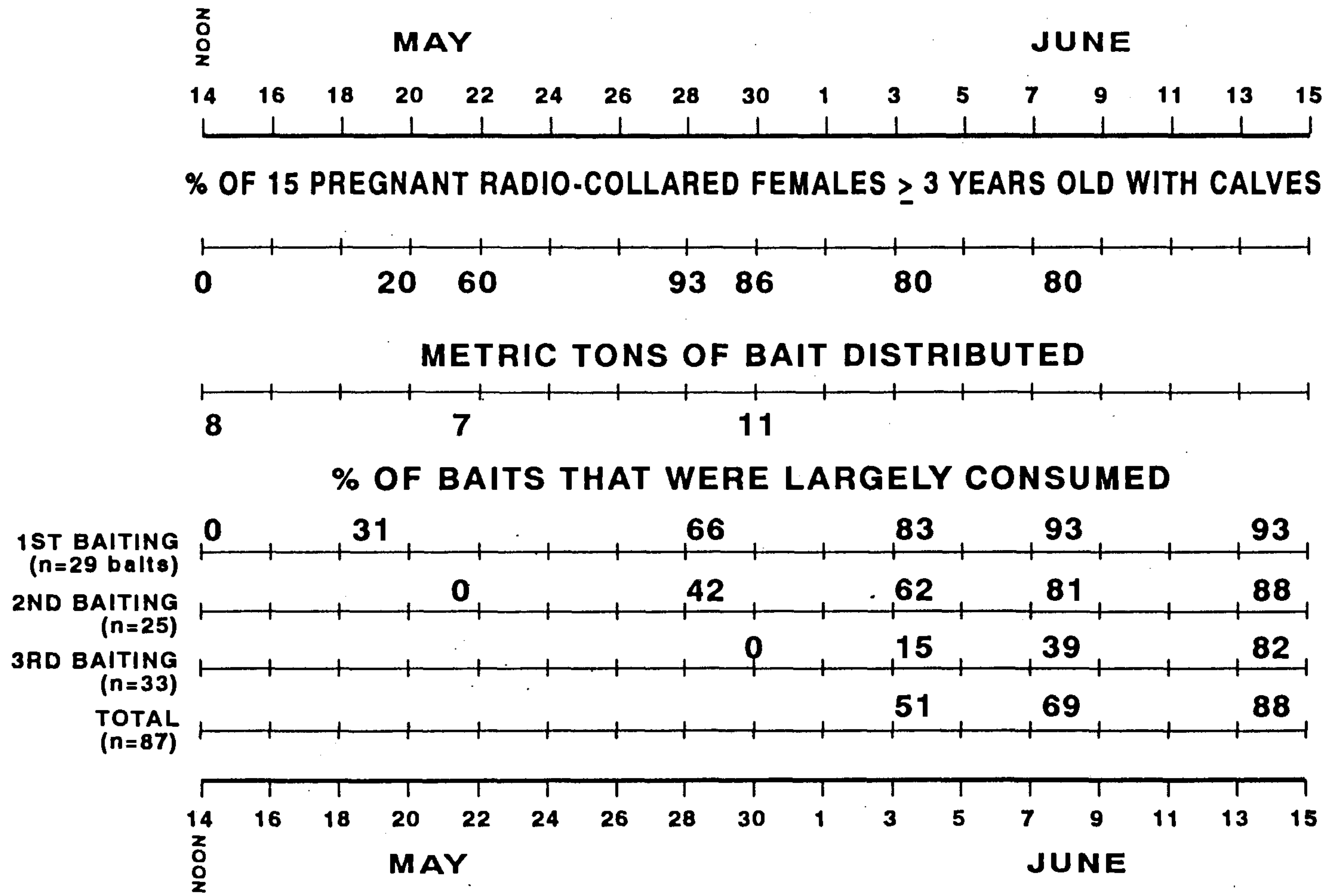

Figure 3. Chronology of caribou calving, calf survival of collared adults, baiting, and consumption of baits on and near the Macomb Plateau, eastcentral Alaska, 1990.

Table 1. Calves:100 cow moose ≥2 years old in the treated, partially treated, and control survey areas during October to December, 1981-92, eastcentral Alaska. Dashes indicate no data were collected.

	Treated area		Partially treated area		Control areas			
	Knob Ridge		Robertson River		Central Creek		Subunit 20E East	
Year	Calves:100 females ≥2 yrs old	No. females ≥2 yrs old	Calves:100 females ≥2 yrs old	No. females ≥2 yrs old	Calves:100 females ≥2 yrs old	No. females ≥2 yrs old	Calves:100 females ≥2 yrs old	No. females ≥2 yrs old
<u>Pre-treatment</u>								
1981	19	31	--	--	--	--	--	--
1982	19	51	16	43	--	--	--	--
1983	34	35	--	--	11	37	--	--
1984	31	64	14	49	12	52	--	--
1985	20	51	26	19	27	52	17	133
1986	12	75	28	78	--	--	29	146
1987	--	--	--	--	--	--	24	142
1988	29	79	48	71	13	90	23	144
1989	38	66	15	89	21	85	--	--
<u>Treated</u>								
1990	42	86	31	67	11	85	27	204
1991	32	100	36	83	16	58	37	225
<u>Post-treatment</u>								
1992	18	60	42	78	5	69	33	97

Table 2. Calves:100 cow caribou $\geq$1 year old in the Macomb, Delta, and Denali herds during September-November 1981-92, Alaska Range. Dashes indicate no data were collected.

	Treated herd		Control herds			
	Macomb		Delta		Denali	
Year	Calves: 100 cows	*n*	Calves: 100 cows	*n*	Calves: 100 cows	*n*
Pre-treatment						
1981	33	445	41	1,451	--	--
1982	26	217	31	1,565	--	--
1983	24	238	46	1,208	--	--
1984	40	351	36	1,093	41	1,608
1985	31	518	36	1,164	28	1,205
1986	--	--	29	1,934	38	1,062
1987	--	--	31	1,682	37	1,221
1988	32	671	35	3,003	33	1,350
1989	34	617	36	1,965	30	1,504
Treated						
1990	17	734	17	2,411	17	1,307
1991	9	560	8	764	7	1,548
Post-treatment						
1992	14	455	11	1,240	16	1,028

APPENDIX A. Paper submitted for publication in the Proceedings of the Second North American Symposium on Wolves, Edmonton, Alberta, August 1992. Edited by L. N. Carbyn and D. Seip (with minor format changes for presentation in this report).

METHODS FOR REDUCING NATURAL PREDATION ON MOOSE IN ALASKA AND THE YUKON: AN EVALUATION

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Abstract: We compared several proposed and current methods of reducing natural predation on moose (*Alces alces*). These included: (i) artificial or "diversionary" feeding of grizzly bears (*Ursus arctos*) or black bears (*U. americanus*) during calving, (ii) enhancing moose habitat, (iii) allowing increases in alternate prey, (iv) reducing predator birth rates, (v) conventional public hunting and trapping of predators, and (vi) aircraft-assisted wolf (*Canis lupus*) harvest. We ranked each method as low, moderate, or high in terms of relative effectiveness in elevating predation-limited moose populations, social acceptability, cost-effectiveness, and ease of implementation.

Diversionary feeding of bears ranked moderate to high in all categories, except in terms of cost-effectiveness. Enhancing moose habitat ranked high in terms of social acceptability and moderate in terms of biological effectiveness, but cost-effective tools are needed. Allowing increases in alternate prey (i.e., caribou [*Rangifer tarandus*]) and reducing wolf birth rates ranked low in terms of biological effectiveness and ease of implementation. Before reducing wolf birth rates, cost-effective, safe, species-specific, and socially acceptable tools need to be developed. Conventional public hunting of bears received high ratings in all categories. Aircraft-assisted wolf harvest also received high ratings, except in terms of social acceptability. A management strategy for reducing predation is outlined.

Introduction

Controlling numbers of wolves, black bears, and/or grizzly bears to enhance moose populations is a biologically sound management strategy when predation is a major limiting factor and moose are below food-limited densities (Gasaway *et al.* 1983, 1992; Ballard and Larsen 1987, Crete 1987, Van Ballenberghe 1987, Bergerud and Snider 1988). Subarctic wolf-bear-moose systems occurring after effective predator control have higher densities of moose. Also, these systems can support higher hunter harvests than similar systems without predator control (Gasaway *et al.* 1992). We believe that the long-term viability of wolf and bear populations can be safely protected while practicing localized predator control.

To reduce controversy over predator control, Gasaway *et al.* (1992) listed 5 alternatives to lethal agency predator control, and recommended that they be evaluated. We attempt this task with the goal of directing future predator-control research and management. We evaluated 6 methods of controlling wolf and/or bear predation: (i) artificial or "diversionary" feeding of bears during calving, (ii) enhancing moose habitat, (iii) allowing increases in alternate prey, (iv) reducing predator birth rates, (v) conventional public harvest of predators, and (vi) aircraft-assisted wolf harvest. Details are provided where these techniques are specific to bears or wolves.

Methods

Evaluations were based on 4 criteria:

(i) How biologically effective will the technique be in elevating low-density, predator-limited moose populations or reversing predator-driven declines in moose (Gasaway *et al.* 1983, 1992)? Substantial population control will be needed in these cases (e.g., reducing the pre-control spring wolf population by 60-85% annually for 4 to 6 years [Gasaway *et al.* 1983, Farnell and Hayes, in prep.] or an equivalent impact on predation rates). Less intensive predator control is often sufficient to maintain moose at high densities (Gasaway *et al.* 1992), but this less intensive control is more difficult to implement because no immediate problem is apparent.

(ii) Are the methods socially acceptable? Social acceptance was evaluated in terms of the likelihood of gaining the political and public support necessary to implement a specific method (Archibald *et al.* 1991).

(iii) What is the relative, expected cost-effectiveness of the technique in terms of agency logistical operating costs? Other associated costs were not considered.

(iv) Disregarding social acceptability, can the technique be easily implemented as the demand arises? Managers must have means for achieving population-management objectives. Without accessible tools, managers will fail to meet time-specific objectives and will lose credibility.

Evaluation of techniques

Artificial or "diversionary" feeding of bears during calving

Feeding bears can potentially increase moose numbers where moose are major prey of bears. High bear predation rates (40-58%) have been documented in all Alaska and Yukon studies of radio-collared moose calves (Boertje *et al.* 1987, Larsen *et al.* 1989, Schwartz and Franzmann 1989, Ballard *et al.* 1991). This predation occurs even when moose are well-nourished (Gasaway *et al.* 1992). Baits can be used to attract bears, because bears are efficient scavengers. Artificial feeding (hereafter "diversionary" feeding) of bears during moose calving diverts bears from killing calves and enhances calf survival through spring. Bears kill relatively few moose calves after spring (Boertje *et al.* 1988).

There are 3 studies where bears and wolves were artificially fed during moose calving and where subsequent moose calf survival was monitored. During May and June 1985, Boertje *et al.* (1987) air-dropped 12 metric tons of moose carcasses and scrap meat in a 1,000-km^2 area to attract bears for collaring in and around a concentrated moose calving area in east-central Alaska. They observed evidence of grizzly bears, black bears, and wolves feeding at carcass sites. The early winter 1985 calf:cow ratio increased to 53:100 (n = 17 cows) compared with 11-15:100 (n = 26-39, P < 0.005; Chi Square Test of Independence) during the preceding 3 years and 26-36:100 (n = 25-27, P < 0.10) during the following 2 years when baits were not available to predators. The 1985 response was not evident in 3 untreated adjacent areas (10-19:100, n = 25-70, P < 0.005). Although these results imply that diversionary feeding resulted in increased calf:cow ratios, some increase could have resulted from the slow recovery of bears (4-5 days) immobilized with drugs.

In 1990, Boertje *et al.* (1990) tested whether diversionary feeding of bears and wolves could improve moose calf:cow ratios in a different 1,650-km² study area in east-central Alaska. Twenty-six metric tons of moose carcasses (n = 87 baits at 61 sites, $\bar{x}$ = 300 kg) were distributed in 3 equal proportions 14-15 May, 21-22 May, and 30 May. Median calving date was 21 May. Bears (mostly grizzly bears) and wolves consumed 79% of the baits by 14 June. This was evidenced by disarticulated skeletons and incidental observations of both bears and wolves consuming baits. Moose calf:cow ratios increased significantly (P < 0.005) during early winter 1990 (42 calves:100 cows 29 months, n = 86 cows) compared with 8 prior years ($\bar{x}$ = 25, range = 12-38:100, n = 51-75) and 1990 untreated sites (11-27:100, n = 85-204).

In 1991, the experiment was repeated in the same 1,650-km² study area with only 16 metric tons of moose carcasses (Boertje *et al.* 1992*a*). During early winter 1991, moose ratios were 32 calves:100 cows 29 months (n = 100) in the treated area, compared with 16-37:100 (n = 58-225) in untreated adjacent areas. The smaller amount of bait may have been insufficient to significantly enhance calf survival, considering the size of the area and number of bears present.

Biologists in the state of Washington have 6 years of experience with diversionary feeding of black bears to protect forest plantations (Ziegltrum 1990). A commercial bear ration was developed and field-tested. Feeding has partially replaced lethal control of bears. Bears were fed a complete, sugar-based pelleted ration *ad libitum* from mid-March through June to divert bears from stripping bark and feeding on exposed sapwood. Feeding proved more cost-effective and more socially acceptable than lethal control of bears. The program has been expanded each year.

Despite success with diversionary feeding, this technique ranked moderately effective as a predator-management tool (Table 1) for 2 reasons. First, diversionary feeding could increase predator numbers by enhancing predator physical condition, productivity, and juvenile survival, and by temporarily attracting predators from adjacent areas. This would confound predator-prey management problems. Feeding could occur for only 3 to 4 weeks to minimize effects on predators and maximize benefits to moose. Also, feeding levels could be adjusted to merely supplant the nutrition naturally obtained from killing neonates, if studies experimented with different levels of preferred food.

Second, although feeding can be successful in reducing early bear predation on moose calves, wolves may compensate with increased predation later in the year. For example, Hayes *et al.* (1991) found that wolves removed 64% of the moose calves in a low-density population during each of 2 winters in the southern Yukon. However, most studies have documented that most moose mortality occurs during the first 3 weeks of life (Boertje *et al.* 1987, 1988; Larsen *et al.* 1989, Ballard *et al.* 1991).

Diversionary feeding ranked high in social acceptability (Table 1) because no killing of predators was involved (Arthur *et al.* 1977). Public attitudes have been favorable in Alaska when predators were fed moose carcasses. Disfavor may arise if costly commercial food sources are used. Disfavor may also arise if bears are perceived as conditioned or dependent on the feeding program, therefore feeding time should be minimal (3-4 weeks).

Diversionary feeding was ranked low in cost-effectiveness and moderate in terms of ease of implementation (Table 1). It is expensive and difficult to acquire, store, and distribute bait that is environmentally safe, socially acceptable, inexpensive, and effective. Local availability of suitable bait may determine the choice of foods. Commercial bear food (e.g., from Washington at $2/kg) may be too expensive unless manufactured close to delivery sites. Twenty metric tons of bait were needed to divert grizzly bears (16 bears/1,000 km², [Boertje *et al.* 1987]) from moose calves in a 1,650-km² area in east-central Alaska. Using commercial food sources, annual bait costs ($40,000 plus transportation costs) would exceed agency operational costs for aircraft-assisted wolf control ($15,000) in the same 1,650-km² area. Transportation costs would escalate if offroad areas were selected for feeding programs.

In the 1985 (Boertje *et al.* 1987) and 1990 (Boertje *et al.* 1990) programs, train-killed moose were collected during winter at the railroad's expense. These moose were stored under sawdust and distributed at the U.S. military's expense during helicopter training missions. In 1991, starved moose and those killed by traffic were collected by volunteer groups in Fairbanks, Alaska (Boertje *et al.* 1992*a*). Moose were distributed using Alaska Department of Fish and Game (ADF&G) vehicles, a DeHavilland Beaver aircraft, and a riverboat. These subsidized operations were affordable ($4,000 to $9,000 per year), but large numbers of moose carcasses are seldom available. Alternative foods need to be tested. Development of chemical attractants for coyotes (*Canis latrans*) (Green 1987, Scrivner *et al.* 1987) may be useful in researching techniques to attract and detain bears.

Enhancing moose habitat

Three mechanisms are listed that could decrease the impact of predation, but further research is needed to test the widespread existence of these mechanisms. First, burning has been associated with improved moose nutritional status (Schwartz and Franzmann 1989), which may decrease the vulnerability of individual moose to predation. However, Gasaway *et al.* (1992) concluded that moose nutrition is a minor factor affecting low-density moose populations in most of Alaska and the Yukon. Second, the killing or hunting efficiency of predators may decline in burns or commercially logged areas. Predators may be disadvantaged by the relatively open habitat of early seral stages. Moose are often scattered throughout large burns in interior Alaska and the Yukon. In contrast, in unburned habitat, moose density is highest in narrow zones of shrubs, e.g., riparian or subalpine areas, where predators can travel easily and predictably find moose. Third, increased moose density following burning has been related to increased productivity (Schwartz and Franzmann 1989), and to increased time moose spend in burns (Peek 1974, Gasaway *et al.* 1989). These factors could indirectly reduce the impact of predation on a moose population by increasing local moose:predator ratios (Gasaway *et al.* 1983, Schwartz and Franzmann 1989).

Evidence that moose density may increase substantially as a result of burning is indicated by a moose density of 417 moose/1,000 km² in the large 26-year-old Teslin burn in the southern Yukon (2,515-km² survey area [Gasaway *et al.* 1992]). This density is 3 times higher than the average density in 20 areas (>2,000 km² each) where wolves and bears were similarly lightly harvested and moose were the primary prey (Gasaway *et al.* 1992). Moose densities in these other areas ranged from 45 to 269 moose/1,000 km². No other area had the uniformly extensive, ideal habitat of the Teslin burn.

Social acceptability of habitat enhancement ranked high (Table 1) relative to other techniques, although decreased air quality from burning has been unfavorable. Cost-effectiveness of this method would be variable depending on the methods of habitat enhancement. Prescribed burns have huge costs associated with containment ($500/km^2 in Alaska). Funds from commercial logging could help pay for ways to encourage browse species favored by moose.

Habitat enhancement of large areas ($>$2,000 km^2) is not currently available as a wildlife management tool. The ADF&G has statutory mandates to manage wildlife, but no statutory authority to enhance habitat for wildlife. Wildfires are usually contained by land managers, regardless of opportunities for enhancing moose habitat. Prescribed burning and extensive logging of moose habitat are in their infancy in Alaska and the Yukon, but may increase in the near future. Managers and researchers need to be capable of implementing coordinated, long-term studies of predator-moose-habitat relationships, pre- and post-habitat enhancement, before habitat enhancement can be evaluated as a tool to decrease predation on moose.

Allowing increases in alternate prey

Gasaway *et al.* (1992) proposed allowing caribou to increase as a method for increasing moose numbers. Caribou have escaped predation limitation without strong human intervention (Skoog 1968). Moose, in contrast, require substantial human intervention to escape predation limitation by both wolves and bears in Alaska and the Yukon (Coady 1980, Yesner 1989, Gasaway *et al.* 1992). Decreased predation on moose may follow large increases in caribou (Holleman and Stephenson 1981, Ballard *et al.* 1987:38, Boertje *et al.* 1992*b*), but exceptions occur when caribou change movement patterns (Boertje *et al.* 1992*b*). Wolf numbers correlate with ungulate biomass (Keith 1983, Fuller 1989, Gasaway *et al.* 1992). Therefore, it may be difficult to reduce total predation on moose when caribou increase, unless measures to prevent increases in wolf populations are implemented.

This method is viewed as a waiting process, not a tool, and therefore ranked low in terms of ease of implementation (Table 1). Hunters would have to forego some opportunity to hunt caribou, while waiting for moose to increase. This lowers the potential social acceptability of this method (Table 1).

Reducing predator birth rates

Surgical neutering, implants, inoculations, and oral administration of drugs have been used to reduce predator birth rates (Stelflug and Gates 1987, Orford *et al.* 1988). However, wolf predation and movement studies indicate that birth control may have low to moderate effectiveness in reducing predation for several reasons. First, the maintenance of wolf pairs in an exploited population can result in significantly higher per capita wolf kill rates (Hayes *et al.* 1991). Second, ingress of subadult wolves into wolf control areas may offset the results of birth control. For example, in a highly exploited wolf population in south-central Alaska, 28% of 135 wolves dispersed, and 22% of dispersers were accepted into existing packs (Ballard *et al.* 1987). Immigrating wolves may be accepted at a greater rate in an area where birth control is practiced. Also, lightly harvested adjacent populations may have a greater percentage of dispersing wolves than observed in the highly exploited wolf population in south-central Alaska. Ingress would be less significant if treated wolf populations were insular or peninsular.

Birth control for grizzly bears is not recommended because of inherently low reproductive rates. Female bears have lower immigration rates than wolves (Ballard *et al.* 1987, Reynolds 1990), therefore bear populations would be slow to recover from birth control. Reducing birth rates of black bears may have some application in specific circumstances, because black bear densities and productivity are higher than those of grizzly bears (Reynolds 1990, Schwartz and Franzmann 1991).

Social acceptability of predator birth control was ranked low to moderate (Table 1). This evaluation was based on numerous negative responses received following a press release that mentioned birth control as a potential predator-control technique in Alaska. The cost-effectiveness of birth control was ranked low, because of high implementation costs (Table 1). Implementation of the most common birth control techniques (surgery, implants, or inoculation) requires immobilization of individual predators, which is extremely difficult and expensive in remote areas of Alaska and the Yukon. For example, recent costs to collar a wolf or a grizzly bear averaged $3,000 in a remote, largely forested study area in east-central Alaska.

Distributing baits containing chemosterilants is an alternative to immobilizing individual predators. The use of chemicals, however, requires registration by the Environmental Protection Agency, and pre-registration research costs may total millions of dollars. Chemosterilants would not be approved if found to impair nontarget species, such as wolverines (*Gulo gulo*). Species-specific delivery systems will be required, thereby necessitating further development costs.

<u>Conventional public hunting and trapping</u>

"Conventional public harvest" of wolves and bears is defined as hunting and trapping exclusive of aircraft-assisted or snowmachine-assisted hunting. As a predator-control technique, conventional harvest receives high ratings in social acceptability, cost-effectiveness, and ease of implementation, in part because of minimal agency involvement (Table 1). Conventional harvest of wolves has effectively reduced or stabilized wolf numbers below food-limited levels near populated areas (e.g., on the Kenai Peninsula [Peterson *et al.* 1984] and north of Anchorage [Gasaway *et al.* 1992:42]). Harvest of black bears using bait likewise has reduced black bear densities near Fairbanks (Hechtel 1991). Attempts have been made in limited remote areas in Alaska to encourage public harvest of wolves and grizzly bears to stimulate increases in ungulates.

The ADF&G promoted trapper-education programs in 2 remote areas to stimulate interest in wolf trapping and snaring and to increase success rates. This promotion included trapper workshops and the production and distribution of a video on canid trapping techniques. A nonprofit Native organization provided wolf snares to trappers in select villages. Total numbers of wolves trapped did not increase from these areas (Pegau 1987, Nowlin 1988). The inherent wariness of wolves and a lack of economic incentives for trapping wolves contributed to the failure of this program to increase wolf harvest.

In contrast, hunters have increased grizzly bear harvest sufficiently to reduce grizzly bear densities in 2 remote Alaska study areas. Reported annual harvests averaged about 8-9% in an east-central Alaska (Boertje *et al.* 1987, Gasaway *et al.* 1992) and a central Alaska study site (Reynolds 1990). These harvest rates can cause long-term, slow declines averaging about 2% annually (Reynolds 1990). Methods used to encourage grizzly bear harvest in east-central Alaska included: liberalizing hunting regulations on grizzly bears, increasing the number of hunters by increasing opportunity to hunt male ungulates, and encouraging hunters to harvest grizzly bears through information and education. Liberalized hunting regulations included: lengthening the hunting season, deleting a resident grizzly bear tag (fee) requirement, and increasing the bag limit to 1 bear/year, as opposed to the usual bag limit of 1 bear/4 years. The harvest of sows accompanied by cubs and yearlings was not authorized.

In the east-central Alaska study site, moose were below food-limited densities, and grizzly predation was a major factor limiting the moose population (Boertje *et al.* 1987, Gasaway *et al.* 1992). Moose calves per 100 cows during fall increased in this area, apparently in response to decreased grizzly numbers. Grizzly harvests averaged 8% annually during 1982-88 (Boertje *et al.* 1987, Gasaway *et al.* 1992). Assuming this harvest rate equates to a 2% annual decline (Reynolds 1990), the grizzly population declined 14% by 1989. Moose calves per 100 cows 2 years old increased from a range of 19-27 ($\bar{x}$ = 23) during 1982-1988 to 32-48 ($\bar{x}$ = 38; $P < 0.05$, Mann-Whitney two-sided test) during 1989-1991. Decreased grizzly predation appears to be the cause of increased moose calf:cow ratios during 1989-1991 because other factors did not favor increased moose calf survival. For example, wolf densities were significantly higher ($P = 0.026$, Student's t-test) during fall 1989-1991 ($\bar{x}$ = 7.3 wolves/1,000 km^2) than fall 1982-1988 ($\bar{x}$ = 5.9 wolves/1,000 km^2), and alternate prey (caribou) declined and snow depths were greater during 1990 and 1991 (Boertje *et al.* 1993).

Further studies on the effects of bear harvest on moose calf survival are needed where: (i) moose are below food-limited densities, (ii) bear predation is a major factor limiting moose, and (iii) bear reductions are publicly sanctioned. Managers need to know the degree to which reductions in bear numbers affect moose calf survival in different ecosystems. Managers also need to know whether decreasing trends in numbers of bears harvested per unit effort will provide sufficient information to manage bears (e.g., without expensive bear population estimates). Increased bear harvests are not recommended: (i) where bear predation accounts for a small fraction of total predation, (ii) where moose are near food-limited densities, unless additional moose harvest is desired, or (iii) in coastal areas where bears are the primary species of management concern.

Aircraft-assisted wolf harvest

Public and agency wolf harvests using aircraft have proven effective at reducing annual fall wolf numbers and stabilizing populations below food-limited levels (Gasaway *et al.* 1983, 1992; Ballard *et al.* 1987, Farnell and Hayes, in prep.). The public has reduced wolf numbers using light, fixed-wing aircraft in areas with high proportions of unforested, open terrain and suitable snow conditions for tracking and landing. Large portions of interior Alaska north of the Alaska Range are ill-suited to this method. The use of aircraft was discontinued where wolves were extremely vulnerable (e.g., portions of northern and northwestern Alaska). In these areas, snowmachines replaced aircraft as a tool to effectively reduce or regulate wolf numbers.

During the 1980s, wolves were regularly held below food-limited densities by public, aircraft-assisted wolf harvest in only a portion of south-central Alaska (Ballard *et al.* 1987). Wary wolves are able to avoid aircraft-assisted harvest in more forested areas of Alaska. The primary method has been land-and-shoot harvest in which the hunter lands near the wolf before shooting. Shooting from the air was discontinued in 1972 in Alaska, except under state permit in specific areas (Harbo and Dean 1983, Stephenson *et al.* 1993). In November 1992, Alaska's Board of Game passed regulations allowing the use of aircraft only for wolf "control" not wolf "harvest."

Agency wolf control programs have involved aerial shooting from light, fixed-wing aircraft and helicopters. Radiotelemetry has occasionally been used in these programs to help locate packs, especially where tracking conditions were poor. Only 1 ADF&G aerial wolf control program survived legal proceedings and reviews for 4 years of effective wolf control (>60% reduction of pre-control wolf numbers). The ADF&G shot 18-67 wolves annually during 4 years in this area (Gasaway *et al.* 1983). The program was followed by a four-fold increase in moose numbers (Gasaway *et al.* 1983, McNay 1992). A similar, 7-year agency wolf control program in east-central Yukon (1983-1989) also resulted in elevated moose numbers (Farnell and Hayes, in prep.).

Aircraft-assisted wolf harvest is viewed as having the lowest social acceptability of the 6 methods evaluated in Table 1. Harbo and Dean (1983) and Stephenson *et al.* (1993) trace the history of court cases reflecting this low social acceptability. Indeed, the major motivation for investigating alternate techniques is the low social acceptability of this method (Gasaway *et al.* 1992).

Cost-effectiveness of this method is relatively high. For example, the public can effectively regulate wolves at low densities without agency assistance in portions of south-central and western Alaska. In interior Alaska and southern Yukon, operating costs of agency-sponsored aerial wolf reductions have ranged from about $500 to $1,000 per wolf, yet returns have been high in terms of additional ungulate harvest (Gasaway *et al.* 1983, 1992; R. Farnell, Yukon Fish and Wildlife Branch, pers. commun.). Administrative and educational costs associated with aircraft-assisted wolf harvest are high, in part because of low social and political acceptability. Social and political factors also affect how easily managers can implement this tool.

Management strategy

Several recommendations are given for circumstances where the local public has sanctioned predator control to meet management objectives for moose. These are: (i) rank areas based on suitable habitat, overall demand, management and research capabilities, and social and economic costs; (ii) evaluate the suitability of several combined techniques for a specific area; (iii) educate and inform the general public, as well as public advisory groups; and (iv) adopt a formal process for approving area-specific wildlife management plans in areas with and without anticipated predator control. It is essential that the public be informed about trade-offs between social- and biological-based management decisions.

Acknowledgements

We appreciate reviews of this manuscript by W. L. Regelin, D. J. Reed, A. K. Ruggles, C. A. Smith, W. B. Ballard, S. D. Miller, J. W. Schoen, and anonymous reviewers. Funding was provided by Federal Aid in Wildlife Restoration and the Alaska Department of Fish and Game.

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Table 1. Relative evaluation of 6 methods of increasing predation-limited moose populations in areas suited to the particular methods, based on 4 criteria.

	Diversionary feeding of bears during calving	Enhancing moose habitat	Allowing increases in alternate prey	Reducing wolf birth rates	Conventional public hunting of bears	Aircraft-assisted wolf harvest
Biological effectiveness	Moderate	Moderate	Low	Low to moderate	Moderate to high	High
Social acceptability	High	High	Moderate to high	Low to moderate	High	Low
Cost-effectiveness	Low	Low to high	High	Low	High	Moderate to high
Ease of implementation	Moderate	Low	Low	Low	High	High

APPENDIX B. Potential Alternatives for Intensively Managing Moose Populations and Predation

Several scientific studies have shown that controlling numbers of wolves, black bears, and/or grizzly bears can increase moose numbers when predation is limiting the moose population and enough habitat exists to support more moose. The long-term viability of wolf and bear populations can be safely protected while practicing localized predator control.

Different methods of managing predators to increase moose numbers have been considered. In this leaflet, we evaluated seven different methods which have been proposed to manage moose populations limited by predation. Those methods are: (1) artificial or "diversionary" feeding of grizzly bears or black bears during the moose calving period, (2) enhancing moose habitat, (3) allowing increases in alternate prey, (4) reducing predator birth rates, (5) conventional public hunting and trapping of predators, (6) aircraft-assisted wolf harvest, and (7) restricting moose hunting by humans.

We have compared these methods and ranked each as low, moderate, or high according to four criteria:

Effectiveness: Can the method be used to efficiently increase numbers of moose or reverse predator-driven declines? High = yes. Moderate = sometimes. Low = not likely to succeed.

Social Acceptability: Can the method gain the political and public support necessary to implement a program? High = yes. Moderate = possibly. Low = expect difficulty.

Cost-effectiveness: Can results be achieved at a reasonable financial cost? (Only agency operating costs were considered.) High = yes. Moderate = possibly. Low = not likely.

Ease of Implementation: Disregarding the above constraints, is the technique a usable tool? High = yes. Moderate = possibly. Low = difficult or time-consuming to implement.

Alternative Evaluations

1. "Diversionary" feeding of bears during calving in areas where moose calves are major prey of bears.

   We found that providing other food for bears (diversionary feeding) during spring diverts bears from killing newborn moose calves and enhances calf survival through spring and summer.

Effectiveness: Moderate. Improved nutrition could increase total bear numbers by improving physical condition and productivity of bears and survival of their cubs. Feeding may temporarily attract bears and wolves from adjacent areas. Also, wolves may compensate with increased predation later in the year. Further research is needed.

Social Acceptability: Relatively high. Public attitudes have been generally favorable in Alaska when predators were fed moose carcasses. Disfavor may arise if costly commercial food sources are used, if bears are perceived as conditioned or dependent on the feeding program, or if bear numbers increase because of feeding.

Cost-effectiveness: Low. It is expensive and difficult to acquire, store, and distribute bait that is environmentally safe, socially acceptable, inexpensive, and effective. Large numbers of moose carcasses are seldom available. Alternative foods need to be tested. Using commercial food sources, annual bait costs could be extremely high.

Ease of Implementation: Moderate. Collecting, storing, and distributing bait can be difficult and success may depend on the cooperation of agencies, volunteer groups, and weather.

2. Enhancing moose habitat

Moose habitat can be enhanced by burning, brush crushing, and logging. This method is proposed to enhance moose populations in three ways: (1) improved moose nutrition may help moose avoid predation, (2) improved moose nutrition may help moose produce more twins, and (3) more open and more expansive habitat may decrease the hunting efficiency of predators.

Effectiveness: Moderate. Long-term studies of predator-moose-habitat relationships are necessary.

Social Acceptability: Relatively high. Concerns exist about logging practices or decreased air quality from smoke and about loss of personal property due to fire.

Cost-effectiveness: Low to high. Prescribed burns are currently expensive but costs will decline as more knowledge and experience is gained. Brush crushing is relatively expensive. Commercial logging could generate funds.

Ease of Implementation: Low. Habitat enhancement of large areas has not been available as a wildlife management tool. The ADF&G has a mandate to manage wildlife, but no direct authority to enhance habitat for wildlife. Wildfires are commonly fought by fire management agencies regardless of opportunities for enhancing moose habitat.

3. Allowing increases in alternate prey

In northern ecosystems, caribou occasionally escape the limits of predation without help from people, but moose cannot. This method is proposed to enhance moose populations by waiting for caribou numbers to increase, which provides more prey for wolves so predation on moose would potentially decrease.

Effectiveness: Low. Wolf numbers increase with prey numbers. When caribou increase, wolf numbers increase and total predation on moose most likely will remain the same or increase. Caribou migrate seasonally, leaving resident moose as the primary prey for wolves.

Social Acceptability: Moderate to high. Hunters would have to give up some opportunity to hunt caribou while waiting for moose to increase.

Cost-effectiveness: High. Minimal agency expense.

Ease of Implementation: Low. This method is basically a waiting process, not a management tool.

4. Reducing predator birth rates

Surgical neutering, implants, inoculations, and oral contraceptives may be used to reduce predator birth rates.

Effectiveness: Low to moderate. Subadult wolves moving into wolf control areas likely will offset the results of birth control. Immigrating wolves will likely be accepted at a high rate in an area where birth control is deployed. Maintaining only pairs of wolves in an exploited population can result in higher kill rates per wolf, compared with wolves in packs. No effective contraceptives exist nor do efficient methods of treating wild animals.

Social Acceptability: Low to moderate. Numerous negative responses were received following a press release that mentioned birth control as a potential predator-control technique in Alaska.

Cost-effectiveness: Low. Immobilizing individual wolves for surgery, implants, or inoculation is extremely expensive. Sterilizing drugs delivered in bait would require expensive research and authorization. Delivery of drugs must be specific to wolves.

Ease of Implementation: Low. The most common birth control techniques require immobilization of individual animals. Distributing baits containing sterilizing drugs is an unproven alternative, but still labor intensive.

Birth control for grizzly bears is not recommended because of inherently low reproductive rates. Female bears have lower immigration rates than wolves, so bear populations would be slow to recover from birth control. Reducing birth rates of black bears may have some application in specific circumstances.

5. Conventional public hunting and trapping

"Conventional public harvest" of wolves and bears is defined as hunting and trapping under existing regulations without use of aircraft for land-and-shoot taking.

Effectiveness: Low for wolves, moderate to high for bears. Wolf numbers are reduced or stabilized near populated areas but not in remote areas. Trapper education programs have not substantially increased wolf harvest to date in remote areas. Hunters have been able to decrease densities of and predation by both black and grizzly bears. Reduction of bear predation on moose may not be effective if wolf predation rates remain high.

Social Acceptability: Relatively high. Hunting of bears and hunting and trapping of wolves is generally acceptable in most areas.

Cost-effectiveness: High. Minimal agency expense.

Ease of Implementation: Low for wolves, high for bears.

6. Aircraft-assisted wolf harvest

Public and agency wolf harvests using aircraft have proven effective at reducing wolf numbers and stabilizing populations at lower levels. Public land-and-shoot taking is effective in open or sparsely forested areas.

Effectiveness: High. Use of aircraft has allowed effective agency control programs resulting in significant increases in moose or caribou numbers in Alaska and Yukon Territory.

Social Acceptability: Low. Low acceptability of this technique has prompted the department to consider other methods.

Cost-effectiveness: Moderate to high. Using aircraft, the public can effectively regulate wolves at low densities in open, sparsely forested portions of southcentral and western Alaska. In interior Alaska department participation has been necessary because of extensive forests. As a result of department participation, costs of aerial wolf reductions have been high. Benefits outweigh costs.

Ease of Implementation: High. Aerial wolf control programs can be conducted relatively easily, but social and political factors may prevent programs from being implemented.

7. Restricting hunting of moose by humans

Hunter harvest is restricted by regulations.

Effectiveness: Low. In most of Alaska, human hunters take only 3-5% of the moose that die each year. Wild predators take between 70% and 85%. Reducing the harvest by human hunters is not sufficient to allow moose numbers to increase, especially because humans take only bulls in most areas.

Social Acceptability: Moderate. Hunters would have to give up opportunity to hunt but moose populations would not increase substantially.

Cost-effectiveness: High. Minimal agency expense.

Ease of Implementation: Low to moderate. Support from Advisory Committees and approval by the Board of Game would be necessary.

Alaska's Game Management Units