Population identity and movements of moose in the Togiak, Kulukak, and Goodnews River drainages, southwest Alaska

March 1998 - April 1999

Progress Report 99-01

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Key words: moose, radio telemetry, Togiak, Unit 17A, calf production, survival, movements, habitat, mortality, age and sex composition, serology, management

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30 August, 1999

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SUMMARY

Thirty-six moose *(Alces alces)* were radio collared from 30 March to 7 April, 1998, within mainland Game Management Subunit (Unit) 17A. Aerial radio tracking was conducted monthly for all moose and weekly for cows during the calving period. Calf production and recruitment in 1998 was 88 and 46 per 100 cows, respectively. Twinning rate was 22.2%. The annual mortality rate of radio-collared moose with known fates was 11.1%. Composition data collected during October and November, 1998, radio tracking flights suggest 107.1 bulls and 31.6 calves per 100 cows. Population surveys conducted 3-4 March, 1999, indicated a minimum of 511 moose in Unit 17A. Preliminary research indicates Unit 17A contains 1,450 km^2 (560 mi^2) and 1,347 km^2 (520 mi^2) of optimal and secondary winter moose habitats, respectively. Work on the development of cooperative management plan for Unit 17A moose continued.

BACKGROUND

Moose are relative newcomers to southwest Alaska and in Unit 17A, aerial surveys conducted in the 1980's and early 1990's often revealed less than 10 moose. Subsequent surveys revealed an increase from 84 moose in 1994 to 429 moose in 1998. The dramatic increase in numbers is attributed to: continued immigration from neighboring Unit 17C; regulation changes implemented by the Alaska Board of Game; an apparent reduction of illegal harvests as a result of poor travel conditions and changing attitudes of local residents; availability of the expanding Mulchatna Caribou Herd in Units 17 and 18; and, good productivity and survival of Unit 17A moose due to mild winters, few predators, and pristine habitat. Along with the moose population increase has come several regulatory requests to open/liberalize hunting seasons. Hunters reported taking 15 and 10 moose during State registration permit hunts in 1997 and 1998, respectively. The development of a cooperative management plan for Unit 17A moose is a high priority to insure their continued success while providing an acceptable level of harvest. Because little was known regarding movements, immigration and population parameters of moose in Unit 17A, a 5 year study (Appendix A) was initiated in 1998 to address these and other factors. Aderman et al (1998) provides a summary of the capture and radio collaring of 36 moose (27 cows, 9 bulls) during 30 March to 7 April, 1998, within Unit 17A.

STUDY AREA

The primary study area is in Togiak National Wildlife Refuge (TNWR), northern Bristol Bay (Unit 17A), the drainages between Cape Newenham and Cape Constantine (Figure 1). Adjacent areas, western Unit 17C and southern Unit 18, also are in the study area. The Wood River and Ahklun mountains begin at the southern boundary (coastline) and rise to over 1,500 m in the northern portion of the study area. Numerous rivers and creeks, bordered by willows *(Salix sp.)* and cottonwoods *(Populus balsamifera)*, begin in alpine tundra and alder *(Alnus sp.)* covered slopes and drain though wet and dry tundra uplands. Most of the study area is Designated Wilderness. Petersen et al (1991) and USDI (1986) provide further detail of the study area.

METHODS

Radiotracking

Monthly aerial radiotracking via fixed-winged aircraft (Cessna 185 or Piper SuperCub) was used to locate 36 moose (27 cows, 9 bulls) instrumented within Unit 17A during late winter 1998 (Aderman et al 1998). Additionally, weekly radiotracking flights were conducted from mid-May to mid-June to determine calf production among radiocollared cows. We followed Samuel and Fuller (1996) for estimating moose locations from the air and attempted to obtain visuals of each animal. Upon locating an animal, we recorded on a data form (Figure 2) the Global Positioning System (GPS) location in degree's and decimal minutes, number and sex and age composition of all moose within 100 m, calves or yearlings associated with radiocollared cows, activity of the radiocollared animal, primary habitat type within 25 m radius of collared moose, and any relevant comments. Radiotracking data were entered into a Lotus 1-2-3 spreadsheet and imported as database files into ArcView GIS. Maps of moose locations were produced to determine distribution and movements and to aid in relocation during subsequent radiotracking flights.

Population Estimate

From 3-4 March, 1999, we surveyed all of mainland Unit 17A (<305 m) east of and including the Matogak River drainage and north of the Nushagak Peninsula (Figure 1). Moose were counted by 2 or 3 observers (including the pilot) from 2 Cessna 185's flown at 80-100 knots at120-180 m above ground level. Age composition (calves or adults) of moose was recorded.

Habitat Assessment

Using computer aided analysis of a Landsat (the U.S. land remote sensing satellite system) scene taken in August 1989, we established 7 intensive mapping areas and visited 9 to 32 sites (104 total) within each for ground truthing of classification in July 1998. Information collected included dominant vegetation species, slope, aspect, and drainage. Photographs were taken of all sites.

Serology

During capture operations, blood (sera) samples were collected from 34 moose. Samples were sent to Alaska Wildlife Serum Bank (Alaska Department of Fish and Game, Fairbanks) and tested for evidence of exposure to disease agents.

RESULTS AND DISCUSSION

Radiotracking

Radiotracking flights occurred on 36 days from 30 March, 1998 (capture), to 14 April, 1999. From 1 to all 36 radiocollared moose were located during a particular flight. A total of 527 locations representing 1,464 moose were recorded. Of these, 471 locations representing 1,306 animals were associated with radiocollared moose; and 56 locations representing 158 moose without radiocollars. Moose not associated with radiocollared individuals were recorded opportunistically except during October and November radiotracking flights when all moose

observed were recorded. Moose group size averaged 2.92 (range 1-30). Group size is biased low because radiocollared moose that were located but not observed were counted as 1 group with 1 individual.

Calf Production, Chronology and Survival

Minimum moose calf production in Unit 17A for 1998 was estimated at 88 calves per 100 cows. This estimate is derived from radio-tracking observations of 22 calves associated with 25 radio collared cows known alive after the calving period. Fourteen cows, of which 2 were 2 years old, had single calves. Four cows had twin calves for a twinning rate of 22.2% (4 of 18). Radio-tracking flights were conducted weekly from mid-May to mid-June. It is likely some cows had calves that perished and/or were not observed on subsequent flights. Results from blood samples taken from 25 cows during collaring indicate all (100%) were pregnant.

Calving generally begins in mid-May and is nearly complete by early June. In 1998, radio-collared cows gave birth to 6 calves by 19 May and 18 calves by 3 June (Table 1). Four calves were born on or after 3 June, 1998.

Calf survival through late November was 54.5% (12 of 22). Because some calves may have been "missed" during calving flights, actual calf survival may be lower. Sources of calf mortality were not determined, but likely include predation, inclement weather, and accidents. A calf associated with a radiocollared cow was killed illegally before 5 March, 1999 along the Middle Fork Goodnews River in Unit 18. November 1998 observations of calves with radio-collared cows indicates a recruitment of 48 calves per 100 cows.

Sex and Age Composition

Aerial surveys to determine moose sex and age composition are usually conducted in late November or early December when adequate snow cover is present and before bulls begin to lose their antlers. These conditions have not existed since November 1994, however, some composition data was collected during October and November, 1998, radio-tracking flights. During those flights, 234 moose were observed in Unit 17A and were classified as follows: 105 (44.9%) bulls; 98 (41.9%) cows; and 31 (13.2%) calves. These numbers suggest 107.1 bulls and 31.6 calves per 100 cows. Because bulls have antlers and form into groups after the rut, they are more easily detected than cows or cows with calves. Thus, there is probably a lower percentage of bulls and a higher percentage of cows and calves than was observed. Also, radio-tracking cows and monitoring their calf production and survival enables determination of calf/cow ratios throughout the year (described in the following section). One further note: all of the moose captured for radio-collaring (n = 36) were estimated to be between 22 and 70 months old ($\bar{x}$ = 42 months), indicating a young population. Moose less than 22 months old were not targeted for capture.

Adult Mortality

Despite the closure (1981 to 1997) of moose hunting season in Unit 17A, local residents continued to harvest moose. Both bulls and cows were taken, with an estimated annual harvest of 15 to 25 moose, although lower in recent years. Moose were taken primarily during late winter

and spring when daylight increases and conditions for traveling by snowmachine are generally excellent.

With the advent of a legal fall (August 20 - September 15) hunt in 1997, hunters reported taking 15 moose. Illegal harvest during the 1997-98 winter was estimated at 6 moose. Additionally, 2 apparent wolf killed moose were observed in February and March, 1998, and 1 bull died during radio-collar capture operations in April. During the fall hunt in 1998, hunters reported taking 10 moose. A minimum of 2 moose were taken illegally during the 1998-99 winter.

Based on 1 years data, the annual mortality rate of radio-collared moose with known fates was 11.1%. As of 14 April, 1999, 4 radio-collared cows had died, suggesting a 14.8% (4 of 27) cow moose mortality rate. One cow died near Ongivinuk Lake (in Unit 17A) by mid-May, 1998. Evidence suggests the cow was killed by a brown bear. Two cows had died by 5 March, 1999. Both had moved from their capture locations in Unit 17A (lower Ongivinuck River and upper Trail Creek) to Unit 18 where they were both killed illegally (Middle Fork Goodnews River and Kwethluk River/Crooked Creek confluence). Another cow was killed illegally in the Kulukak drainage sometime before 14 April, 1999. The status of one cow, captured in Trail Creek and last relocated 18 June, 1998, is unknown.

Distribution and Movements

In recent years, moose have been observed throughout most of the suitable habitats in mainland Unit 17A. Generally, suitable habitats occur along the waterways. Moose are more dispersed during summer months and tend to aggregate in winter (Figure 3). In late August and early September 1998 (during the hunting season) moose observed during radio-tracking flights were generally inaccessible by boat based hunters (Figure 4).

Radio-tracking data as of 14 April, 1999 indicated a minimum of 9 moose moving outside Unit 17A. Two cows went to Unit 18 and were killed illegally in late winter, 1999. Seven moose (4 cows and 3 bulls) went to Unit 17C, however, 5 of them (3 cows and 2 bulls) returned to Unit 17A. This data indicates the majority of moose in Unit 17A are staying in the unit. Within Unit 17A, some radio-collared moose appear to be residents (i.e. moose that remain on the same range during winter and summer) while others appear migratory (i.e. those that use separate winter and summer ranges). Individual radiocollared moose movements appear in Appendix B (Figures B1-B36).

Population Estimate

We observed a total of 511 moose in 15.45 survey hours (33.07 moose/hour). Sex composition data was not obtained as most bulls had cast their antlers. A minimum of 47 (9.2%) calves were observed. A total of 108 Sample Unit's (SU) were surveyed, of which nearly one half (53) did not have any moose. Search intensity was approximately 2.6 km^2/minute but varied among SU's dependent on the amount and type of habitat and the number of moose encountered. The greatest concentration of moose was observed along the Togiak River between the confluences of the Ongivinuck and Kemuk rivers. Moose group size averaged 3.38 (range 1-25).

The Alaska Department of Fish and Game (ADF&G) started moose surveys in Unit 17 in 1971 (Faro 1973). In 1981, the first major survey of Unit 17A was conducted and only three moose were observed. Additional surveys were conducted by ADF&G and TNWR in 1982, 1984 and 1987 with similar results. In 1989, in an effort to determine factors contributing to low moose densities, ADF&G/TNWR biologists radio collared 30 moose in western Unit 17C. Subsequent radio-tracking flights from 1989 to 1992 indicated movement of only one moose from the western part of Unit 17C into Unit 17A (Jemison 1994). However, the moose population in western Unit 17C showed an apparent increase since the study (Table 2), and it is possible younger, non-collared moose, with less home range affinity, began dispersing to Unit 17A.

Surveys conducted during the 1990's indicated an increase in moose in Unit 17A (Figure 5). In January 1994, 84 moose were observed. A more thorough survey (Gasaway et al. 1986) was conducted for moose in Units 17A and 17C in February 1995. Survey results and extrapolation of the survey data indicated a population of 136 moose in Unit 17A (Aderman et al. 1995). During this survey, movement of 29 moose from Unit 17C into Unit 17A was documented. Surveys conducted in late February and early March 1997 indicated a minimum of 234 moose in Unit 17A. Surveys conducted in February, 1998, revealed a minimum Unit 17A population of 429 moose. The dramatic growth and expansion of moose in Unit 17A parallels that of western Unit 17C during the 1980's and early 1990's.

Habitat Assessment

Unit 17A contains 9,132 km^2 (3,526 mi^2) of land, of which approximately 8,806 km^2 (3,400 mi^2) is mainland. Using computer aided analysis of a Landsat scene taken in August 1989, along with ground truthing of classification in July 1998, suggests Unit 17A contains a minimum of 1,450 km^2 (560 mi^2) of optimal moose winter habitat. Optimal habitats include mixed spruce/birch forest, closed/open birch/cottonwood forest, and tall/low shrub willow. Areas with open low shrub willow, or secondary moose winter habitat, comprised another 1,347 km^2 (520 mi^2). These estimates are preliminary and do not include southern Unit 17A (Nushagak Peninsula or west of the Matogak River).

Condition of browse species has not been assessed, however, incidental observations made during ground truthing and other work suggest moose have had little impact to date.

Serology

Blood (sera) samples were collected from 34 moose (9 bulls, 25 cows) and tested for evidence of exposure to the following disease agents: Infectious bovine rhinotracheitis virus (IBR); Bovine viral diarrhea virus (BVD); Parainfluenza 3 virus (PI3); Respiratory syncytial virus (RSV); Epizootic hemorrhagic disease virus; Bluetongue virus; and 5 serovars of *Leptospira interrogans*. With the exception of PI3, there was no evidence of exposure to these agents. Ten of the 34 samples (3 bulls, 7 cows) had significant levels of antibody to PI3. The first four agents listed (IBR, BVD, PI3 and RSV) are commonly referred to as the "bovine respiratory group." In domestic livestock, they generally cause the same sort of illness which people would experience with human strains of influenza. They are not typically fatal and are assumed to behave similarly in wildlife species (R. Zarnke pers. comm.). In a long-term survey of Alaska wildlife (Zarnke

1992), these viruses were most common in caribou north of the Brooks Range. They occasionally appeared in other species and other geographic areas, however, prevalence was always very low. Therefore, the results for this study are unusual.

ACKNOWLEDGMENTS

The success of this project is due to the cooperation of many people. We appreciate the blood analysis work provided by Tom Stephenson and Randy Zarnke (ADF&G, Soldotna and Fairbanks). We thank fixed-winged pilots Tom Tucker (Tucker Aviation, Dillingham), Rick Grant (Tikchik Airventures, Dillingham), and John Sarvis (Fish and Wildlife Service, Anchorage) for their safe flying during radiotracking and moose counting. Helicopter pilot Bruce Alumbaugh (Kenai Air, Kenai) was instrumental in transportation during ground truthing habitat work. Rob MacDonald, Allen Miller, Geoff Beyersdorf, and Missy McClaran (TNWR) helped as observers during radiotracking and/or moose survey flights. We appreciate the efforts of Steve Kovach, George Walters (Yukon Delta NWR, Bethel) and Roger Seavoy ADF&G, Bethel) for listening for "missing" TM13. We recognize the writing skills of Mike Reardon (Yukon Delta NWR, Bethel) for the article in the Tundra Drums newspaper after the poaching loss of TM12 and TM26. Gail Collins (TNWR) produced most of the individual moose maps (Appendix B) and we appreciate her talents with ArcView GIS.

We also wish to thank the financial support given us by Aaron Archibeque (TNWR), Steve Machida (ADF&G, Anchorage), and the Office of Subsistence Management (Fish and Wildlife Service, Anchorage). Finally, to the local villages, Advisory Commmittee/Council members, and residents who support the project and take great interest in the health of status of the moose population, we give our thanks.

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Table 1. Production and survival of calves associated with Unit 17A radiocollared moose (n = 27), southwest Alaska, 1998

Cow Moose			Survey Date and Calf Observations										Cumu-
#	Age	Status	Apr 17	May 18/19	May 27/28	Jun 2/3	Jun 18/23	Jul 15-17	Aug 18/Sep 1	Sep 24/29	Oct 26/30	Nov 25/30	lative
1	4	alive	0	0	0	1	1	NV	1	1	1	1	1
2	3 or 4	alive	0	0	1	-	NV	NV	0?	NV	0	0	1
3	4	alive	0	0	NV	0	0	NV	0	NV	0	0	0
5	3	alive	0	0	0	0	NV	NV	1	1	NV	1	1
7	6	alive	0	1	-	-	NV	NV	2	2	2	2	2
10		alive	0	0	-	0	0	NV	0	0	-	0	0
12	4 or 5	alive	0	0	-	1	NV	NV	0	NV	-	0	1
13	2	unk	0	0	-	0	0	NH	NH	NH	-	NH	-
14	4 or 5	alive	0	0	0	0	0	NV	0	0	-	0	0
16	3 or 4	alive	NV	0	0	0	NV	NV	0	0	-	0	0
17	5+	alive	0	0	0	0	1	NV	1	1	1	1	1
18	2	DEAD	0	DEAD	-	-	-	-	-	-	-	-	-
19	3 or 4	alive	0	0	1	-	1	NV	0	0	-	0	1
21	4 or 5	alive	0	0	-	1	NV	0?	0?	0	0?	0	1
22	4	alive	0	1	-	-	NV	NV	1	0	1	1	1
25	3 or 4	alive	0	NV	0	0	NV	NV	NV	0	0	0	0
26	3 or 4	alive	0	0	1	-	1	NV	1	NV	-	1	1
27	3 or 4	alive	0	2	-	-	NV	NV	1	0	1	1	2
29	4 or 5	alive	0	0	-	0	NV	0?	0	0	0	0	0
30	3	alive	0	0	2	-	1	NV	1	1	1	1	2
31	4 or 5	alive	0	0	-	0	0	NV	NV	NV	0	0	0
33	3	alive	0	0	0	1	0?	0?	1	0	1	1	1
36	2	alive	0	0	1	-	NV	NV	1	1	1	1	1
37	3	alive	0	0	0	0	1	NV	0	NV	0	0	1
38	3	alive	0	NV	NV	0	0	1	0	0	0	0	1
39	3 or 4	alive	0	0	2	-	1	0?	1	1	1	1	2
41	2	alive	0	1	-	-	NV	NV	0?	0	0	0	1
Cumulative			0	6	14	18	20	21	22	22	22	22	22

= visual collar number
- = not monitored
NV = no visual
NH = not heard
0? = cow observed in/near heavy cover and no calf observed
unk = unknown

calves/100 cows = 88
survival @ 6 months = 54.5%

Table 2. Minimum moose numbers observed in Unit 17C (west) drainages, 1986-1997.

Date	Weary River	Killian Creek	Youth Creek	Sunshine Valley	Total
27 Dec 86	NS	NS	NS	123	123+
13 Nov 87	NS	NS	NS	76	76+
05 Dec 88	NS	NS	NS	113	113+
13 Dec 90	NS	NS	NS	101	101+
21 Nov 91	6	NS	NS	102	108+
24 Nov 93	33	NS	NS	NS	33+
7-9 Feb 94	NS	91	48	186	325+
29-30 Nov 94	44	NS	NS	187	231+
17-19 Feb 95	29*	49	98*	171	347
23 Jan 96	NS	51	59	173	283+
13-14 Mar 97	29	56	23	203	311

29* is sum of standard searches in SU# 93 & #101. SU# 79 & #91 were not searched.

98* includes 29 moose that emigrated from Youth Creek to No Lake Creek (GMU 17A).

NS = Not Surveyed

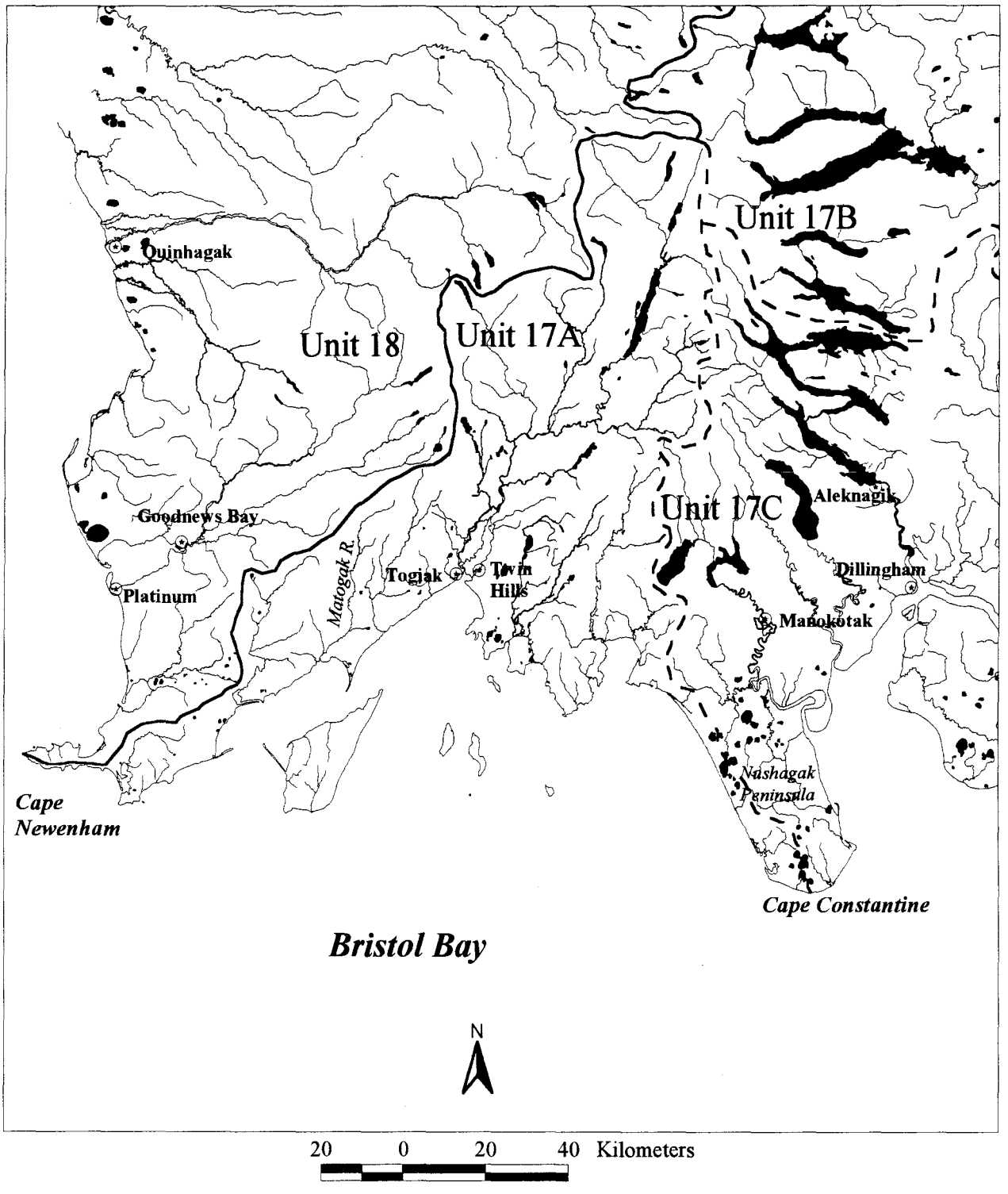

Figure 1. Study area for moose management study, southwest Alaska.

Togiak Moose Study Date_____ Hobbs start_____ end_____ Aircraft_____w/_____ Pilot_____

Observer(s)_____ Time start_____ end_____ Temp:____F Precip:_____ Turb:_____

Winds_____@_____ Skies_____O B S C Light type:___bright ___flat Intensity:___high___medium___low Leaf out/Leaf fall_____

Snow age:__fresh(1-2 days) __mod(2-5 days) __old(>5 days) Snow cond:__complete __veg showing __bare Snow elevation:_____

Remarks:_____

Association: NV=No Visual; N=Alone; N?=possibly alone; 1C=one calf; 1Y=one yearling; Activity: NV=No Visual; ST=Standing; LY=Lying; WA=Walking; RU=Running; FI=Fighting; MA=Mating. Habitat: WL=Willows; CT=Cottonwoods; AL=Alders; BI=Birch; DT=Dry Tundra; WT=Wet Tundra; GR=Gravel Bar; GS=Grass; WA=Water

Mortalities: .010 .120 .170 .180 .250 .260 .330 .370

Obs #	Freq	Lat	Lat'	Long	Long'	Total	Bull	Cow	Calf	Yrlg	Uncl	Assoc	Activity	Habitat	Elev	Comments

Figure 2. Radiotracking data form for moose management study, southwest Alaska.

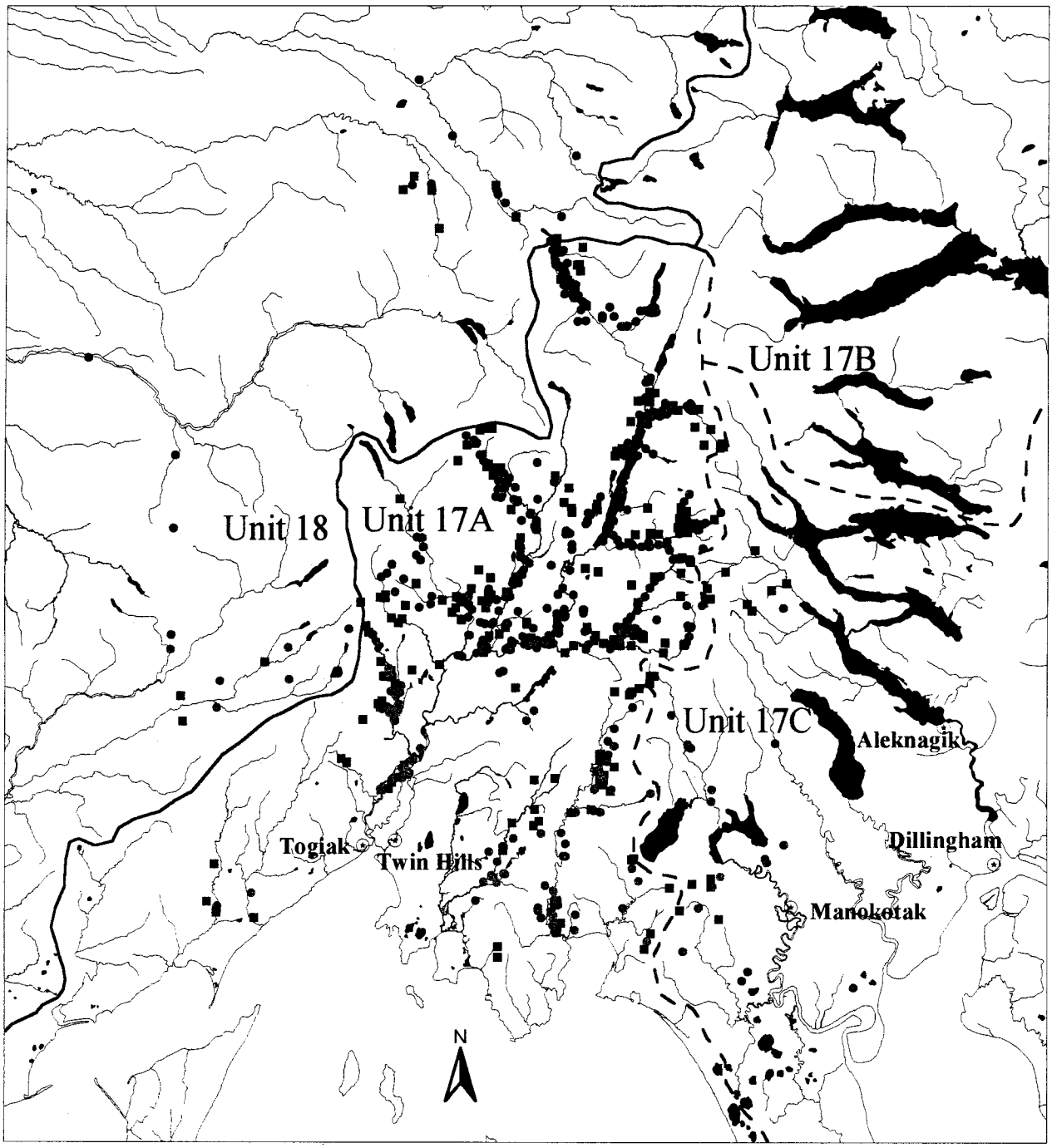

Figure 3. Seasonal distribution of all moose observed in Unit 17A and adjacent areas, 1996 - 1999.

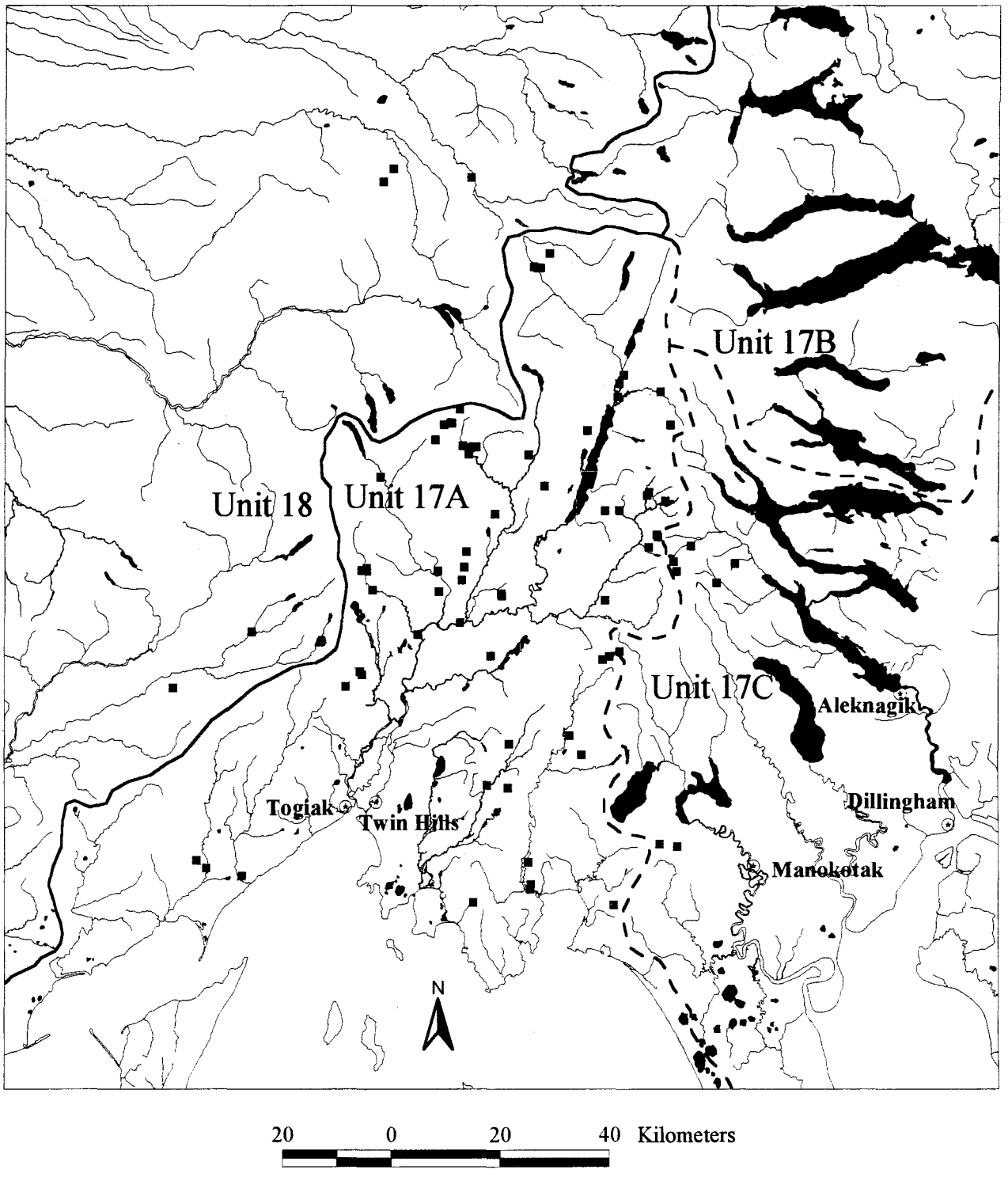

Figure 4. Location of all moose observed during August and September, 1998.

Appendix A. MANAGEMENT STUDY PROPOSAL

Togiak National Wildlife Refuge
and
Alaska Department of Fish and Game

Title: Population identity and movements of moose in the Togiak, Kulukak, and Goodnews River drainages, southwest Alaska.

Problems Addressed:

Little is known regarding movements, immigration and population parameters of moose on the Togiak National Wildlife Refuge (TNWR). Moose numbers have generally been low and illegal harvest high. Recent increases in numbers and the expansion of their range in Subunit 17A has resulted in several proposals to liberalize seasons. In 1997, a limited registration hunt was opened for moose in GMU 17A. It is unknown what effect increased hunting, in concert with unreported illegal harvest will have on the growth and expansion of moose on the refuge. Radio-collaring and subsequent tracking will provide the information necessary to set harvest limits which allow the continued growth and expansion of moose on the refuge while meeting the nutritional needs of local people.

Objectives:

1. Identify seasonal movements and distribution of moose within portions of TNWR and determine what portion of the moose observed during winter surveys are resident and what portion are migratory.

2. Identify potential areas in which trend count areas can be established, and times when composition counts can be conducted in those areas.

3. Investigate population dynamics of moose to establish productivity and mortality parameters so that more accurate models can be developed for management.

4. Educate local residents on the importance of protecting moose until a viable population can be established.

5. Analyze habitat to better define the number of moose the area can support.

Appendix A. continued

Background and Justification:

Moose appear to be relatively new inhabitants in the Bristol Bay area, possibly immigrating into the area from middle Kuskokwim River drainages during the last century. Until recently, populations were low and moose were found primarily in the Nushagak/Mulchatna River system. Local residents harvested moose opportunistically, however, caribou, reindeer, and beaver were historically the main sources of game meat. Alaska Department of Fish and Game (ADF&G) staff began collecting data on the Unit 17 moose population in 1971. At that time, moose were not abundant in the unit and animals close to the villages were subject to heavy hunting pressure (Faro 1973).

Illegal harvests along the Nushagak and Mulchatna Rivers have decreased in the past 10 years. There has also been a notable decline in the number of female moose taken. This has resulted in a significant increase in moose populations in those areas. However, illegal harvest continues to be a problem in Subunit 17A. Some subunit residents actively pursue moose with aircraft and snowmachines during the winter and spring. Both male and female moose are taken, with an estimated annual harvest of 15 - 25 moose (Van Daele 1996).

In spite of this harvest, the moose population in Subunit 17A has increased dramatically in the past couple of years from 6 moose observed in 1992 to over 100 in 1995. Data from a joint ADF&G/TNWR radio telemetry study indicated that although most moose radio-collared in Subunit 17C stayed in the subunit, there was some movement into Subunit 17A (Jemison 1994). However, that investigation was completed prior to the recent population increase in the subunit. During the February 1995 census, 29 moose moved into 17A from the upper Sunshine Valley in 17C (Aderman et al. 1995). This observation, coupled with the rapid increases in moose observed in recent years strongly suggests immigration into the subunit. It appears that this immigration is continuing west into the Goodnews River drainage in GMU 18. Further research into the nature of these movements needs to be conducted.

The current population size in Subunit 17A is probably around 250 moose. In February 1995 we censused the moose population in Subunits 17A and 17C (west). The 1395 mi^2 study area contained an estimated 458 moose (+\-11.95% at 90% C.I.). We also derived an estimate of 100.9 moose (+\- 21.11% at 90% C.I.) for the Subunit 17A portion of the study area (1042 mi^2) (Aderman et al. 1995). Aerial surveys during winter 1996-1997 indicated a minimum of 234 in 17A.

In 1997, a limited registration hunt was opened for moose in GMU 17A, with a harvest limit of 10 bulls during the fall season. Local residents recognize the importance of being conservative, and would like to see the moose population attain the target level of 600-1000. Residents of Nushagak River villages are also interested in a conservative management approach for Subunit 17A moose. Part of the reason for the immigration of moose from 17C to 17A is because of voluntary hunting restrictions Nushagak River villagers have imposed on themselves to encourage westward movements of moose.

A moose management guideline, jointly developed by ADF&G, TNWR, and local residents attempts to balance the nutritional needs of local residents with the objective of allowing the moose population to grow to its potential (ADFG and TNWR 1996). Establishment of target levels for a hunting season (100 moose), liberalization of hunting seasons (300), and an objective level (600-1000) will allow managers to objectively evaluate the status of the herd. These target levels can be adjusted as results from future research projects become available. Both state and federal law enforcement personnel are working closely with local villagers and Traditional Councils to curtail illegal moose harvests. Cooperation between ADF&G, TNWR, and the local residents is critical to the success of this plan.

There has been no objective analysis of the moose habitat in Subunit 17A. Assuming vegetative and weather patterns similar to adjacent areas in Subunits 17B and 17C, we estimate that the subunit could ultimately support from 600 to 1000 moose. We should investigate methods to refine that estimate possibly through habitat analysis by remote sensing techniques and associated ground truthing, The use of vegetation utilization plots should also be investigated to evaluate the impacts of moose on this relatively virgin range.

Methods:

Adult moose will be captured by darting them from a helicopter with Carfentanil. Capture operations will occur sometime between January and April 1998, whenever suitable weather conditions, moose concentrations, and logistical considerations allow. A total of 36 moose (9 males, 27 females) will be collared with Telonics Mod 600 radio collars with 12 hour mortality sensors and frequencies within the 150.000 - 153.999 range. Radio-collars will be distributed within the Ongivinuck, Kemuk, Gechiak, Kulukak, Trail Creek and Izavieknik River drainages, proportional to the number of moose in each of those areas (Figure 1).

Telemetry flights will be conducted monthly throughout the year, and weekly during calving (late May through early June), for 5 years (1998 - 2003). Attempts will be made to determine the cause of death for any collared moose that die during the project.

Meetings in affected villages will be conducted to educate local residents on the importance conservative hunting seasons and protecting immigrating moose until a population can be established. Information bulletins will also be completed periodically to keep local residents informed.

Habitat analysis will be achieved by developing a general land cover map through computer-aided analysis of satellite imagery. General cover types will be delineated, ground truthed, and cataloged. These data will be used to estimate the amount of moose winter habitat available and derive a target population level for the area.

Anticipated Results:

Analysis of radio telemetry data will provide a basis for determining population identity, seasonal movements and distribution, and provide basic population parameters so more accurate models can be developed for management. These data will allow biologists to better predict the effects of various harvest levels on the growth and expansion of moose on the refuge. Habitat analysis will provide a better estimate of how many moose the area can support. Managers will be able to adequately address future hunt proposals, management goals and objectives. Progress reports will be submitted to the Refuge Manager.

Cooperators and Responsibility:

This management proposal will be a cooperative effort between ADF&G and TNWR. Principle investigators will be Larry Van Daele, Area Wildlife Biologist, ADF&G, Andy Aderman, Wildlife Biologist, TNWR, and Michael Hinkes, Wildlife Biologist/Pilot, TNWR. The principle investigators will be jointly responsible for defining or modifying study design or objectives.

The U.S. Fish and Wildlife Service (USFWS), through its Subsistence Division, will have primary responsibility for funding this project, including flight time, telemetry equipment, radio-collars, and capture drugs. ADF&G will be responsible for the operational phase of the capture and collaring program. Refuge wildlife biologists will assist during the capture phase and have joint responsibility with the ADF&G biologist for conducting telemetry flights. Telemetry flights will be conducted using refuge aircraft as much as possible for cost savings.

TNWR biologists will work with Division of Information Resource personnel to complete computer-aided analysis of satellite imagery for land cover mapping. The principle investigators will be jointly responsible for ground truthing, and developing an estimate of "carrying capacity". TNWR biologists will be responsible for data archive, including computer database and GIS technology. The principle investigators will be jointly responsible for data analysis and progress report preparation.

A portion of the study will occur on or adjacent to lands administered by the Bureau of Land Management (BLM). This study will be coordinated with the BLM and they may become a cooperator through staffing and/or funding at a future date. The extent of their support would be negotiated annually.

Appendix A. continued

Funding Requirements:

Capture (FY 98):	
36 Radio-collars (Telonics Mod 600 w/mortality sensor) @ $500	$18,000
30 hrs. helicopter charter @ $550/hr	$16,500
10 hrs spotter plane charter @ $250/hr	$2,500
15 hrs refuge spotter plane @ $125/hr	$1,875
800 gallons Jet A fuel @ $4/gal	$3,200
Drugs, maps, and incidentals	$2,000
Total Capture Costs	$ 44,075
Land cover mapping (FY 99):	
Acquire satellite imagery	$1,200
Initial aerial reconnaissance	$2,000
Develop preliminary classification	$2,000
	$5,200
Land cover mapping continued (FY 00)	
Ground truthing 12 hrs helicopter charter @ $550/hr	$6,600
360 gallons Jet A fuel @ $4/gal	$1,440
Develop final cover map, type descriptions, products	$3,000
	$10,040
Monitoring (FY 98 - FY 02):	
5 charter flights @ 8 hrs/flight @ $250/hr	$10,000
10 Refuge flights @ 8 hrs/flight @ $125/hr	$10,000
Miscellaneous radio-tracking equipment	$1,000
Annual Monitoring Costs	$21,000

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Appendix B. Location and movements of radiocollared moose.

Appendix B withheld until completion of study.