Species Management Report and Plan ADF&G/DWC/SMR&P-2017-3

Moose Management Report and Plan, Game Management Unit 20A:

Report Period 1 July 2010–30 June 2015, and

Plan Period 1 July 2015–30 June 2020

Donald D. Young Jr.

2017

Alaska Department of Fish and Game Division of Wildlife Conservation

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Species management reports and plans provide information about species that are hunted or trapped and management actions, goals, recommendations for those species, and plans for data collection. Detailed information is prepared for each species every 5 years by the area management biologist for game management units in their area, who also develops a plan for data collection and species management for the next 5 years. This type of report is not produced for species that are not managed for hunting or trapping or for areas where there is no current or anticipated activity. Unit reports are reviewed and approved for publication by regional management coordinators and are available to the public via the Alaska Department of Fish and Game's public website.

This species management report and plan was reviewed and approved for publication by Doreen I. Parker McNeill, Management Coordinator for the Division of Wildlife Conservation, Fairbanks.

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Cover photo: Angry cow moose in Unit 20A. ©2007 ADF&G Photo by Donald D. Young Jr.

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Purpose of this Report

This report provides a record of survey and inventory management activities for moose in Unit 20A for the previous 5 regulatory years (RY; RY10–RY14) and plans for survey and inventory management activities in the 5 years following the end of that period (RY15–RY19). A regulatory year begins 1 July and ends 30 June (e.g., RY10 = 1 July 2010–30 June 2011). This report is produced primarily to provide agency staff with data and analysis to help guide and record its own efforts but is also provided to the public to inform them of wildlife management activities. In 2016 the Alaska Department of Fish and Game's (ADF&G) Division of Wildlife Conservation launched this new type of 5-year report to more efficiently report on trends and describe potential changes in data collection activities over the next 5 years. It replaces the moose management reports of survey and inventory activities that were previously produced every 2 years and supersedes the 1976 draft Alaska wildlife management plans (ADF&G 1976).

I. RY10–RY14 MANAGEMENT REPORT

Management Area

Unit 20A is in Interior Alaska immediately south of Fairbanks and across the Tanana River and is centered on 64°10′N latitude and 147°45′W longitude. Unit 20A encompasses 6,796 mi^2, but only 5,040 mi^2 contain topography and vegetation characteristically used by moose. The study area was described in detail by Gasaway et al. (1983). The northern portion consists of the northern lowlands (Tanana Flats) with elevations ranging 350–1,000 feet. The southern portion consists of the northern foothills and mountains of the Alaska Range with elevations varying up to 14,000 feet. Lowland vegetation is a mosaic of shrub and young forest dominated seres, climax bogs, and mature black spruce (*Picea mariana*) forest (Gasaway et al. 1983). Vegetation in the hills, foothills, and mountains grades from taiga at lower elevations into shrub-dominated communities with alpine tundra at higher elevations. The climate is typical of Interior Alaska, where temperatures frequently reach 80°F in summer and −40°F in winter. Snow depths are generally below 32 inches in the northern lowlands.

Summary of Status, Trend, Management Activities, and History of Moose in Unit 20A

Moose are presently found throughout the Tanana Flats and adjacent Alaska Range foothills at moderate to high densities (2.0–2.5 moose/mi^2). Gasaway et al. (1983) presented a detailed history of the Unit 20A moose population through 1978 that included a dramatic decline from high abundance in the 1960s caused by severe winters, wolf predation, and liberal antlerless harvest. Boertje et al. (1996) updated the case history through 1994 to include abundance recovery following wolf control during 1976–1982. More recent publications discuss important management implications of density-dependent responses and use of antlerless harvest to mitigate decline in nutritional condition and detrimental browsing effects on vegetation, including Young and Boertje (2004, 2008, 2011), Young et al. (2006), Boertje et al. (2007, 2009), and Paragi et al. (2015).

Preferred moose habitat is composed of riparian willow, poorly drained meadows, shallow lakes, early successional forest, and subalpine shrub communities. Suitable moose habitat covers approximately 5,040 mi^2 of the unit (the area below 4,000 feet in elevation exclusive of large lakes). After decades of relatively few fires, approximately 700,000 acres burned during 2001–2013 that should improve moose nutrition, productivity, and carrying capacity (Young 2014).

Young (2014) reviewed the complex landownership patterns, regulatory situation, and moose management in Unit 20A. Past regulatory changes in Unit 20A, which were designed to reduce the harvest of bulls to sustainable levels and increase the harvest of cows and calves, have been controversial, but successful (see prior citations, 2004–2015). Regulatory changes included a shorter, then longer, general season; unitwide antler restrictions for resident and nonresident hunters; drawing permit hunts for "any bull;" and drawing and registration hunts for antlerless moose. Currently the department is managing for a stable moose population in Unit 20A. In 2012 the Alaska Board of Game (board) revised the intensive management (IM) population objective from 10,000–12,000 to 12,000–15,000 moose and the harvest objective from 1,400–1,600 to 900–1,100 moose.

Antlerless moose hunts remain controversial and divisive because some hunters favor maximizing sustainable harvest, whereas others have concern that female harvest could precipitate a decline as observed in the early 1970s (Gasaway et al. 1983). Public opposition to antlerless harvest tends to wax and wane. In December 2013 Alaska State Senators Click Bishop, John Coghill, and Cathy Giessel hosted a legislative inquiry soliciting concerns and opinions from local hunters regarding cow moose hunts in the Fairbanks area. Given public concerns that moose abundance is now lower than a decade ago, the department was asked by the board to provide a feasibility assessment for IM at the March 2016 statewide meeting that would consider wolf control in parts of Unit 20A.

Access restrictions for moose hunting are also controversial. Motorized vehicles other than aircraft are not permitted in the Wood River and Yanert controlled use areas in Unit 20A.

Entry to some military land is also prohibited. This is especially controversial in those portions of Unit 20A with excellent moose hunting opportunity.

Management Direction

Existing Wildlife Management Plans

- Direction for the management of Unit 20A moose was outlined in the draft wildlife management plans (ADF&G 1976), which were reviewed and modified through public comments, staff recommendations, and Board of Game actions over the years. A record of the changes can be found in the division's management report series. The plan portion of this report contains the current management plan for moose in Unit 20A.

Goals

- Protect, maintain, and enhance the moose population and its habitat in concert with other components of the ecosystem.

- Provide the greatest sustained opportunity to participate in hunting moose.
- Provide an opportunity to view and photograph moose.

CODIFIED OBJECTIVES

Amount Reasonably Necessary for Subsistence Uses

- Unit 20A, that portion outside the boundaries of the Fairbanks nonsubsistence area, has a customary and traditional use finding for moose, with amounts necessary for subsistence uses of 50–75 moose.

Intensive Management (revised as of 2012)

- Population Objective: 12,000–15,000 moose.
- Harvest Objective: 900–1,100 moose.

MANAGEMENT OBJECTIVES

1. Manage population levels based on multi-year mean spring twinning rates in conjunction with at least one of the following signals to substantiate low twinning-based nutritional status: 1) <50% of 36-month-old moose are parturient; 2) average multi-year short-yearling mass is <385 lb (175 kg); or 3) >35% of annual browse biomass is removed by moose (Boertje et al. 2007):

   a. <10% twinning rate (manage for population reduction).

   b. 10–20% twinning rate (manage for population stability).

   c. >20% twinning rate (manage for population growth).

2. Manage for a posthunting sex ratio of ≥30 bulls:100 cows overall and ≥20 bulls:100 cows in the Tanana Flats, western foothills-mountains, and eastern foothills-mountains areas.

MANAGEMENT ACTIVITIES

Methods for data collection and results for all activities during 2010 are in Young (2012) and during 2011 and 2012 are in Young (2014).

1. Population Status and Trend

ACTIVITY 1.1. Geospatial population estimation (GSPE) surveys.

Data Needs

Moose abundance and age-sex composition are integral components of management. GSPE is the preferred technique for estimating abundance and also provides age-sex composition with variance. These estimates are used for monitoring demographic trends in response to management actions intended to influence type of harvest (sex, antler configuration, total amount that is sustainable yield) for meeting IM population objectives and bull:cow objectives. Monitoring calf:cow and yearling:cow ratios allow understanding of demographic changes indicative of production and natural mortality on calves.

Methods

Fall 2013

We used the GSPE method (Kellie and DeLong 2006) and surveyed 122 sample units (SU; 84 high density and 38 low density; 710 mi^2) of 987 SUs (5,747 mi^2) during 29 November–8 December. A simple random sample of 104 SUs (73 high density and 31 low density) was selected from each stratum using Microsoft®Excel using Windows®7 software (Redmond, Washington). An additional 18 SUs (11 high density and 7 low density) were selected to fill gaps in the randomized coverage. We eliminated 1 SU (#80), a posteriori, from the analysis because none of it was moose habitat. Data were recorded on the "Fairbanks Area Spatial Moose Survey Form" (Appendix A).

Search time per SU with 100% moose habitat averaged 7.8 min/mi^2 (n = 85 SUs). Survey conditions (Gasaway et al. 1986) with regard to snow (age and cover), light (intensity and type), and wind (strength and turbulence) were mostly excellent (46%) and good (44%) with the remainder being fair (8%) and poor (2%; n = 122).

Fall 2014

We used the GSPE survey techniques to calculate composition ratios (Kellie and DeLong 2006). We surveyed 53 SUs (37 high density and 16 low density; 309 mi^2) of 987 SUs (5,747 mi^2) during 26–29 November. A simple random sample of 50 SUs (35 high density and 15 low density) was selected from each stratum using Microsoft Excel, Windows 7 software. An additional 3 SUs (2 high density and 1 low density) were selected to fill gaps in the randomized coverage.

Search time per SU (all SUs irrespective of percent moose habitat) averaged 3.1 min/mi^2 (range = 5–33 min; n = 53 SUs). We observed 27.7 moose/hour of survey time. Survey conditions (Gasaway et al. 1986) with regard to snow (age and cover) and light (intensity and type) were too poor to conduct the desired annual population estimation survey (requires adequate survey conditions to meet sightability standards), so we conducted a composition survey in which results (i.e., sex and age ratios) are not measurably affected by poor survey conditions that negatively influence sightability.

Fall 2015

We used the GSPE method (Kellie and DeLong 2006) and surveyed 150 SUs (105 high density and 45 low density; 873 mi^2) of 987 SUs (5,747 mi^2) during 10–30 November. A simple random sample of 135 SUs (95 high density and 40 low density) was selected from each stratum using Microsoft Excel, Windows 7 software. An additional 15 SUs (10 high density and 5 low density) were selected to fill gaps in the randomized coverage. We eliminated 1 SU (#2, high density), a posteriori, from the analysis because it was 100% non-moose habitat and mistakenly surveyed 1 SU (#350, high density), which we included in the analysis.

Search time per SU with 100% moose habitat averaged 8.19 min/mi^2 (n = 103 SUs). Survey conditions (Gasaway et al. 1986) with regard to snow (age and cover), light (intensity and type), and wind (strength and turbulence) were mostly good (51%) and excellent (45%) with the remainder being fair (4%) and none being poor (n = 150).

For all GSPE surveys we calculated 90% binomial confidence intervals around population estimates and composition ratios in ADF&G's Wildlife Information Network (WinfoNet; Kellie and DeLong 2006) for comparisons of survey results with management objectives. Natural mortality was estimated from measures of annual survival obtained via GSPE surveys conducted during November and December. To infer cohort survival from 5 months to 17 months, we compared calves:100 cows (both sexes) with yearlings (yearling bulls × 2):100 cows the subsequent fall, recognizing that harvest of yearling bulls may be substantially higher in areas with spike-fork hunts such as Unit 20A. We used a linear mixed effects model using the Akaike information criterion (AIC) and smoothed estimates to evaluate trends in moose population abundance.

Results and Discussion

Moose population estimates were within the IM objective during the reporting period, except for 2013 when poor survey conditions likely resulted in the estimate being biased low (Table 1; Appendices B and C.). Excluding 2013 it appears that moose numbers were stable 2011–2015 at an estimated 2.4–2.5 moose/mi^2 in the estimated 5,040 mi^2 of moose habitat. Yearling bull recruitment to harvestable age appeared to decline 2013–2015 compared to 2010–2012 based on yearling bull:100 cow estimates (Table 1). Also, estimated percent yearlings in the population (GSPE yearling bulls + reported harvest yearling bulls × 2/ GSPE moose) was lower in 2013 and 2015 ($\bar{x}$ = 8.1%; range = 7.7–8.4%) than 2010–2012 ($\bar{x}$ = 9.8%; range = 9.6–10.1%). Moose populations with >10% yearlings during fall, particularly in areas where mortality factors such as deep snow or predation are of minimal importance, likely exceed maintenance level recruitment (Bishop and Rausch 1974:573). Qualifications for interpreting yearling metrics are described in Young (2012).

Bull:cow ratio during the reporting period varied closely around the management objective for Unit 20A overall (Table 1), with mean bull:cow ratios of 31:100 (range 28–34) during 2010–2015. To stabilize bull:cow ratios at roughly 30:100, we adjusted the number of "any bull" drawing permits during the reporting period from as few as 752 (RY11) to as many as 1,000 (RY13) to maintain the harvest of bulls at 4–5% of the estimated prehunt moose population or 15–20% of the prehunt bull moose population. This harvest strategy of regulating bull harvest via an antler-restricted general hunt in combination with a restricted "any bull" drawing hunt has proven to be successful at unitwide and smaller hunt area scales (Young and Boertje 2008; Young 2012). That is, we also met our objective of ≥20 bulls:100 cows in the Tanana Flats, western foothills–mountains, and eastern foothills–mountains of Unit 20A as we were able to adjust the number of "any bull" drawing permits annually to regulate harvest and ultimately bull:cow ratios across the 7 hunt zones (Fig. 1).

Table 1. Unit 20A moose fall composition and estimated population size from geospatial population estimates, Interior Alaska, calendar years 2010–2015.

Calendar year	Bulls:100 cows[a]		Yearling bulls:100 cows[a]		Calves:100 cows[a]		Percent calves[b]		Adults	Moose observed	Estimated population w/SCF = 1.21[a,c]		Moose/mi[2d]
2010	32	(6.6)	9	(2.5)	32	(4.9)	20	(2.0)	1,196	1,486	14,497	(2,354)	2.9
2011	33	(4.8)	9	(1.8)	28	(3.7)	17	(1.8)	1,363	1,651	12,723	(1,948)	2.5
2012	34	(5.5)	9	(2.3)	31	(6.5)	18	(2.2)	1,014	1,244	12,193	(1,922)	2.4
2013	28	(6.4)	7	(3.5)	31	(5.6)	19	(2.4)	875	1,085	10,156	(1,477)	2.0
2014	32	(12.1)	7	(7.0)	24	(5.4)	15	(3.3)	381	449	–[e]		
2015	29	(4.4)	7	(3.1)	31	(3.2)	22	(2.0)	1,326	1,708	12,315	(1,608)	2.4

[a] Ninety percent confidence interval, plus and minus the estimate, in parentheses.
[b] Ninety-five percent confidence interval, plus and minus the estimate, in parentheses.
[c] SCF = sightability correction factor (Boertje et al. 2009).
[d] Based on an estimated 5,040 mi^2 of moose habitat in Unit 20A.
[e] The 2014 survey was a composition survey only due to poor conditions/sightability, thus population size was not estimated.

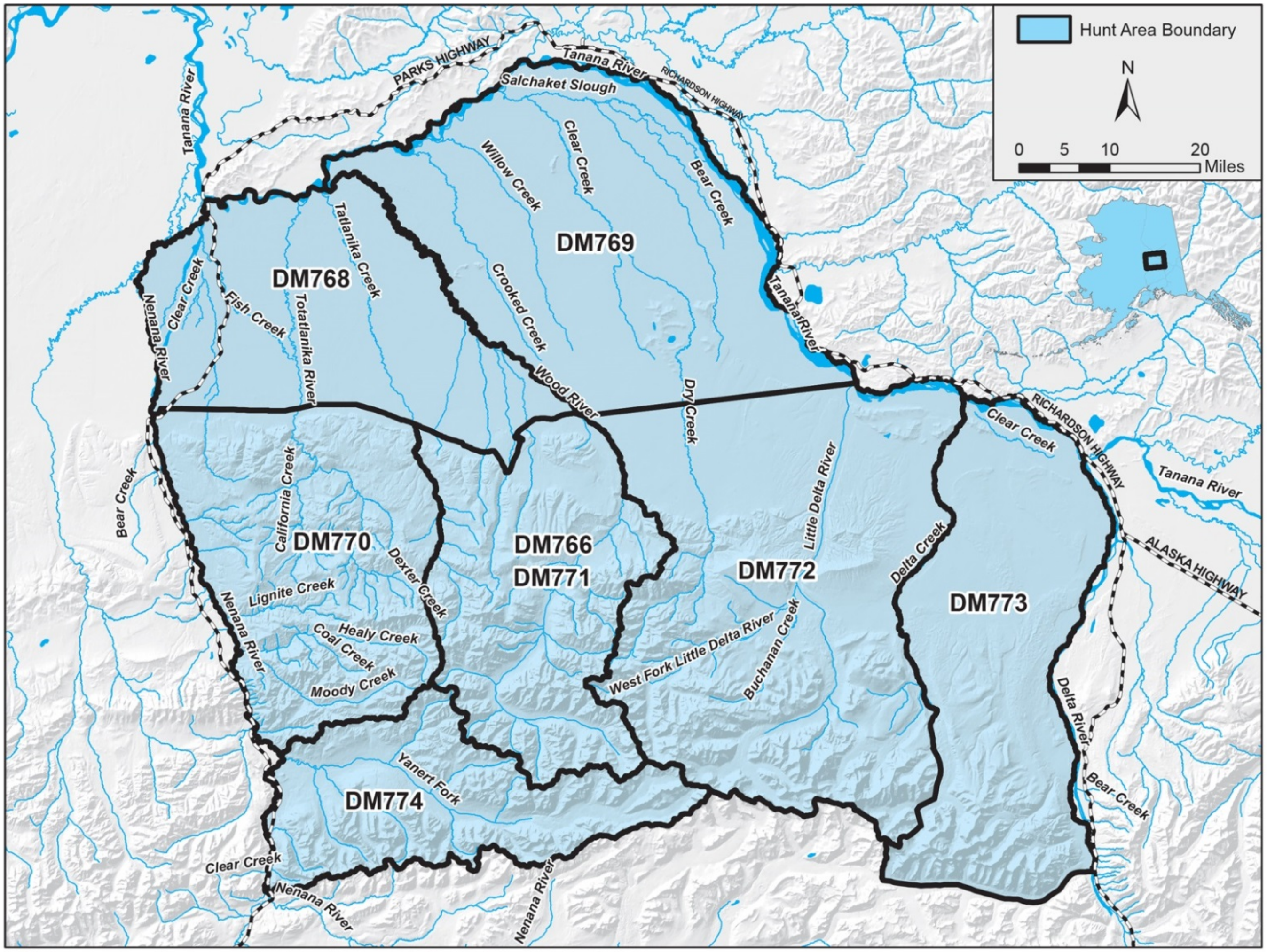

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Figure 1. Bull drawing permit hunts DM768–DM774, Interior Alaska, regulatory years[a] 2010–2014.

[a] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 2010 = 1 July 2010–30 June 2011).

Recommendations for Activity 1.1

- Recommend to the Board of Game lowering IM population objective from 12,000–15,000 to 10,000–15,000.

- Continue to conduct GSPE surveys annually in order to monitor and evaluate trends in abundance, productivity, survival, recruitment, and bull escapement.

- Incorporate sightability correction factor (SCF) trials into GSPEs when practical to improve accuracy of population estimates and incorporate SCF variance in precision for a more informed trend analysis.

- Evaluate trends in the moose population's productivity (calves:100 cows), survival-recruitment (yearlings:100 cows), and sustainable bull harvests (bulls:100 cows) with a linear mixed effects model using AICs and smoothed estimates over roughly 5-year periods.

- Utilize memos to archive details of future abundance and composition surveys to reduce detail in methods and results text of management reports.

ACTIVITY 1.2. Spring twinning surveys.

Data Needs

Estimates of moose nutritional condition and productivity are integral to management on a sustained yield basis over the long term and the goal of protecting moose health and habitat. Data gathered during twinning surveys about how many cows have twins provide an indication of condition and productivity.

Methods

Twinning rate surveys were expanded in 2006 beyond the traditional survey areas in the central Tanana Flats to include the eastern and western Tanana Flats to monitor condition and productivity more broadly across the unit. Surveys consisted of roughly parallel transects flown at approximately ½-mile intervals at ≤500 feet above ground level in PA-18 or Scout aircraft by experienced pilots with observers. All moose observed were classified as bull; yearling cow; adult cow without a calf; or adult cow with single, twin, or triplet calves (Appendix D). Twinning rate surveys were flown in late May during or within a few days of the median calving date (Boertje et al. 2007) to minimize potential biases resulting from predation on one calf of a pair of twins. To increase the power of statistical comparisons between survey areas and across years, we established a priori, a desired sample size of ≥50 cows with calves (Boertje et al. 2007). Twinning rate was calculated as the proportion of cows with twins or triplets from the sample of all cows with calves. We compared point estimates of observed twinning rates to thresholds adopted in our management objectives.

Results and Discussion

Overall twinning rates (i.e., northcentral Tanana Flats, western Tanana Flats, and eastern Tanana Flats–foothills combined) during spring 2011–2015 averaged 15.4% (Table 2; Appendices E, F, G, H, and I). In accordance with management objective 1, multi-year twinning rates fall between

10% and 20%, indicating that we should be managing the Unit 20A moose population for a stable population.

Recommendations for Activity 1.2

- Continue spring twinning rate surveys.
- Continue managing for a stable population.

ACTIVITY 1.3. Short-yearling mass estimates (Objectives L2, M1).

Data Needs

Estimates of moose nutritional condition and productivity are integral to management on a sustained yield basis over the long term and the goal of protecting moose health and habitat. Short-yearling mass is a more sensitive index to moose nutritional condition and can substantiate low twinning rates.

Methods

This activity is designed to estimate the difference in mass of male and female short-yearling pre-treatment (1997–2003) versus post-treatment (2015 and 2016), and to the 385 lb threshold identified to substantiate low twinning-based nutritional status (Boertje et al. 2007). Boertje et al. (2007) recommended multi-year averages when using short-yearling mass and/or twinning rates to evaluate nutritional status of a moose population in order to incorporate annual variation resulting from differences in environmental conditions (e.g., weather, snow conditions, etc.). Our initial goal was to weigh 60 female short-yearlings (30 in the Tanana Flats and 30 in the Foothills) during March 2015. However, we had difficulty finding females due to low birth rates in 2014 and finding females in the foothills. As a result, we weighed 48 female and 12 male short-yearlings. The 2 population sample t-test was used to test for differences between pre- and post-treatment short-yearling mass stratified by sex. Confidence intervals and α were at the 95% level.

Results and Discussion

We captured and weighed 60 short-yearlings (n = 48 females and 12 males) during March 2015. For female short-yearlings, the difference of 11 lb between post-treatment (373 lb, n = 48) and pre-treatment mass (362 lb, n = 191) was not significant (t = 1.4046, DF = 23; P = 0.1614). For male short-yearlings, the difference of 58 lb between post-treatment (422 lb, n = 12) and pre-treatment mass (364 lb, n = 31) was significant (t = 4.7194, DF = 41; P = 0.0002753).

Recommendations for Activity 1.3

- Continue and modify capture and weighing of short-yearlings.
- Capture 30 male and 30 female short-yearlings during March 2016 to increase sample size of both males and females to improve power to detect difference in mean mass pre- versus post-treatment years.

Table 2. Unit 20A moose twinning rates from transect surveys, Interior Alaska, calendar years 2011–2015.

Calendar year	Date	Cows observed w/Single calf	w/Twins	Total	Twinning rate[a] (estimate)
2011	24–27 May	101	22	123	17.9 (6.9)
2012	25–27 May	109	17	126	13.3 (6.0)
2013	29 May–1 Jun	108	15	123	12.2 (5.9)
2014	24–28 May	76	10	86	11.6 (6.9)
2015	21–25 May	112	32	144	22.2 (6.9)

[a] Proportion of cows with calves that had twins (95% confidence interval, plus and minus the estimate).

2. Mortality-Harvest Monitoring and Regulations

ACTIVITY 2.1. Monitor and analyze harvest data and other mortality.

Data Needs

Monitoring and analyzing harvest data are essential to determine whether the IM harvest objective has been achieved, and harvests are sustainable.

Methods

We estimated annual harvest from required harvest report cards. Harvest data were summarized by regulatory year. This included data from report cards from the harvest ticket hunt, drawing hunts (i.e., bull hunts DM768–DM774, November muzzleloader bull hunt DM766, and antlerless hunts DM683–DM697 [RY10–RY11], DM628–DM679 [RY12–RY13]; Figs. 1–3), and registration hunts (i.e., antlerless hunts RM764 and RM768; Figs. 4–8). Hunters received 1 or 2 reminder letters and usually an e-mail and telephone calls if we did not receive timely harvest reports. We summarized data on hunter residency, hunter success, harvest chronology, and transport methods contained in the WinfoNet database. When antler size of bulls was reported, we considered bulls with antler spreads <30 inches to be yearlings.

We estimated total take by humans (excluding mortality by motor vehicles and trains) as reported hunter harvest times 1.35 (Boertje et al. 2009), which includes all other types of reported (e.g., defense of life or property, dispatched, potlatch, stickdance) and unreported (e.g., illegal, snaring, other, and wounding loss) types of take by humans. We estimated accidental mortality by motor vehicles and trains from Alaska Department of Public Safety and Alaska Railroad Corporation records.

We compared total annual reported harvest to the lower limit of the IM harvest objective for Unit 20A and reported harvest outside the boundaries of the Fairbanks nonsubsistence area to the lower limit of amounts reasonably necessary for subsistence (ANS) for moose harvest in that portion of Unit 20A.

Results and Discussion

Harvest by Hunters

Reported harvest of moose fell short of the IM harvest objectives of 1,400–1,600 (RY10–RY11) and 900–1,100 (RY12–RY14) adopted by the board in 2012 (Table 3). However, harvest densities were the highest recorded for similarly large areas of Interior Alaska. Reported harvest was within the ANS range of 50–70 moose RY10–RY12 (57–68 moose) but was below the lower limit in RY13 (32 moose) and RY14 (20 moose).

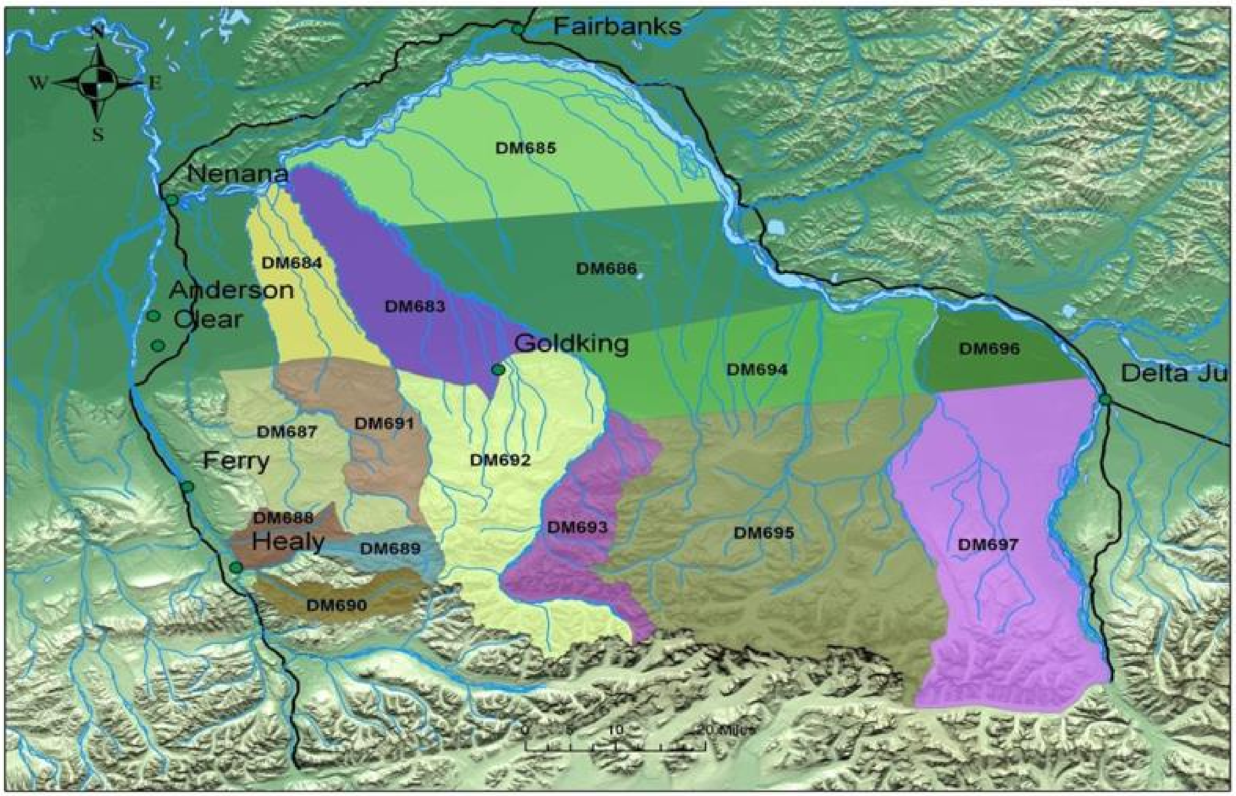

Figure 2. Antlerless drawing permit hunts DM683–DM697 hunt areas, Interior Alaska, regulatory years[a] 2010 and 2011.

[a] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 2010 = 1 July 2010–30 June 2011).

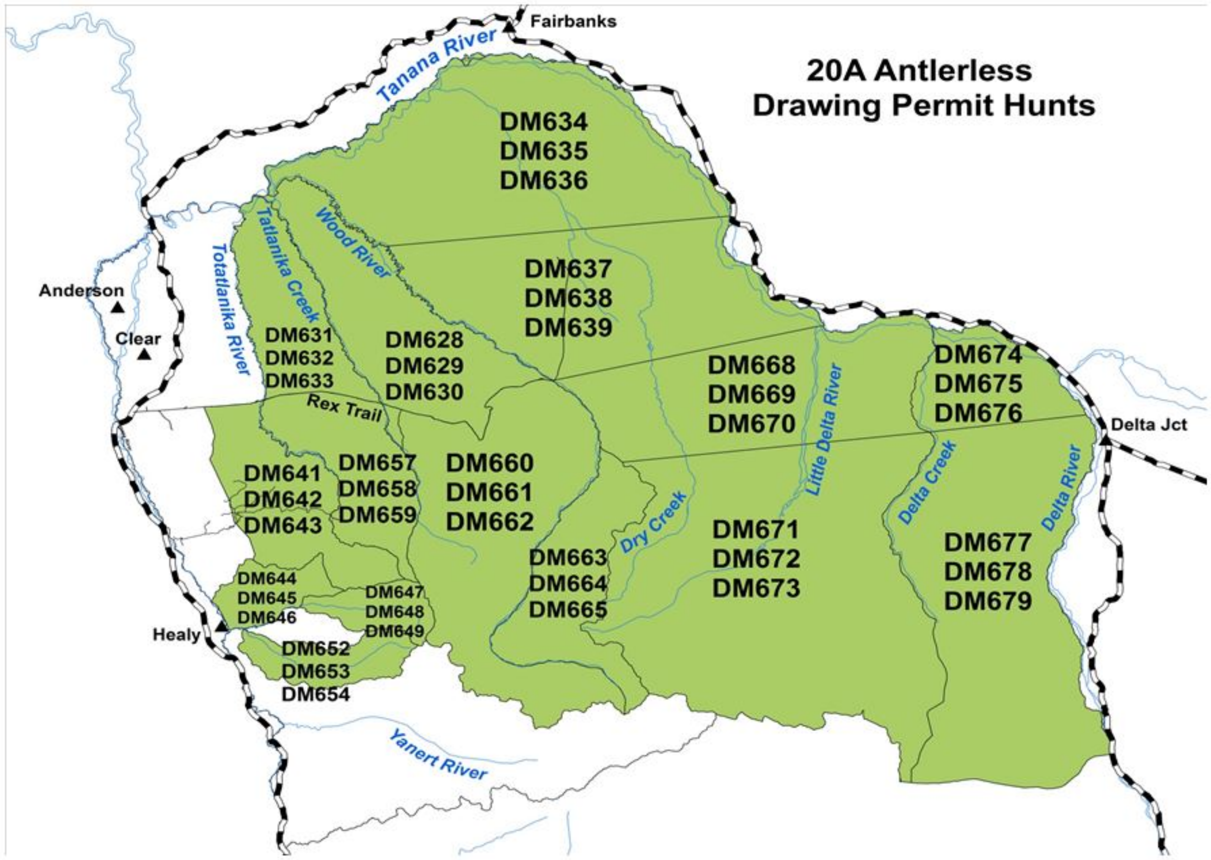

Figure 3. Antlerless drawing permit hunts DM628–DM679 hunt areas, Interior Alaska, regulatory years[a] 2012 and 2013.

[a] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 2012 = 1 July 2012–30 June 2013).

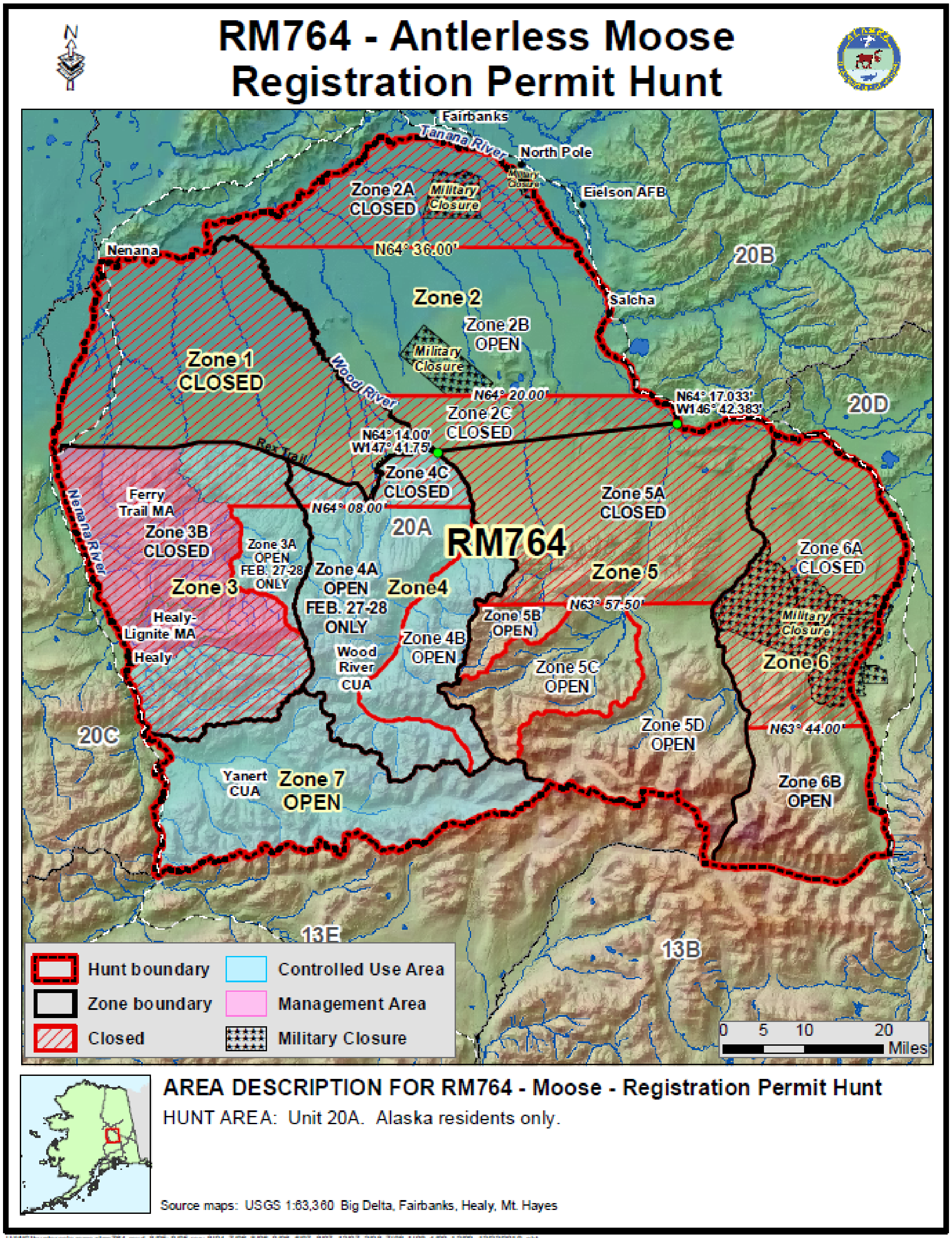

Figure 4. Antlerless moose registration hunt RM764 hunt areas, Interior Alaska, regulatory year[a] 2010.

[a] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 2010 = 1 July 2010–30 June 2011).

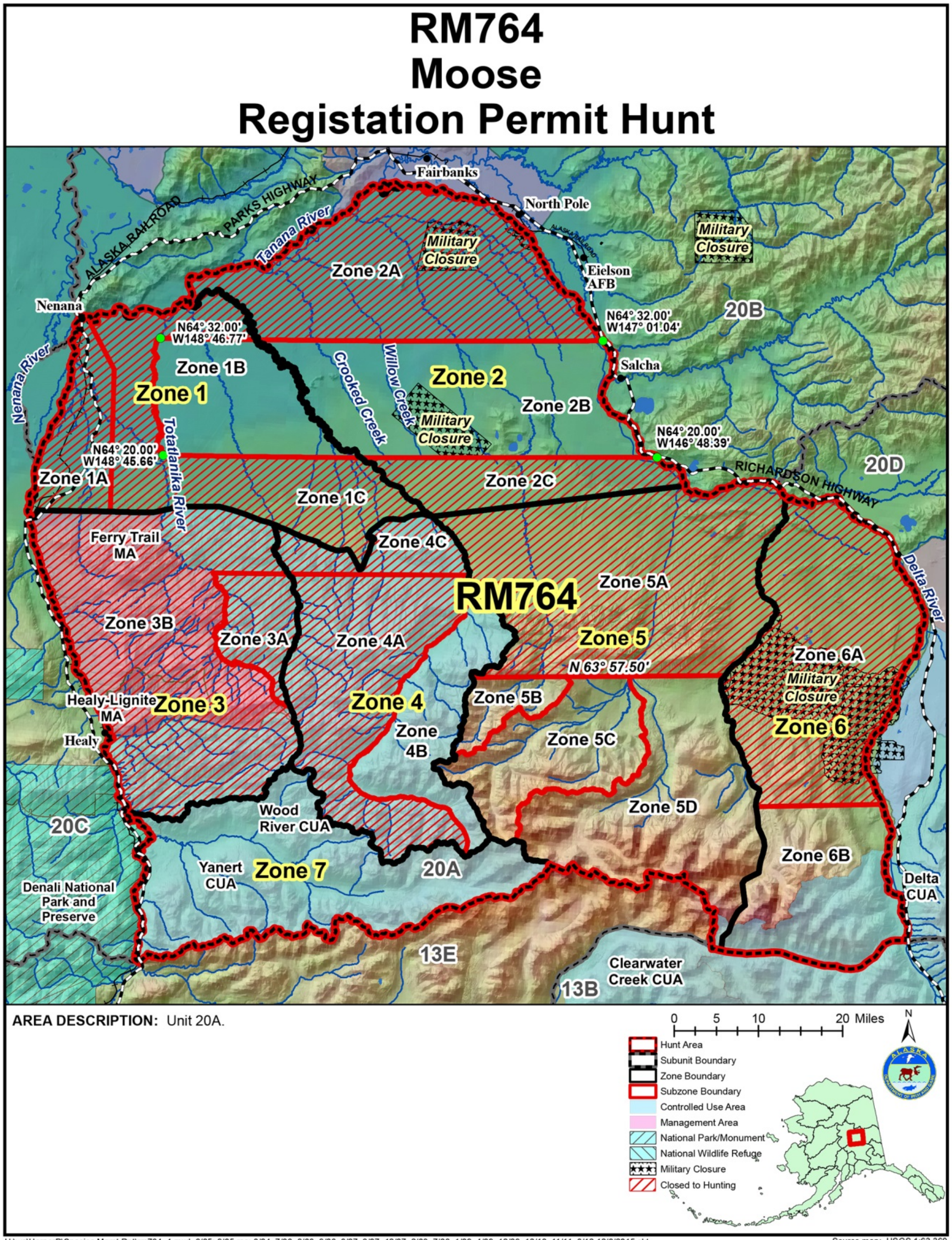

Figure 5. Antlerless moose registration hunt RM764 hunt areas, Interior Alaska, regulatory year[a] 2011.

[a] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 2011 = 1 July 2011–30 June 2012).

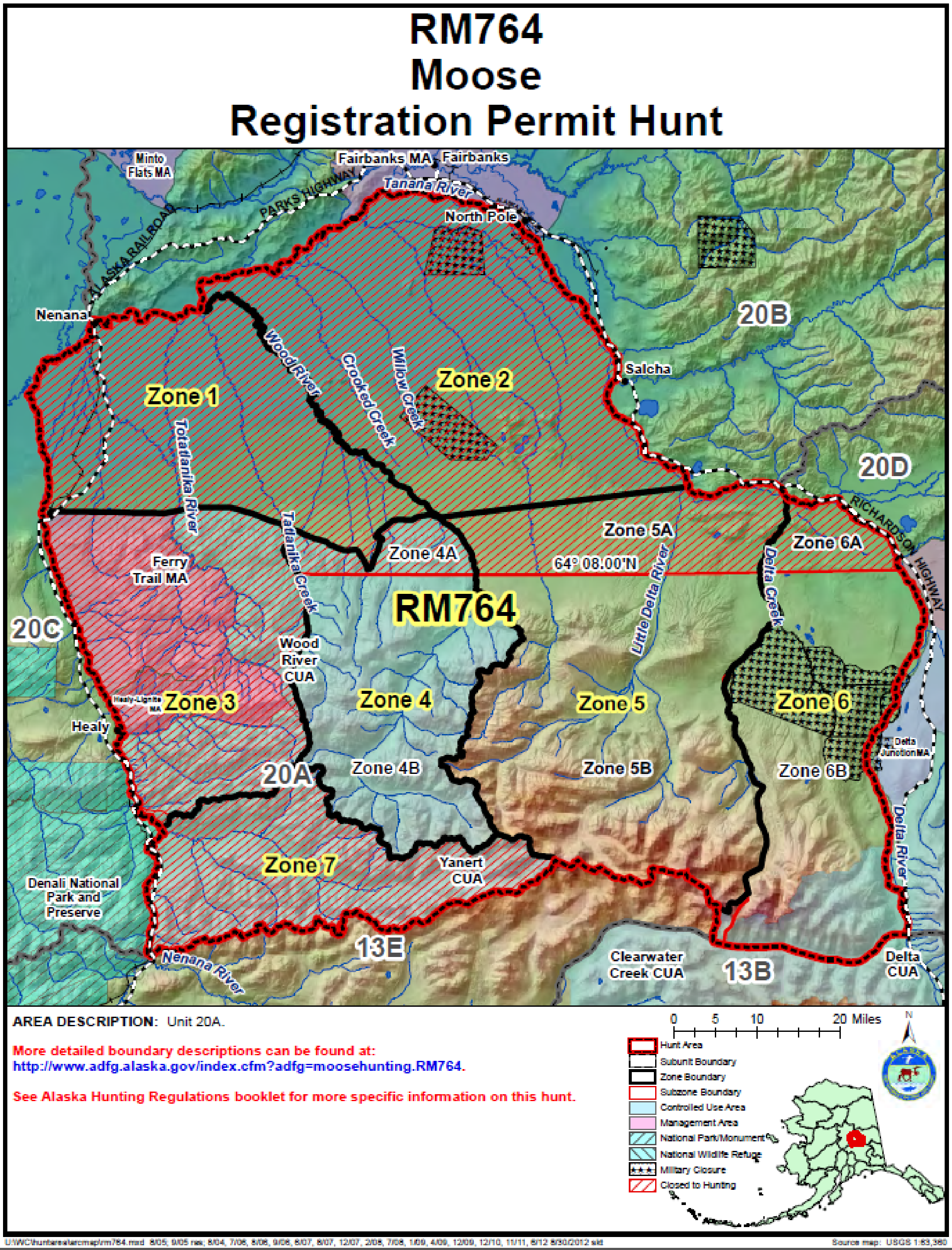

Figure 6. Antlerless moose registration hunt RM764 hunt areas, Interior Alaska, regulatory year[a] 2012.

[a] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 2012 = 1 July 2012–30 June 2013).

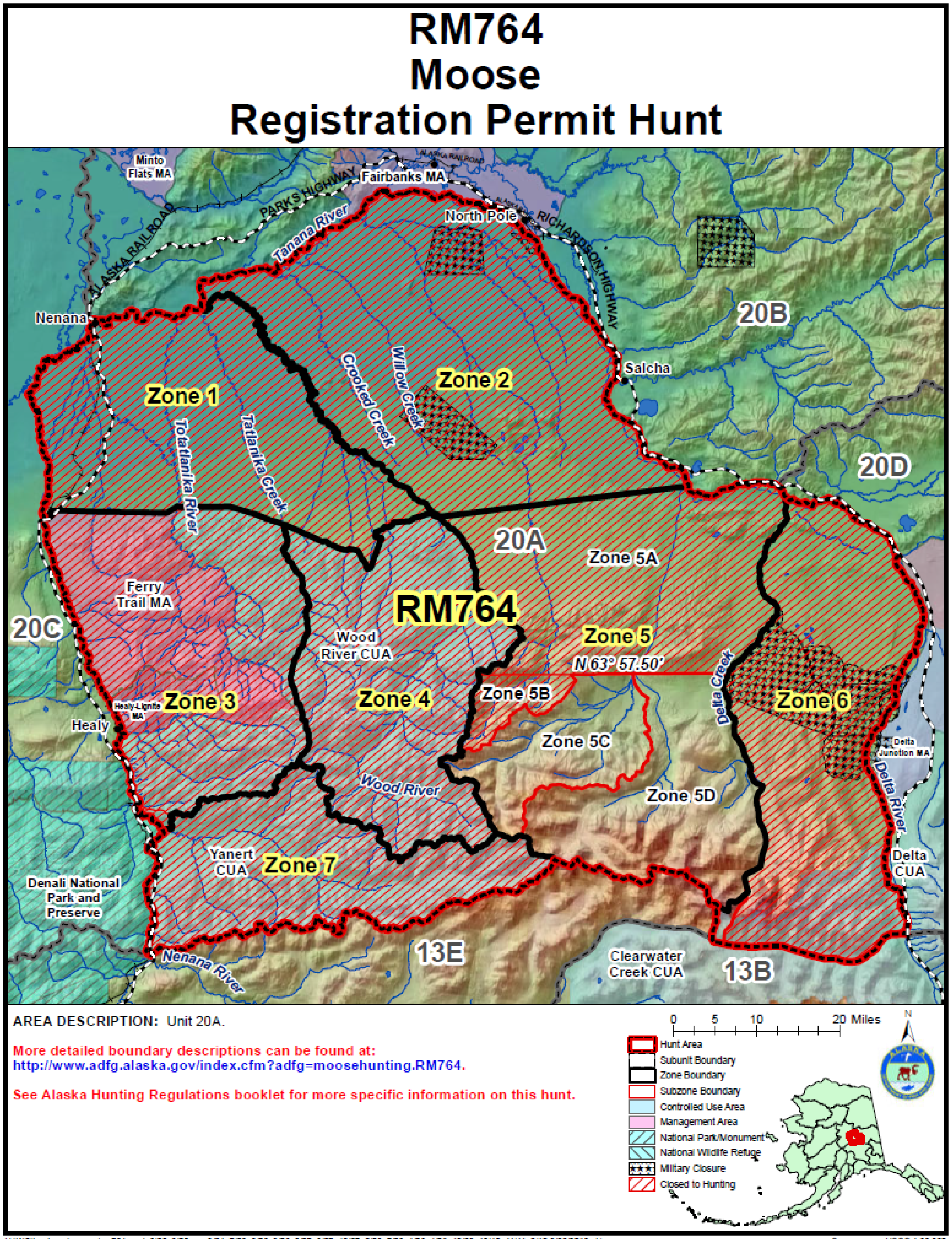

Figure 7. Antlerless moose registration hunt RM764 hunt areas, Interior Alaska, regulatory year[a] 2013.

[a] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 2013 = 1 July 2013–30 June 2014).

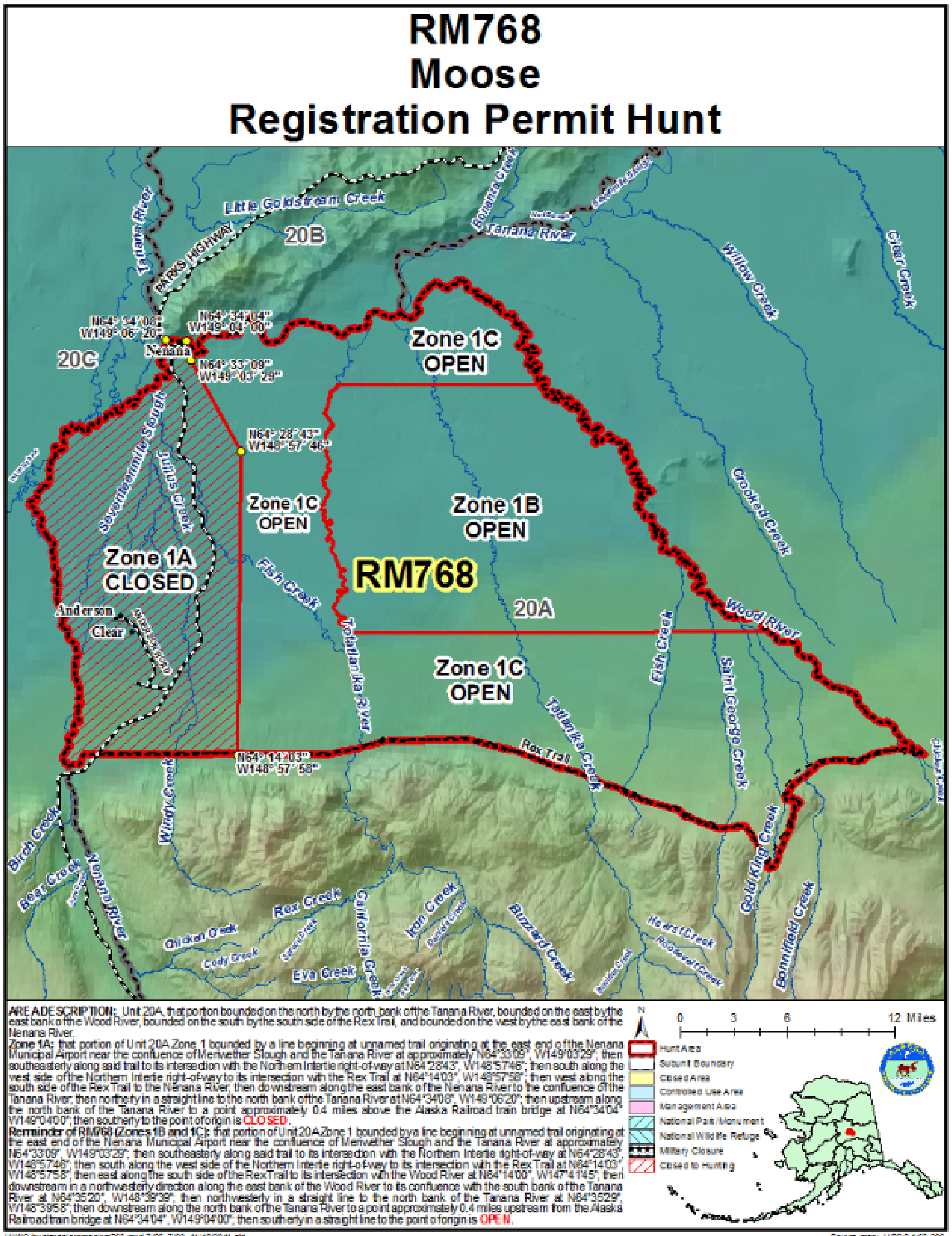

Figure 8. Antlerless moose registration hunt RM768 hunt area, Interior Alaska, regulatory years[a] 2010–2013.

[a] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 2010 = 1 July 2010–30 June 2011).

Table 3. Estimate of Unit 20A moose harvest[a] and accidental death, Interior Alaska, regulatory years[b] 2010–2014.

Regulatory year	Human take: Reported harvest by hunters M	F	Unk	Total	Estimated total[c]	Accidental death: Reported Road[d]	Train[e]	Total	Grand total
2010	593	231	3	827	1,116	1	7	8	1,124
2011	545	254	4	803	1,084	1	11	12	1,096
2012	519	177	0	696	940	1	11	12	952
2013	412	81	0	493	666	1	4	5	671
2014	430	0	2	432	583	1	1	2	585

[a] Includes general and permit hunt harvest.
[b] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 2010 = 1 July 2010–30 June 2011).
[c] Reported total harvest times 1.35 (Boertje et al. 2009); includes all other types of reported (e.g., defense of life or property, dispatched, potlatch, stickdance) and unreported (e.g., illegal, snaring, other, and wounding loss), except train and roadkill.
[d] Documented kills; actual number killed by vehicles is certainly greater. Average reported killed RY03–RY08.
[e] Confirmed dead between Alaska Railroad mileposts 371.0 and 411.7; "Missing" moose (moose hit but not recovered) are not included. Data provided by the Alaska Railroad.

General Season

Reported harvest of bull moose declined during RY10–RY14 likely due to a reduction in moose numbers and concurrent decline in the number of moose hunters (Table 4). In addition, a record late spring in 2013 and high mortality of yearlings likely resulted in fewer yearling bulls harvested during the RY13 season, particularly during the spike-fork/50″ restricted general season. Also, a record-setting wet summer greatly restricted access to the western Tanana Flats (i.e., the portion of Unit 20A "outside the Fairbanks nonsubsistence rea") via the Rex Trail which likely resulted in substantially lower harvest.

Permit Hunts

Bull

Beginning in 2010 we lowered the number of drawing permits for bull moose (DM768–DM774 and DM766) from 1,079 (RY13) to as low as 628 (RY14) to reduce the harvest of bulls and maintain bull:cow ratios near 30:100 (Table 5). We issued drawing permits for "any bull" based on population parameters (i.e., estimated number of bulls and bull:cow ratios within each hunt area) and hunter success rates to regulate harvest within the 7 hunt areas and, ultimately, more effectively manage bull:cow ratios and harvest distribution of bull moose across the unit (Young 2010, 2012, 2014).

Antlerless

Beginning in RY09, the department again (as in RY96–RY03) issued drawing permits for antlerless moose with the goal being to obtain as much of the antlerless harvest as possible during the fall (versus the winter registration hunt) in order to address social issues (e.g., reduce the take of antlerless bulls, reduce conflicts with trappers. During RY10–RY13, 43% (116/269), 57% (156/271), 57% (107/188), and 61% (56/92) of the antlerless moose were harvested during drawing permit hunts held during fall (Table 5). In general, antlerless moose permits declined from over 1,300 (RY10 and RY11) to 0 (RY14) as the moose population declined to our target of 12,000 moose, although it was a lower than the expected estimate of 10,156 moose in 2013 that resulted in antlerless permits being reduced to 0 in RY14.

Hunter Residency and Success

Moose hunter numbers steadily declined during the reporting period (Tables 4 and 5). The reduction in resident hunters, especially local hunters, may be in response to reduced opportunity as antlerless hunts were scaled back. However, the reduction in nonresident participation is more likely explained by knowledge of the reduction in moose numbers in Unit 20A.

Success rates averaged 24% (RY10–RY14) and were remarkably consistent with the exception of RY13 (Table 4). Lower success rates in RY13 were likely the result of fewer yearling bulls being available due to high mortality during spring 2013 and poor weather during the early part of the hunting season. Nonresident hunters had higher success rates than residents, which can likely be explained by the greater use of guides by nonresidents (Young 2008, 2010, 2012, 2014).

Other Mortality

No new information was gathered on natural or human-caused mortality outside of harvest during this reporting period. Historic information on predation and vehicle or train accidents are summarized in Young (2012).

Recommendations for Activity 2.1

- Continue to monitor total harvest for comparison with the IM harvest objective.
- Modify comparisons of reported harvest to the lower threshold of the IM harvest objective using 3-year running means to account for annual variability.
- Recommend to the Board of Game lowering IM harvest objectives from 900–1,100 to 500–720.

Table 4. Unit 20A general season moose hunter[a] residency and success, Interior Alaska, regulatory years[b] 2010–2014.

Regulatory year	Successful					Unsuccessful					Total hunters
	Local[c] resident	Nonlocal resident	Nonresident	Unk	Total (%)	Local[c] resident	Nonlocal resident	Nonresident	Unk	Total (%)	
2010	135	80	103	30	348 (26)	563	277	101	51	992 (74)	1,340
2011	136	97	74	8	315 (27)	470	298	80	21	869 (73)	1,184
2012	126	81	70	11	288 (25)	429	325	78	26	858 (75)	1,146
2013	84	54	52	3	193 (17)	484	371	93	10	958 (83)	1,151
2014	130	67	77	3	277 (27)	430	242	82	8	762 (73)	1,039

[a] Excludes hunters in permit hunts.
[b] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 2010 = 1 July 2010–30 June 2011).
[c] Residents of Unit 20.

Table 5. Unit 20A moose harvest data by permit hunt, Interior Alaska, regulatory years[a] 2010–2014.

Permit hunt	Regulatory year	Permits issued	Successful hunters (%)	Unsuccessful hunters (%)	Did not hunt (%)	Male (%)	Female (%)	Unk	Harvest
Totals for antlered drawing permit hunts	2010	936	208 (40)	307 (60)	421 (45)	208 (100)	0 (0)	0	208
	2011	827	216 (47)	242 (53)	369 (45)	216 (100)	0 (0)	0	216
	2012	871	219 (46)	261 (54)	391 (45)	219 (100)	0 (0)	0	219
	2013	1,079	206 (36)	364 (64)	509 (47)	206 (100)	0 (0)	0	206
	2014	628	153 (48)	164 (52)	311 (50)	153 (100)	0 (0)	0	153
Totals for antlerless drawing permit hunts	2010	645	116 (35)	216 (65)	313 (49)	1 (1)	115 (99)	0	116
	2011	765	154 (39)	245 (61)	366 (48)	0 (0)	156 (95)	0	156
	2012	571	107 (36)	188 (64)	276 (48)	4 (4)	103 (96)	0	107
	2013	439	56 (33)	113 (67)	270 (62)	3 (5)	53 (95)	0	56
	2014	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0	0
Totals for antlerless registration permit hunts	2010	710	153 (41)	220 (59)	337 (47)	38 (26)	110 (74)	5	153
	2011	618	115 (43)	151 (57)	352 (57)	14 (13)	97 (87)	4	115
	2012	558	81 (51)	77 (49)	400 (72)	7 (9)	74 (91)	0	81
	2013	232	36 (53)	32 (47)	164 (71)	9 (25)	27 (75)	0	36
	2014	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0	0
Totals for all antlerless permit hunts	2010	1,355	269 (38)	436 (62)	650 (48)	39 (15)	225 (85)	5	269
	2011	1,383	269 (40)	396 (60)	718 (52)	14 (5)	253 (95)	4	271
	2012	1,129	188 (42)	265 (58)	676 (60)	11 (6)	177 (94)	0	188
	2013	671	92 (39)	145 (61)	434 (65)	12 (13)	80 (87)	0	92
	2014	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0	0

[a] Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 2010 = 1 July 2010–30 June 2011).

3. Habitat Assessment-Enhancement

ACTIVITY 3.1. Assess habitat condition.

- None.

Data Needs

Monitoring forage utilization by moose and forage plant condition enables evaluation of whether moose density is having an adverse effect on habitat. This is necessary to meet the goal of protecting moose habitat.

Methods

There were no habitat monitoring efforts this reporting period, but area staff assisted with a research project in 2012 that evaluated forage production and offtake by moose in areas partly affected by recent burns in Unit 20A (Paragi et al. 2015). Indirect monitoring of moose response to recent burns is also addressed in Activities 1.1 and 1.2.

Results and Discussion

None this reporting period.

Recommendations for Activity 3.1

- Continue to evaluate the need for estimating browse offtake and browse plant condition to be obtained as a confirmatory metric when abundance of moose changes substantially or twinning surveys indicate substantial change in moose nutritional condition. Guidelines for degree of change warranting browse surveys is provided in Boertje et al. (2007) and Paragi et al. (2015), both of which have information specific to Unit 20A.

- Continue to evaluate the opportunity for habitat enhancement in areas of late-seral condition through fire management options (suppression policy), prescribed fire, or mechanical treatments designed to enhance early-seral habitat, particularly in areas accessible to hunters.

NONREGULATORY MANAGEMENT PROBLEMS OR NEEDS

The Alaska Railroad Corporation Northern Rail Extension Project's proposed alignment between Fairbanks and Delta Junction remains an issue and the department has been involved in discussions to mitigate these impacts (Young 2014).

The military has development plans that also could restrict moose movements. In 2011 ADF&G expressed its concerns in comments submitted on the military's proposed Joint Pacific Alaska Range Complex (JPARC) Modernization and Enhancement Draft Environmental Impact Statement (ADF&G Draft Scoping Comments 2011, Office of the Commissioner, 9 July 2012, Juneau). Proposed restricted access corridors and expansion within Unit 20 could impair the ability of the department to continue long-standing, on-going research projects, increase costs due to the need to circumvent airspace or schedule additional flights, and cause researchers to reduce, abandon, or not undertake future projects to monitor moose or other species if predictable, adequate access to airspace cannot be assured. Without the continued ability to free access to the airspace in the region, particularly below 7,000 feet above ground level, necessary fish and wildlife population management in this area could be reduced. A reduction in the quantity and quality of data could result in a need to manage species on a more conservative basis, leading to fewer opportunities for harvest, including subsistence. Of particular concern is the active management of the Nelchina caribou herd, Units 13 and 20 moose and wolf populations, and Gulkana River Chinook and sockeye salmon, all of which are highly sought by the public. These species are managed by the department through extensive oversight and deliberative processes, including direction from the Alaska Boards of Fisheries and Game. Proposed access restrictions that could accompany the expansion may have a chilling effect on the ability of the public to freely use and enjoy the area. Public access and spontaneous use associated with good weather days could be curtailed, as would public access of desired areas due to possible corridor closures, the need to request entry authorizations, and other restrictions to airspace that would result in the public incurring extra monetary expenditures in fuel and time to avoid military operations. Additionally, Alaska is notorious for poor weather-related flying conditions, and the ability of the average private pilot to understand and comply with flight restrictions under poor flying conditions may pose a hazard to both military and private pilots operating in the area.

Recording

- GSPE Moose Survey Form (Appendix A).
- Moose Twinning Survey Form (Appendix D).
- Calf weights, morphometric measurements and other pertinent information will be recorded on a standardized ‘UNGULATE DATACARD’ (Appendix J).
- Topo!®Version 4.2.4, ©2006 National Geographic Holdings.

Archiving

- GSPE and harvest data are stored on an internal database housed on a server (http://winfonet.alaska.gov/index.cfm). Field data sheets for surveys are stored in 3-ring binders located in the Fairbanks Area Biologist office.
- All other electronic data and files such as survey memos and reports are located on the computer (C:\Users\ddyoung\Documents\Moose\) in the Fairbanks Area Biologist office (Room 120) and regional office server (S:\FAIRBANKS AREA\Moose\). Field data sheets, paper files, hard copies, etc. are located in the file cabinet located in Fairbanks Area Biologist office.

Conclusions and Management Recommendations

Population estimates indicate the Unit 20A moose population remained above 12,000 moose (lower end of revised IM population objective) during the reporting period except for 2013, when abundance was estimated at 10,156 moose.

Continued low twinning rates and relatively low short-yearling mass indicate the moose population at this density (~2.5 moose/mi^2) remains relatively unproductive. Research indicated that moose production in Unit 20A was reduced because of high moose densities and declining habitat condition (Boertje et al. 2007; Boertje et al. 2009; Paragi et al. 2015). Our long-term objective is to stabilize the moose population unless we observe improvements in moose productivity, condition, or winter forage from reduced moose densities and habitat improvements caused by recent wildland fires.

Antlerless moose harvest should continue to be evaluated as a tool to prevent an overabundance of moose that are vulnerable to the synergistic effects of adverse weather and increased predation (Boertje et al. 1996). In addition, it remains important to improve habitat quality and determine the status of the Unit 20A moose population relative to nutritional and climate limitations, and potentially increasing predator numbers.

We met our management objectives for bull:cow ratios. High or increasing bull:cow ratios during 2001–2008 indicated that unitwide antler restrictions initiated in RY02 were effective (Young and Boertje 2008), and harvest rates of bulls were below maximum sustainable levels. During RY10–RY14 I recommended retaining unitwide antler restrictions for both resident and nonresident hunters in conjunction with a limited drawing permit hunt for “any bull” moose to optimize harvest. I also recommended a harvest rate for bulls of 15–20% of the prehunt bull population. For RY15–RY19 I recommend that we continue to use antler restrictions as the primary mechanism to regulate the harvest of bulls to maintain desired bull:cow ratios and to manage hunter and harvest densities at various spatial scales (e.g., Unit 20A, management area, controlled use area, and subarea). We should continue to closely monitor bull:cow ratios both at unitwide and lesser spatial scales to monitor the effects of current regulatory changes on those ratios.

We did not meet the IM harvest objective of 1,400–1,600 moose annually in RY11 or 900–1,100 moose during RY12–RY14. To meet this harvest objective, it will be necessary to harvest moose across all sex and age classes (i.e., adult bulls, adult cows, and calves) at a relatively high rate that is not sustainable over the long term. Given that moose abundance in Unit 20A is within the desired level, I recommend a selective harvest strategy (i.e., antler-restricted bull hunts, limited “any bull” drawing permit hunts, and antlerless hunts including both cows and calves) with a harvest ratio of approximately 60 bulls:20 cows:20 calves to maximize yield.

II. PROJECT REVIEW AND RY15–RY19 PLAN

Review of Management Direction

MANAGEMENT DIRECTION

There are no changes to the management direction for moose in Unit 20A.

GOALS

- Protect, maintain, and enhance the moose population and its habitat in concert with other components of the ecosystem.
- Provide the greatest sustained opportunity to participate in hunting moose.

Existing management goals are appropriate and will remain the same.

OBJECTIVES

Recommended changes or clarification of decision frameworks for objectives are noted below. Linkage of management recommendations to metrics of population trend, nutritional status, and bull:cow ratio in the context of management objectives is specified in a decision framework (Appendix K).

CODIFIED OBJECTIVES

Amount Reasonably Necessary for Subsistence Uses (ANS)

C1. Unit 20A, that portion outside the boundaries of the Fairbanks nonsubsistence area has a customary and traditional use finding for moose with amounts reasonably necessary for subsistence uses of 50–75 moose (New: this objective will be considered to be met if the midpoint of the annual prehunt population estimate and 5% harvest rate [reported harvest] is greater than or equal to the lower threshold of ANS).

Intensive Management

C2. Population objective: 10,000–15,000 moose (New: objective considered to be met if at least 2 of the last 3 point estimates of the fall population is greater than or equal to the lower threshold of the IM population objective).

C3. Harvest objective: 500–900 moose (New: objective considered to be met if reported harvest is greater than or equal to the lower threshold of IM harvest objective for at least 2 of the last 3 years).

**New IM population and harvest objectives of 10,000–15,000 moose and 500–900 moose (5–6% reported harvest rate) were adopted by the Alaska Board of Game at their March 2016 meeting.*

MANAGEMENT OBJECTIVES

M1. Manage population levels based on multi-year mean spring twinning rates in conjunction with at least one of the following signals to substantiate low twinning-based nutritional status: 1) <50% of 36-month-old moose are parturient; 2) average multi-year short-yearling mass is <385 lb; or 3) >35% of annual browse biomass is removed by moose (Boertje et al. 2007):

a. <10% twinning rate (manage for population reduction).

b. 10–20% twinning rate (manage for population stability).

c. >20% twinning rate (manage for population growth).

Objective M1 remains the same.

M2. Manage for a posthunting sex ratio of ≥25 bulls:100 cows.

Objective M2 is revised for RY15–RY19. The department will manage for a posthunting sex ratio of ≥25 bulls:100 cows (reduced from to 30 bulls:100 cows). The Fairbanks and Middle Nenana Fish and Game advisory committees were informed of this change in February 2016. The prior objective of ≥20 bulls:100 cows in the Tanana Flats, western foothills, and eastern foothills areas will be dropped.

Rationale

Schwartz (1998) noted that lower bull:cow ratios may suffice to ensure pregnancy in higher density populations compared to widely distributed populations with lower densities. Since Unit 20A has a relatively high moose density (>2 moose/mi^2), a ratio lower than the standard 30 bulls:100 cows is biologically feasible. Also, we do not have adequate precision in our GSPE bull:cow ratio estimates at the subarea scale (i.e., 90% CI ± 25–40%) to manage by subarea (i.e., Tanana Flats, western foothills, and eastern foothills).

REVIEW OF MANAGEMENT ACTIVITIES

1. Population Status and Trend

ACTIVITY 1.1. Geospatial population estimation (GSPE) surveys (Objectives C1, C2, C3, M2).

Data Needs

No change from prior reporting period, but desired precision is specified: we seek to estimate annual abundance (annual population estimates, 90% CI ± 13–18%), productivity (i.e., calf:cow ratios with 90% CI ± 10–20%) and survival/recruitment/escapement (yearling bull:cow ratios with 90% CI ± 20–50%; bull:cow ratios with 90% CI ± 15–25%) to evaluate population status and trend.

Moose abundance and age-sex composition are integral components of management. GSPE is the preferred technique for estimating abundance and also provides age-sex composition with variance. These estimates are used for monitoring demographic trends in response to management actions intended to influence type of harvest (sex, antler configuration, total amount that is sustainable yield) for meeting IM population objectives and bull:cow objectives. Monitoring calf:cow and yearling:cow ratios allow understanding of demographic changes indicative of production and natural mortality on calves.

Methods

- GSPE with SCF trials (see *Population Status and Trend*, *Methods* in the Management Report portion of this document; Kellie and DeLong 2006).
  - Maintain SU ratio of 70 high:30 low moose density.
  - Alternate high (≥100 SUs) and low intensity (≥60 SUs) GSPE surveys annually (Kellie and DeLong 2006:42) in Unit 20A, since we also need to conduct GSPE surveys annually in Unit 20B, which also has IM objectives. Adequate resources (pilots,

observers, adequate weather and daylight) are not available to accomplish 2 high intensity surveys each year.

  - Abundance estimates (90% CI) will be compared to the lower limit of the ANS and IM population objectives.
  - Biometric review:
    - Estimate the abundance of moose by using the GSPE with sightability correction factor such that a 90% CI has bounds between 13% and 18%. Biometrician and biologist to review the ability to achieve the level of precision before surveys.
    - Estimate trend in moose populations using linear mixed effects models. (DeLong and Taras 2009).

- Composition estimates:
  - Evaluate bull:cow ratio estimates (90% CI) in relation to the lower limit of the bull:cow ratio management objective (New: 25 bulls:100 cows).
  - Use linear mixed effects models to evaluate changes in trend in population, calf: yearling: and bull:100 cows over 5-year periods.
  - Biometric review:
    - Estimate bull:cow, yearling bull:cow and calf:cow ratios and construct 90% CI using the GSPE. Review the historical precision of the surveys and determine the precision necessary to compare survey results to the objective.

ACTIVITY 1.2. Spring twinning surveys (Objectives C2, M1).

Data Needs

No change from prior reporting period. Estimates of moose nutritional condition and productivity are integral to management on a sustained yield basis over the long term and the goal of protecting moose health and habitat. Data gathered during twinning surveys about how many cows have twins provide an indication of condition and productivity.

Methods

- No change from prior reporting period except specified desired precision of 95% CI ± 5–8%.
  - Multi-year mean unitwide twinning rates (95% CI ± 5–8%) for assessing status among categories in objective M1.

- Biometric review: Estimate twinning rates and construct 95% CI. Review the historical precision of the surveys and then determine the precision necessary to compare survey results to the objective M1.

ACTIVITY 1.3. Short-yearling mass estimates (Objectives C2, M1).

Data Needs

Short-yearling mass provides information about the nutritional condition of the moose population that is integral to management on a sustained yield basis over the long term.

Methods

- Compare mass of 120 short-yearlings captured in 2015–2016 (after population reduction aided by liberal antlerless harvest) with short-yearlings weighed during 1997–2003 (before liberal antlerless harvest and population reduction) and to the 385 lb threshold identified to substantiate low twinning-based nutritional status (Boertje et al. 2007). Multi-year samples (2015–2016) will be incorporated to account for annual variation in short-yearling weights resulting from differences in environmental conditions (e.g., weather, snow conditions, etc.)
- Test differences in the mean mass of short yearlings pre- and post-treatment stratified by sex.
- Compare mean female short-yearling mass (95% CI) against 385 lb threshold (Boertje et al. 2007).
- Biometric review: Estimate the mean mass and test differences between pre- and post-treatment using 2 population sample *t*-test. Area biologist and biometrician to determine what difference in short-yearling mass is biologically significant and the statistical power needed to detect that change for the next survey.

2. Mortality-Harvest Monitoring and Regulations

ACTIVITY 2.1. Monitor and analyze harvest data and other mortality (Objectives C3, M2).

Data Needs

No change from prior reporting period. Monitoring and analyzing harvest data are essential to determine whether the IM harvest objective has been achieved, and harvests are sustainable.

Methods

- Monitor total harvest for comparisons with the IM harvest objective (methods will be those described in Management Report section under *Mortality-Harvest Monitoring and Regulations*).
- Compare reported harvest to the lower limit of the IM harvest objective using 3-year running means to account for annual variation in harvest.
- Use linear regression models to evaluate harvest trends.
- Biometric review: We may need to review management or research questions about harvests (hunter behavior or population monitoring) that are meaningful to include in management reports and for decisions. A biometrician needs to review the harvest card procedures, consistency of data (e.g., reporting rates, nonreporting), and independence issues for analysis with attention to possibly autocorrelation.

3. Habitat Assessment-Enhancement

ACTIVITY 3.1. Assess habitat condition (Goal of protecting habitat).

Data Needs

No change from prior reporting period. Monitoring forage utilization by moose and forage plant condition enables evaluation of whether moose density is having an adverse effect on habitat. This is necessary to meet the goal of protecting moose habitat.

Methods

No change from prior reporting period. There were no habitat monitoring efforts this reporting period, but area staff assisted with a research project in 2012 that evaluated forage production and offtake by moose in areas partly affected by recent burns in Unit 20A (Paragi et al. 2015). Indirect monitoring of moose response to recent burns is also addressed in Activities 1.1 and 1.2.

NONREGULATORY MANAGEMENT PROBLEMS OR NEEDS

- Work with the U.S. Air Force to mitigate conflicts between training and fall hunting seasons for moose, caribou, and Dall sheep with respect to hunter disturbance and access restrictions.

- The Alaska Railroad Corporation Northern Rail Extension Project's proposed alignment between Fairbanks and Delta Junction would traverse the Tanana Flats just south of the Tanana River, potentially between Salcha and Delta Junction. The rail extension would bisect important moose habitat in the Fairbanks area in Units 20A and 20B. Of greatest concern is potential moose mortality caused by trains, primarily during winter months. If fences are built, these will be impediments to seasonal moose migrations between the Tanana Flats calving areas and the adjacent Tanana Hills in Unit 20B. The Fairbanks Area management staff has been involved in discussions to mitigate these impacts.

Recording

- GSPE Moose Survey Form (Appendix A).
- Moose Twinning Survey Form (Appendix D).
- Delorme Topo North America V. 10.0 desktop software (used to record and store location data).
- Calf weights, morphometric measurements, and other pertinent information will be recorded on a standardized 'UNGULATE DATACARD' (Appendix J).
- Capture and harvest data will be entered into the WinfoNet database. Field data sheets will be scanned to PDF and housed on the computer in the Fairbanks Area Biologist office (C:\Users\ddyoung\Documents\Moose\2015\Capture) and regional office server (S:\FAIRBANKS AREA\Moose\2015\Capture) and paper files (file cabinet Room 120).

Archiving

- GSPE data will be stored on an internal database housed on a server (http://winfonet.alaska.gov/index.cfm) and archived in WinfoNet under Survey and Inventory Tools. Field data sheets will be stored in 3-ring binders located in the Fairbanks Area Biologist office (Room 120).
- All other electronic data will be located on the computer (C:\Users\ddyoung\Documents\Moose\) in the Fairbanks Area Biologist office and regional office server (S:\FAIRBANKS AREA\Moose\).
- Survey memos will be archived in WinfoNet Data Archive.
- Field data sheets, paper files, hard copies, etc. will be located in the file cabinet located in Fairbanks Area Biologist office.

Agreements

- U.S. Army Fort Wainwright Cooperative Agreement dated 30 June 2012.

Permitting

- ADF&G Collecting Permit (Don Young #98-082).
- IACUC Unit 20A Moose #'s 2015-02, 2016-02.

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♦ ♦ ♦

Appendix A. Fairbanks area spatial moose survey form, Interior Alaska.

FAIRBANKS AREA SPATIAL MOOSE SURVEY FORM

Page ___ of ___ | Form CTS 12/15/04

SEARCH IDENTIFICATION

Date: ________ SU #: ______
GMU: ________
Location: ____________________
Observer: ____________________
Pilot: ____________________
Aircraft Type: ________ Temp (F) ______

SEARCH TYPE
(check one or both)
☐ Standard
~8-9 min/mi²
☐ Composition
~ 4 min/mi²
Strata pre-survey: ______
Strata post-survey: ______

Lat
Lon

SEARCH TIMES
(in minutes)
Stop@ ________
Start@ ________
Elapsed ________

OVERALL SURVEY RATING: ☐ Excellent ☐ Good ☐ Fair ☐ Poor

SEARCH CONDITIONS

SNOW AGE
☐ 1. Fresh
☐ 2. < 1 week
☐ 3. >1 week

LIGHT TYPE
☐ 1. Bright
☐ 2. Flat

SNOW COVER
☐ 1. Complete
☐ 2. Some Low veg Showing
☐ 3. Bare Ground Showing

LIGHT INTENSITY
☐ 1. High
☐ 2. Medium
☐ 3. Low

% PREDOMINANT HABITAT TYPE IN SU
____1. Open lower elevation, pradam shrub, riparian, or wetland
____2. Mixed Open Forest with some shrub understory
____3. Dense Spruce Forest
____4. Dense Deciduous Forest Birch, Aspen, etc. Few Shrubs
____5. Subalpine Shrub
____6. Burn- take a guess at the year burned ________
____7. Other (describe):
____8. Non search habitat (rock, ice, alpine, etc)

CHECK ADDITIONAL CONDITIONS THAT MAY HAVE AFFECTED THE QUALITY OF THE SEARCH

☐ Classification Errors
☐ Uncooperative Pilot
☐ Inadequate Search Effort
☐ Short on Fuel
☐ Windy/Turbulent
☐ Other (Explain):
☐ Inadequate Snow Cover
☐ Inexperienced Pilot
☐ Movement In/Out Of Intensive
☐ Movement In/Out of SU
☐ Improper Aircraft
☐ Poor Light
☐ Inexperienced Observer
☐ Too Many Moose in Intensive (>15)
☐ Observer Airsick
☐ Low Clouds or Fog
☐ Poor Visibility/Snow on Trees
☐ Problems finding SU Boundaries
☐ Observer Sleeping

OTHER SPECIES— ________# of Ptarmigan seen in unit

Group No.	Bulls					Cows				MISC		Total Moose	Remarks/Waypoint/Lat-Lon
	Yearling		Medium		Lg.	Cow w/0	Cow w/1	Cow w/2	Cow w/3	Lone Calf	Unk.		
	≤8F	>8F	31-40	41-50	>50								
1.													
2.													
3.													
4.													
5.													
6.													
7.													
8.													
9.													
10.													
11.													
12.													

Additional Lines on Back of Sheet If Needed

Survey Summary (Do not add calves to cows in column totals)														
1-12													Survey Unit Summary:	
13-46													# Moose in SU Search:	
Total													% Potential search habitat in SU:	

Appendix B. Unit 20A moose survey memorandum, Interior Alaska, 2010.

STATE OF ALASKA

SEAN PARNELL, GOVERNOR

DEPARTMENT OF FISH AND GAME

DIVISION OF WILDLIFE CONSERVATION

1300 College Road
Fairbanks, AK 99701-1599
PHONE: (907) 459-7213
FAX: (907) 452-6410

MEMORANDUM

TO: Roy Nowlin

FROM: Don Young, Fairbanks Area Biologist

DATE: 29 March 2011

SUBJECT: GSPE Moose Survey, Unit 20A, 2010

We conducted moose population estimation/composition surveys in Unit 20A 3-7 and 12 December, 2010. Observers were ADF&G employees S. Dubois, T. Hollis, Nate Pamperin, L. Parrett, C. Roberts, M. Taras, R. St. Louis, J. Wells, D. Young and volunteers Amal Ajmi (Ft. Wainwright Natural Resources biologist), Cam Carroll (UAF graduate student intern), Rachael Crawford (UAF wildlife student), Jesse Cummings (Golden Eagle Outfitter's), Debbie Wagaman-Curnow (Fairbanks F&G AC member), Vince Holton, Leonard Jewkes (Fairbanks F&G AC member), G. Kuhn (ADF&G retired), and Bret Taylor. Surveys were flown in Scout and Supercub aircraft piloted by T. Cambier (Chena River Aviation), Jim Cummings (Golden Eagle Outfitter's), Jesse Cummings (Golden Eagle Outfitter's), E. Finch (Alaska Wilderness Safaris), A. Greenblatt (Shadow Aviation), M. Keech (ADF&G), T. Seaton (ADF&G), M. Snyder (Alaska Hunting Adventures), M. Webb (Tundra Air), and P. Zaczkowski (Papa Zulu Air).

- **Methods**

We surveyed 114 (78 high-density and 36 low-density; 670 mi^2) of 987 survey units (SUs; 5747 mi^2) using the Geospatial Population Estimator method (GSPE), a modification of the standard Gasaway technique. A simple random sample of 70 high-density and 30 low-density SUs was selected using Microsoft®Excel Windows®07 software. An additional 13 SUs were selected to fill gaps in the coverage and 1 SU (low-density SU 225) was done mistakenly.

We flew 82.5 total hours (ferry time excluded). Average search time per SU with 100% moose habitat (n=76) was 48.0 minutes. Survey conditions (Gasaway et al. 1986; n=111) with regard to snow (age and cover), light (intensity and type), and wind (strength and turbulence) were mostly good (55%) with the remainder being fair (26%), excellent (14%), and poor (5%). In general, survey conditions during 2010 were less favorable than in 2009 (good [66%] and the remainder excellent [19%] and fair [15%]), which likely affected sightability.

- **Results**

- Unit 20A survey results are presented in Table 1.

- **Summary**

  - The current population estimate of 14,497 (12,545–16,448; 90% CI) moose along with moderate calf:cow ($\bar{x}$ = 32:100, 2008-2010), and yearling:cow ($\bar{x}$ = 20:100, 2008-2010) ratios and female harvest rates (<2% of the prehunt moose population, RY 2008-2010) suggests that moose numbers are increasing;
  - Moose density remains high at an estimated 2.9 moose/mi^2 (5040 mi^2 of suitable moose habitat);
  - 32 calves:100 cows similar to 1999-2009; and
  - 32 bulls:100 cows above management objective of 30:100 for seventh straight year.

- **Recommendations**

I recommend a harvest of 300-450 (2%-3% of estimated 15,000 moose prehunt) female moose in RY 2011. My long-term objective is to slowly reduce the moose population to the upper limit of the IM population objective of 10,000-12,000 moose, unless we begin to observe improvements in indices of the moose population’s nutritional plane (e.g., twinning ratios, short yearling weights,) resulting from reduced moose density and recent habitat improvements (i.e., 2001 Fish and Survey Line, 2006 Parks Highway, 2009 Wood River Buttes and Rex fires).

Improved bull:cow ratios, 2003-2008, indicated that unit wide antler restrictions (begun RY02) were effective in recovering low bull:cow observed in the late 1990’s and early 2000’s. We intentionally lowered bull:cow ratios from the high 30’s in 2008 to the low 30’s in 2009 and 2010 by increasing the number of “any bull” drawing permits and, ultimately, harvest rates of bulls. I recommend that we continue to use a combination of antler restrictions and limited “any bull” drawing permits to regulate the harvest of bulls to maintain desired bull:cow ratios.

cc: R. Boertje
K. Kellie
M. Keech
T. Paragi
B. Taras
S. DuBois
T. Seaton
T. Hollis
D. Parker McNeill

TABLE 1. Unit 20A aerial moose fall composition counts and estimated population size, calendar years 1999–2010

Calendar year	Bulls:100 Cows	Yearlings: 100 Cows[a]	Calves:100 Cows	Percent calves	Adults	Moose observed	Estimated population (90% CI)[b]	Estimated population w/SCF = 1.21[c]	Moose/mi² w/SCF = 1.21[d]
1999	24	13	33	21	760	965	11,205 (± 14%)	13,558	2.7
2000	22	10	33	21	1,089	1,377	10,557 (± 18 %)	12,774	2.5
2001	26	18	26	17	737	887	11,511 (± 15%)	13,928	2.8
2002[e]									
2003	32	22	28	18	1,212	1,483	14,684 (± 13%)	17,768	3.5
2004	35	21	36	21	1,512	1,922	13,566 (± 15%)	16,415	3.3
2005	38	18	30	19	1,370	1,684	13,348 (± 15%)	16,151	3.2
2006	36	22	34	20	1,232	1,536	12,773 (± 16%)	15,455	3.1
2007[e]									
2008	37	25	35	20	1,335	1,672	10,361(± 11%)	12,537	2.5
2009	32	18	30	19	1,411	1,740	12,956 (± 12%)	15,677	3.1
2010	32	17	32	20	1,196	1,486	11,981(± 13%)	14,497	2.9

[a] Yearlings:100 cows = Yearling bulls:100 cows × 2.
[b] Geospatial population estimation (GSPE) method.
[c] Sightability studies conducted in Unit 20A suggest a sightability correction factor (SCF) of 1.21 using the GSPE method.
[d] Based on an estimated 5,000 mi² of moose habitat in GMU 20A.
[e] Surveys were not conducted due to lack of snow.

Appendix C. Units 20A and 20B fall composition survey memorandum, Interior Alaska, 2014.

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

DIVISION OF WILDLIFE CONSERVATION

Bill Walker,
GOVERNOR

1300 College Road
Fairbanks, AK 99701-1551
PHONE: (907) 459-7213
FAX: (907) 452-6410

MEMORANDUM

TO: Doreen Parker McNeill, Management Coordinator, RIII

FROM: D. Young and T. Hollis, Fairbanks Area biologists

DATE: 1 September 2015

SUBJECT: 2014 Units 20A and 20B Fall Composition Surveys

BACKGROUND

Unit 20A - Identified by the Board of Game (board) for Intensive Management (IM) of moose with a population objective of 12,000-15,000 moose. In addition, we have a management objective to manage for a posthunting sex ratio of ≥30 bulls:100 cows overall and ≥20 bulls:100 cows in the Tanana Flats, western foothills, and eastern foothills areas. Finally, annual measures of productivity and survival/recruitment/escapement are important in determining population trends. Despite not being able to conduct a population estimate due to the lack of sufficient snow cover and poor sightability, we were able to conduct composition surveys and obtain information on population parameters (i.e., calf/yearling bull/bull:100 cow ratios).

Unit 20B – Also identified by the Board of Game as an IM area, has a population objective of 12,000-15,000 moose and is managed for a posthunting sex ratio of ≥30 bulls:100 cows unitwide and ≥20 bulls:100 cows in each count area (i.e., eastern Unit 20B, central Unit 20B, western Unit 20B, and MFMA). We were not able to conduct a population estimate survey due to lack of snow cover and poor sightability in the region, so we conducted composition surveys in central and western Unit 20B to collect data on indices (i.e., calf/yearling bull/bull:100 cow ratios) used to help manage this population.

METHODS

Unit 20A - We used the GSPE survey techniques to calculate composition ratios (Kellie and Delong 2006). We surveyed 53 SUs (37 high density and 16 low density; 309 mi2) of 987 SUs (5,747 mi2) during 26 – 29 November (Fig. 1). A simple random sample of 50 SUs (70% high density and 30% low density) was selected from each stratum using Microsoft®Excel Windows®07 software. An additional 3 SUs (2 high density and 1 low density) were selected to fill gaps in the randomized coverage. We eliminated 1 SU (#80), a posteriori, from the analysis because it was 100% non-moose habitat.

Search time per SU (all SUs irrespective of percent moose habitat) averaged 3.1 min/mi^2 (range = 5-33 min; n = 53 SUs). We observed 27.7 moose/hour of survey time. Survey conditions (Gasaway et al. 1986) with regard to snow (age and cover), light (intensity and type) were poor but not a factor since this survey was intended only to be used to collect composition information.

Unit 20B – We used the GSPE survey techniques to calculate composition ratios (Kellie and Delong 2006) in the central and western portion (West/Central) of the unit. We surveyed 50 SUs (32 high density and 18 low density; 281 mi^2) of 1203 SUs (6,771 mi^2) during 26-28 November (Fig. 2). A simple random sample of 50 SUs (64% high density and 36% low density) was selected from each stratum using Microsoft®Excel Windows®07 software.

Search time in each sample unit ranged from 13 minutes to 30 minutes. Survey conditions were poor but not a factor since the survey was intended to collect composition data.

RESULTS AND DISCUSSION

Unit 20A – GSPE technique [24 calves:100 cows (± 23% @ 90% CI); 7 yearling bulls:100 cows (± 47% @ 90% CI) ; 32 bulls:100 cows (± 37% @ 90% CI)] (Table 1).

Yearling survival/recruitment (i.e., yearlings:100 cows) was moderately strong during 2010–2012, averaging 20:100 (range = 18:100; Table 1). Due to the record setting late spring of 2013, yearling bull ratios appeared to decline in 2013 due to high mortality of 11- to 13-month olds. That late spring and commensurate short summer likely compromised calves born during spring 2013 resulting in higher winter (2013-2014) mortality and subsequent poor recruitment of 18-month olds to fall, 2014. In addition, the lingering effects of that late spring on moose nutrition and condition likely contributed to the poor calf production observed in 2014.

Bull:cow ratios were above objective 2010-2012 (Table 1). The apparent decline below the management objective (30 bulls:100 cows) in 2013 was likely due to fewer yearling bulls in the population due to the high mortality of 11- to 13-month olds during the late spring of 2013 and/or sampling error. Consequently, we lowered the number of “any bull” drawing permits from 1000 issued in RY13 to 554 in RY2014. Because bull:cow ratios were estimated to be greater than the management objective during fall surveys 2014, we increased the number of “any bull” drawing permits to 777 in RY15.

Unit 20B – The Unit 20B composition survey data estimated a bull:cow ratio of 36:100 (± 42% @ 90% CI) in the West/Central region of the unit (38:100 in western and 34:100 in central). The calf:cow and yearling bull:cow ratios were 32:100 (± 40% @ 90% CI) and 7:100 (± 60% @ 90% CI).

The average yearling:100 cow ratio in central and western Unit 20B during 2006-2013 was 19:100 and 18:100, respectively (Table 2). Since the yearling bull:100 cow ratio was 7:100 (8:100 in Central 20B and 7:100 in Western 20B) in this survey we can assume the yearling:100

cow ratio is double at 14:100. It is likely that this is lower than the 2006-2013 average for the same reasons as mentioned for Unit 20A (i.e., weather).

Bull:cow ratios in central and western Unit 20B during 2006-2013 averaged 28:100 and 32:100, respectively. The unit wide (Western, Central, and Eastern combined) objective is for a bull:cow ratio of 30:100. This survey estimated that West/Central 20B had a ratio of 36:100 (38:100 in western and 34:100 in central) which is above the objective.

RECOMMENDATIONS

In years when GSPE population estimates are not possible due to poor survey conditions, conduct GSPE composition surveys since ratio estimates are affected minimally by sightability. Composition surveys provide information on productivity, survival (to 18-months), yearling recruitment, and adult bull escapement.

Evaluate trends in the moose population’s productivity (calves:100 cows), survival/recruitment (yearlings:100 cows), and sustainable bull harvests (bulls:100 cows) with linear mixed effects model using AICs and smoothed estimates over roughly 5-year periods.

Data Archiving

Field forms will be stored in a 3-ring binder in the Fairbanks Area Biologist’s office or cabinet in the Region III office. Pertinent electronic files will be saved on D. Young’s Home Drive H:\ARCHIVES\MOOSE\2014. Analysis can be found in WinfoNet: **Home -> Survey and Inventory Tools -> Moose Surveys -> Moose Surveys - Population/Ratio Estimates** -20A COMPOSITION,Fall,2014 and 20B COMPOSITION,Fall,2014.

ECC: K. Seaton
T. Paragi
D. Bruning
A. Crawford
J. Kephart

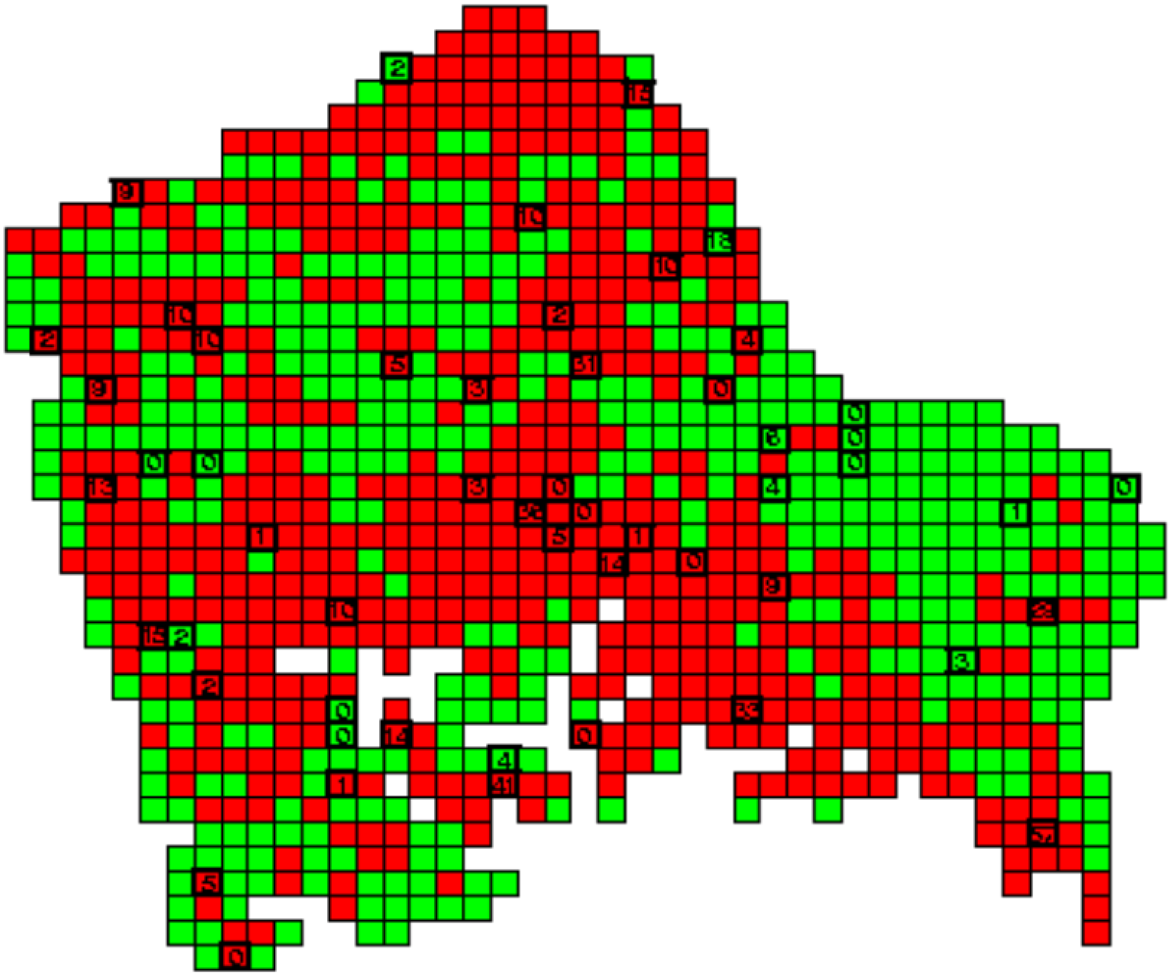

Figure 1. Composition survey units, Unit 20A, 2014.

Table 1. Unit 20A aerial moose fall composition counts, 2010–2014.

Year	Bulls:100 Cows	Yearling bulls:100 Cows	Calves: 100 Cows	Percent calves	Adults	Moose observed	Estimated population[a] w/SCF = 1.21[b] (90% CI)	Moose/mi^{2}[c]
2010	32	9	32	20	1,196	1,486	14,497 (±16.2%)	2.9
2011	33	9	28	21	1,363	1,651	12,723 (±15.3%)	2.5
2012	34	9	31	18	1,014	1,244	12,193 (±15.8%)	2.4
2013	28	7	31	19	875	1,085	10,156 (±14.5%)	2.0
2014[d]	32 (± 37%)[e]	7 (± 47%)	24 (± 23%)	15	381	449		

[a] Geospatial population estimation (GSPE) method.
[b] Sightability correction factor (Boertje et al. 2009).
[c] Based on an estimated 5,040 mi^2 of moose habitat in Unit 20A.
[d] Composition surveys only.
[e] Precision at the 90% confidence interval.

Appendix D. Moose survey form for spring twinning surveys.

MOOSE SURVEY FORM--Spring Twinning Surveys

Page ___ of ___

Form MT1 5/26/09

SEARCH IDENTIFICATION

Date: __________ SU #: __________
GMU: __________
Location: __________
Observer: __________
Pilot: __________
Aircraft Type: __________ Temp (F) __________

SEARCH TYPE
(check one or both)

☐ Standard
~4-6 min/mi²
☐ Intensive
~ 12 min/mi²
Strata: __________
Area (mi²): __________

SEARCH TIMES
(in minutes)

	Standard	Standard
Stop@		
Start@		
Elapsed		

OVERALL SURVEY RATING: ☐ Excellent ☐ Good ☐ Fair ☐ Poor

SEARCH CONDITIONS

GREEN-UP
☐ 1. Early
☐ 2. Mid
☐ 3. Late

LEAF OUT
☐ 1. None
☐ 2. Partial
☐ 3. Complete

LIGHT TYPE
☐ 1. Bright
☐ 2. Flat

LIGHT INTENSITY
☐ 1. High
☐ 2. Medium
☐ 3. Low

PREDOMINANT HABITAT TYPE IN SU
☐ 1. Open lower elevation, poadaro shrub, riparian, or wetland
☐ 2. Mixed Open Forest with some shrub understory
☐ 3. Dense Spruce Forest
☐ 4. Dense Deciduous Forest Birch, Aspen, etc. Few Shrubs
☐ 5. Subalpine Shrub
☐ 6. Burn
☐ 7. Other (describe):

CHECK ADDITIONAL CONDITIONS THAT MAY HAVE AFFECTED THE QUALITY OF THE SEARCH

☐ Classification Errors
☐ Uncooperative Pilot
☐ Inadequate Search Effort
☐ Short on Fuel
☐ Windy/Turbulent
☐ Inadequate Snow Cover
☐ Inexperienced Pilot
☐ Movement In/Out Of Intensive
☐ Movement In/Out of SU
☐ Improper Aircraft
☐ Poor Light
☐ Inexperienced Observer
☐ Too Many Moose In Intensive (>15)
☐ Observer Airsick
☐ Low Clouds or Fog
☐ Poor Visibility/Snow on Trees
☐ Problems finding SU Boundaries
☐ Observer Sleeping
☐ Other (Explain):

	Group No.	Adult Bulls	Cow w/0	Cow w/1	Cow w/2	Cow w/3	Yearlings	Total Adult Moose	Remarks (e.g., bears observed incl. lat/lon)
☐	1.								
☐	2.								
☐	3.								
☐	4.								
☐	5.								
☐	6.								
☐	7.								
☐	8.								
☐	9.								
☐	10.								
☐	11.								
☐	12.								
☐	13.								
☐	14.								
☐	15.								

Additional Lines on Back of Sheet If Needed

Survey Summary

								SCF Plot Summary:	
1-15									
16-50								# Moose in Reg Search:	
Total								# Moose in Intensive Search:	

Appendix E. Units 20A, 20B, and 20C moose twinning survey memorandum, Interior Alaska, 2011.

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

DIVISION OF WILDLIFE CONSERVATION

Sean Parnell, GOVERNOR

1300 College Road
Fairbanks, AK 99701-1551
PHONE: (907) 459-7213
FAX: (907) 452-6410

MEMORANDUM

TO: R. Nowlin, Management Coordinator RIII

FROM: D. Young, T. Seaton, T. Hollis Fairbanks Area biologists

DATE: June 2011

SUBJECT: Units 20A, 20B, and 20C Moose Twinning Surveys, 2011

UNIT 20A TANANA FLATS

2011 Twinning Surveys. Surveys were flown mornings/afternoons (09:37–13:10) and afternoons/evenings (16:30–20:30). Leaf-out was approximately 70% when we started and 100% during the last surveys. Weather, turbulence and airsickness were not factors. We were unable to obtain a sample of 50 cows with calves in western (n = 43) and eastern (n = 30) Unit 20A. Total flight time (including ferry time) was 12.9 hours ($3342) and total survey time was 10.8 hours. We observed 518 moose ≥ 1 year (48 moose/hour); 123 (24%) parturient moose; and 11 parturient moose/hour. **Mean (Northcentral, Western and Eastern Tanana Flats) observed twinning rate was 18.6% (Table 1)**. We observed 5 black bear units (4 in the Northcentral Tanana Flats; 1 in the Western Tanana Flats).

Northcentral Tanana Flats — Surveys were conducted on 24 May east of Crooked Creek, east of the Tanana River and north of approximately N64˚38.00′. Total flight time was 3.1 hours ($636) and actual survey time was 3 hours. We observed 247 moose (≥1 year old) or 82 moose/hour; 50 (20%) parturient moose; and 17 parturient moose/hour. **The observed twinning rate was 10% (5/50; Table 1).**

Western Tanana Flats — Surveys were conducted on 26 May west of Tatlanika Creek, east of the George Parks Highway and north of the Rex Trail. Total flight time was 4.6 hours ($943) and actual survey time was 4 hours. We observed 148 moose (≥1 year old) or 37 moose/hour; 43 (29%) parturient moose; and 11 parturient moose/hour. **The observed twinning rate was 26% (11/43; Table 1).**

Eastern Tanana Flats/Foothills — Surveys were conducted on 27 May east of Delta Creek and west of the Delta River. Total flight time was 5.2 hours ($1066) and actual survey time was 3.8 hours. As in 2008, most moose were observed in the northern portion of the survey area (i.e., within the Karla Lake fire perimeter). We observed 123 moose (≥1 year old) or 32 moose/hour; 30 (24%) parturient moose; and 8 parturient moose/hour. **The observed twinning rate was 20% (6/30; Table 1).**

CC: R. Boertje
M. Keech
K. Kellie
T. Paragi
T. Seaton
S. Dubois
J. Caikoski

TABLE 1. Unit 20A moose twinning rates from transect surveys, calendar years 2002–2011.

Calendar year	Date	Cows w/Single calf	Cows w/Twins	Cows Total	% Twins[a]	Mean[b]
2002[c]	24–25 May	52	6	58	10	
2003[c]	27–28 May	53	5	58	9	
2004[c]	23 May	57	3	60	5	
2005[c]	23 May	49	5	54	9	
2006[c]	23 May	49	6	55	11	
2006[d]	24 May	32	6	38	16	14
2006[e]	25 May	30	6	36	17	
2007[c]	25 May	58	2	60	3	
2007[d]	28 May	28	9	37	24	13
2007[e]	2 Jun	36	4	40	10	
2008[c]	23 May	57	6	63	10	
2008[d]	27 May	46	14	60	23	15
2008[e]	26 May	36	5	41	12	
2009[c]	23–24 May	55	5	60	8	
2009[d]	27–28 May	52	6	58	10	10
2009[e]	30 May	32	4	36	11	
2010[c]	24, 26 May	51	3	54	6	
2010[d]	27 May	30	6	36	17	12
2010[e]	28 May	26	4	30	13	
2011[c]	24 May	45	5	50	10	
2011[d]	26 May	32	11	43	26	19
2011[e]	27 May	24	6	30	20	

[a] Percentage of cows with calves that had twins.
[b] Mean of percent twins for central, western and eastern Tanana Flats.
[c] Central Tanana Flats.
[d] Western Tanana Flats.
[e] Eastern Tanana Flats.

Appendix F. Units 20A, 20B, and 20C moose twinning survey memorandum, Interior Alaska, 2012.

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

DIVISION OF WILDLIFE CONSERVATION

Sean Parnell,
GOVERNOR

1300 College Road
Fairbanks, AK 99701-1551
PHONE: (907) 459-7213
FAX: (907) 452-6410

MEMORANDUM

TO: R. Nowlin, Management Coordinator RIII

FROM: D. Young and T. Hollis, Fairbanks Area biologists

DATE: 15 June 2012

SUBJECT: Units 20A, 20B, and 20C Moose Twinning Surveys, 2012

UNIT 20A

Surveys were flown 25–27 May 2012 during afternoons andevenings (13:28–19:13) in a Bellanca Scout with pilot Marty Webb (Tundra Air) and observers D. Young, C. Roberts and M. Smith. We generally searched open habitats (i.e., open meadows, tundra, shrubfields, burns) and avoided closed canopy forest. We flew roughly parallel transects 0.5-1.0 miles apart. To increase statistical power, we established, a priori, a desired sample size of ≥50 cows with calves. Leaf-out was approximately nearly complete. Weather, turbulence and airsickness were not factors. Total flight time (including ferry time) was 17.5 hours ($3938) and total survey time was 14.8 hours. We observed 683 moose ≥ 1 year (46 moose/hour); 128 (19%) parturient moose; and 9 parturient moose/hour. We observed 2 independent black bears, both in the Northcentral Tanana Flats. **Mean (Northcentral, Western Tanana Flats, and Eastern Tanana Flats-foothills) observed twinning rate was 12% (Table 1)**.

Northcentral Tanana Flats — Surveys were conducted on 25 May south of the Tanana River, east of the Wood River, west of the Blair Lakes Impact Area Trail, and north of approximately N64°22.5′ (Fig.1). Total flight time was 5.5 hours ($1238) and actual survey time was 5.1 hours. We observed 279 moose (≥1 year old) or 55 moose/hour; 54 (19%) parturient moose; and 11 parturient moose/hour. **The observed twinning rate was 22% (12/54; Table 1).**

Western Tanana Flats — Surveys were conducted on 26 May south of the Tanana River, west of Tatlanika Creek, east of the George Parks Highway and north of the Rex Trail (Fig. 1). Total flight time was 6.2 hours ($1395) and actual survey time was 5.3 hours. We observed 205 moose (≥1 year old) or 39 moose/hour; 42 (21%) parturient moose; and 8 parturient moose/hour. **The observed twinning rate was 10% (4/42; Table 1).**

Eastern Tanana Flats-Foothills — Surveys were conducted on 27 May south of the Tanana River, east of Delta Creek, west of the Delta River, and north of N63°53.5′ (Fig.1). Total flight time was 5.8 hours ($1305) and actual survey time was 4.4 hours. We observed 199 moose (≥1 year old) or 45 moose/hour; 32 (16%) parturient moose; and 7 parturient moose/hour. **The observed twinning rate was 3% (1/32; Table 1).**

CC: R. Boertje
M. Keech
K. Kellie
T. Paragi
D. Bruning
C. Roberts
M. Smith

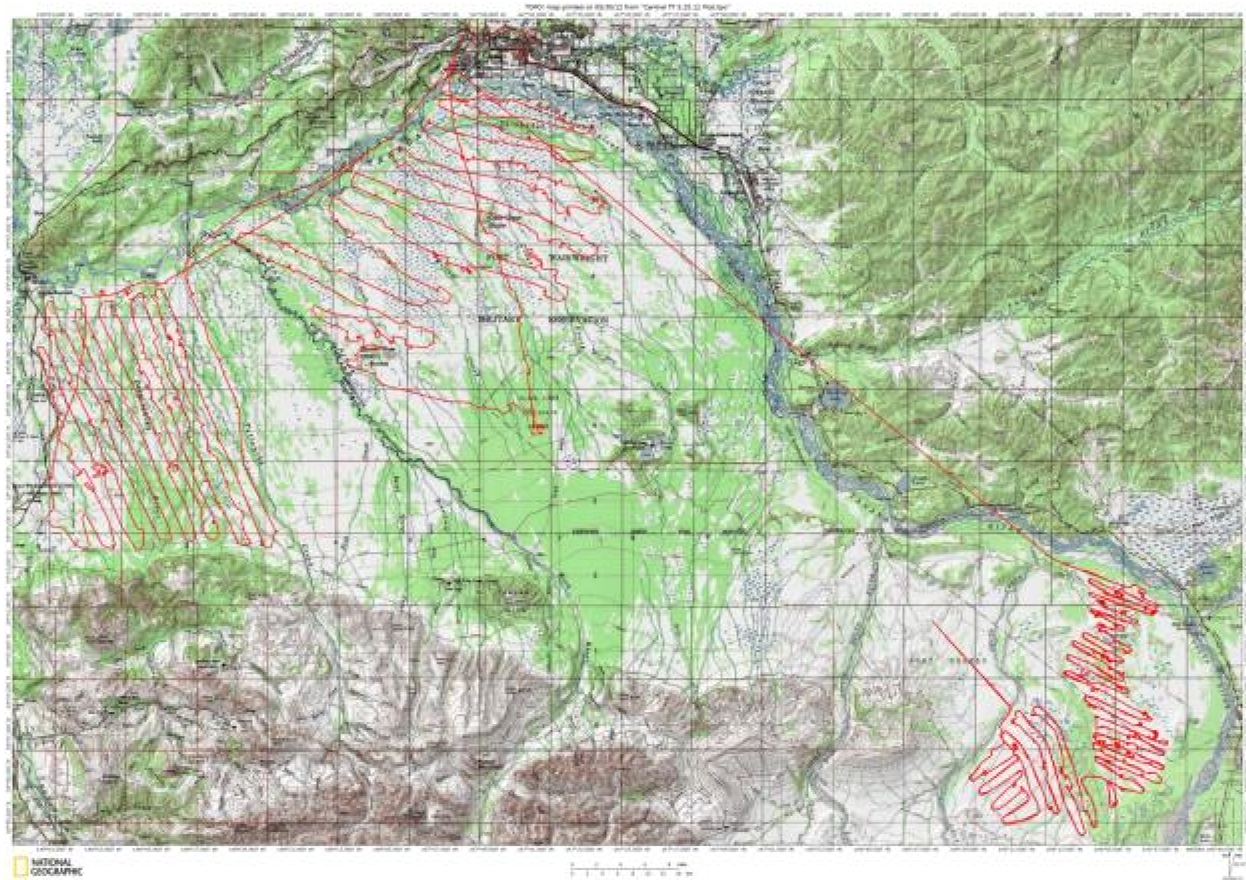

Figure 1. Northcentral Tanana Flats, Western Tanana Flats, and Eastern Tanana Flats-foothills twinning survey areas and flight paths, Unit 20A, 2012.

TABLE 1. Unit 20A moose twinning rates from transect surveys, Interior Alaska, calendar years 2002–2012.

Calendar year	Date	Cows			% Twins[a]	Mean[b]
		w/Single calf	w/Twins	Total		
2002[c]	24–25 May	52	6	58	10	
2003[c]	27–28 May	53	5	58	9	
2004[c]	23 May	57	3	60	5	
2005[c]	23 May	49	5	54	9	
2006[c]	23 May	49	6	55	11	
2006[d]	24 May	32	6	38	16	14
2006[e]	25 May	30	6	36	17	
2007[c]	25 May	58	2	60	3	
2007[d]	28 May	28	9	37	24	13
2007[e]	2 Jun	36	4	40	10	
2008[c]	23 May	57	6	63	10	
2008[d]	27 May	46	14	60	23	15
2008[e]	26 May	36	5	41	12	
2009[c]	23–24 May	55	5	60	8	
2009[d]	27–28 May	52	6	58	10	10
2009[e]	30 May	32	4	36	11	
2010[c]	24, 26 May	51	3	54	6	
2010[d]	27 May	30	6	36	17	12
2010[e]	28 May	26	4	30	13	
2011[c]	24 May	45	5	50	10	
2011[d]	26 May	32	11	43	26	19
2011[e]	27 May	24	6	30	20	
2012[c]	25May	42	12	54	22	
2012[d]	26 May	37	4	41	10	12
2012[e]	27 May	31	1	31	3	

[a] Percentage of cows with calves that had twins.
[b] Mean of percent twins for Northcentral, Western Tanana Flats and Eastern Tanana Flats-foothills.
[c] Northcentral Tanana Flats.
[d] Western Tanana Flats.

Appendix G. Units 20A, 20B, and 20C moose twinning survey memorandum, Interior Alaska, 2013.

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

DIVISION OF WILDLIFE CONSERVATION

Sean Parnell, GOVERNOR

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Fairbanks, AK 99701-1551
PHONE: (907) 459-7213
FAX: (907) 452-6410

MEMORANDUM

TO: R. Nowlin, Management Coordinator RIII

FROM: D. Young and T. Hollis, Fairbanks Area biologists

DATE: 3 July 2013

SUBJECT: Units 20A, 20B, and 20C Moose Twinning Surveys, 2013

UNIT 20A

Surveys were flown 29–30 May and 1 June, 2013 during afternoons and evenings (13:25–21:10) in a Bellanca Scout or Supercub with pilot Marty Webb (Tundra Air) and observer D. Young. We generally searched open habitats (i.e., open meadows, tundra, shrubfields, burns) and avoided closed canopy forest and recently burned areas. We flew roughly parallel transects 0.5-1.0 miles apart depending on the openness of the habitat. To increase statistical power, we established, a priori, a desired sample size of ≥50 cows with calves. Leaf-out was nearly complete. Weather, turbulence and airsickness were not factors. Total flight time (including ferry time) was 16.4 hours ($3690) and total survey time was 13.35 hours. We observed 629 moose ≥ 1 year (47 moose/hour); 123 (20%) parturient moose; and 9 parturient moose/hour. We observed 3 independent grizzly bears (a breeding pair and a female with 2 dependent cubs) both in the 2009 Rex Burn in the Western Tanana Flats. We observed no black bears. **Mean (Northcentral, Western Tanana Flats, and Eastern Tanana Flats-foothills) observed twinning rate was 12% (Table 1)**.

Northcentral Tanana Flats — Surveys were conducted on 29 May south of the Tanana River, east of the Wood River, west of the Blair Lakes Impact Area Trail, and north of approximately N64°22.22′ (Fig. 1). Total flight time was 5.0 hours ($1125) and actual survey time was 4.78 hours. We observed 261 moose (≥1 year old) or 55 moose/hour; 48 (18%) parturient moose; and 10 parturient moose/hour. **The observed twinning rate was 10% (5/48; Table 1).**

Western Tanana Flats — Surveys were conducted on 30 May south of the Tanana River, west of Tatlanika Creek, east of the George Parks Highway and north of the Rex Trail (Fig.1). Total flight time was 5.9 hours ($1327.50) and actual survey time was 4.97 hours. We observed 208 moose (≥1 year old) or 42 moose/hour; 41 (20%) parturient moose; and 8 parturient moose/hour. **The observed twinning rate was 12% (5/41; Table 1).**

Eastern Tanana Flats-Foothills — Surveys were conducted on 1 June south of the Tanana River, east of Delta Creek, west of the Delta River, and north of N63°46.0′ (Fig. 1). Total flight time was 5.5 hours ($1237.50) and actual survey time was 3.6 hours. We observed 160 moose (≥1 year old) or 44 moose/hour; 34 (21%) parturient moose; and 9 parturient moose/hour. **The observed twinning rate was 15% (5/34; Table 1).**

ECC: K. Kellie
T. Paragi
D. Brunning

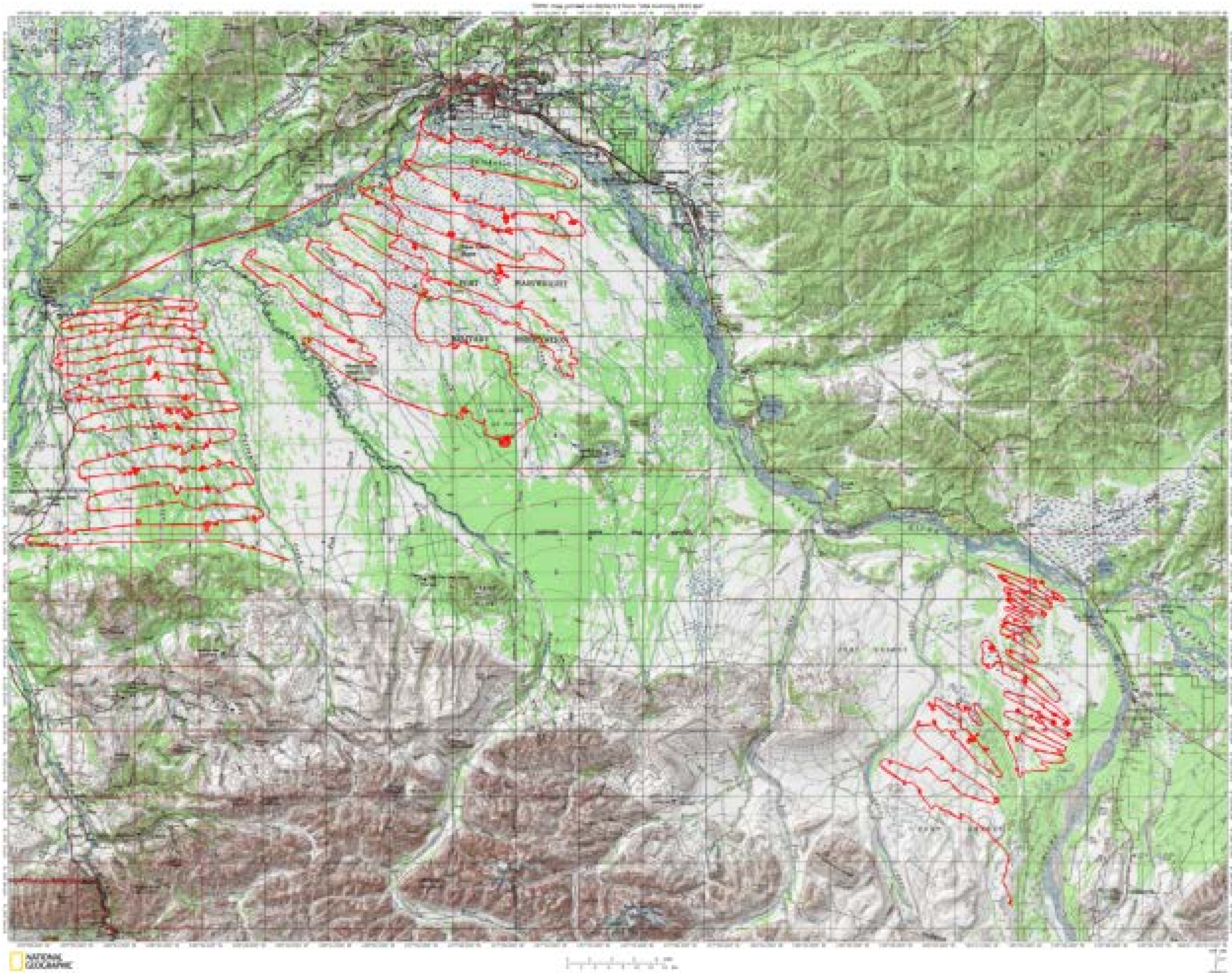

Figure 1. Northcentral Tanana Flats, Western Tanana Flats, and Eastern Tanana Flats-foothills twinning survey areas and flight paths, Unit 20A, 2013.

TABLE 1. Unit 20A moose twinning rates from transect surveys, Interior Alaska, calendar years 2002–2013

Calendar year	Date	Cows w/Single calf	Cows w/Twins	Cows Total	% Twins[a]	Mean[b]
2002[c]	24–25 May	52	6	58	10	
2003[c]	27–28 May	53	5	58	9	
2004[c]	23 May	57	3	60	5	
2005[c]	23 May	49	5	54	9	
2006[c]	23 May	49	6	55	11	
2006[d]	24 May	32	6	38	16	14
2006[e]	25 May	30	6	36	17	
2007[c]	25 May	58	2	60	3	
2007[d]	28 May	28	9	37	24	13
2007[e]	2 Jun	36	4	40	10	
2008[c]	23 May	57	6	63	10	
2008[d]	27 May	46	14	60	23	15
2008[e]	26 May	36	5	41	12	
2009[c]	23–24 May	55	5	60	8	
2009[d]	27–28 May	52	6	58	10	10
2009[e]	30 May	32	4	36	11	
2010[c]	24, 26 May	51	3	54	6	
2010[d]	27 May	30	6	36	17	12
2010[e]	28 May	26	4	30	13	
2011[c]	24 May	45	5	50	10	
2011[d]	26 May	32	11	43	26	19
2011[e]	27 May	24	6	30	20	
2012[c]	25May	42	12	54	22	
2012[d]	26 May	37	4	41	10	12
2012[e]	27 May	31	1	31	3	
2013[c]	29May	43	5	48	10	
2013[d]	30 May	36	5	41	12	12
2013[e]	1 June	29	5	34	15	

[a] Percentage of cows with calves that had twins.
[b] Mean of percent twins for Northcentral, Western Tanana Flats and Eastern Tanana Flats-foothills.
[c] Northcentral Tanana Flats.
[d] Western Tanana Flats.
[e] Eastern Tanana Flats-foothills.

Appendix H. Units 20A, 20B, and 20C moose twinning survey memorandum, Interior Alaska, 2014.

STATE OF ALASKA

Sean Parnell,
GOVERNOR

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DEPARTMENT OF FISH AND GAME

DIVISION OF WILDLIFE CONSERVATION

MEMORANDUM

TO: Doreen Parker McNeill, Management Coordinator RIII

FROM: D. Young and T. Hollis, Fairbanks Area biologists

DATE: 8 August 2014

SUBJECT: Units 20A, 20B, and 20C Moose Twinning Surveys, 2014

Background

Annual twinning rate surveys are conducted to estimate twinning rates (i.e., an index to nutritional status of the moose population) and address the management objective to: Manage population levels based on 3-year mean twinning rates in conjunction with at least one of the following signals to substantiate low twinning-based nutritional status: 50% of 36-month-old moose are parturient, average multiyear short yearling mass is <385 pounds (175 kg), or >35% of annual browse biomass is removed by moose (Boertje et al. 2007):

- <10% twinning rate — reduce the moose population
- 10–20% twinning rate — maintain a stable moose population
- >20% twinning rate — manage for population growth

Methods

Unit 20A

Surveys were flown 24–28 May in a PA-18 Supercub with pilot Marty Webb (Tundra Air) and observers Tony Hollis, Nate Pamperin, and Marion Glaser. We generally searched open habitats (i.e., open meadows, tundra, shrubfields, burns) and avoided closed canopy forest and recently burned areas. We flew roughly parallel transects 0.5-1.0 miles apart depending on the openness of the habitat. To increase statistical power, we established, a priori, a desired sample size of ≥50 cows with calves. Leaf-out was nearly complete. Weather, turbulence and airsickness were not factors during eastern and western Unit 20A, however it was windy/turbulent during the northcentral Unit 20A flight. Total flight time (including ferry time) was 18.0 hours ($4230) and total survey time was 16.6 hours. We observed 583 moose ≥ 1 year (35 moose/hour); 86 (15%) parturient moose; and 5 parturient moose/hour. We observed one cinnamon black bear with 2

COY. **Mean (Northcentral, Western Tanana Flats, and Eastern Tanana Flats-foothills) observed twinning rate was 9% (Table 1)**.

Northcentral Tanana Flats — Surveys were conducted on 24 May south of the Tanana River, east of the Wood River, west of the Blair Lakes Impact Area Trail, and north of approximately N64˚22.22′ (Fig.1). Total flight time was 7.3 hours ($1715.50) and total survey time was 6.9 hours. We observed 337 moose (≥1 year old) or 49 moose/hour; 40 (12%) parturient moose or 5.8 parturient moose/hour. **The observed twinning rate was 2.5% (1/40; Table 1).**

Western Tanana Flats — Surveys were conducted on 26 May south of the Tanana River, west of Tatlanika Creek, east of the George Parks Highway and north of the Rex Trail (Fig.1). Total flight time was 7.2 hours ($1692.00) and actual survey time was 6.7 hours. We observed 169 moose (≥1 year old) or 25 moose/hour; 37 (22%) parturient moose or 6 parturient moose/hour. **The observed twinning rate was 24% (9/37; Table 1).**

Eastern Tanana Flats-Foothills — Surveys were attempted in Eastern Tanana Flats on 28 May but we did not complete the survey. A fire in 2013 burned the main calving area in the eastern Tanana Flats displacing most of the moose that calved in the area. It is likely the moose were displaced to deciduous forest adjacent to the calving area, but due to the early leaf out, moose were not visible in this area. Total flight time was 3.5 hours ($822) and actual survey time was 3.0 hours. We observed 77 moose (≥1 year old) or 26 moose/hour; 9 (12%) parturient moose or 3 parturient moose/hour. **The observed twinning rate was 0% (0/9; Table 1).**

RECOMMENDATIONS

Continue to collect twinning rate information in Units 20A and 20B to calculate 3-year running means. Discontinue twinning surveys in Unit 20C because estimated twinning rates averaged >20%, 2010-2014 (mean = 29.5, SE = 4.5). Manage the Units 20A and 20B moose populations for zero growth, and the Unit 20C population for positive growth.

Data Archiving

Field forms will be photocopied and saved as PDFs on D. Young’s Home Drive H:\MOOSE\2014.

ECC: K. Kellie
T. Paragi
D. Bruning

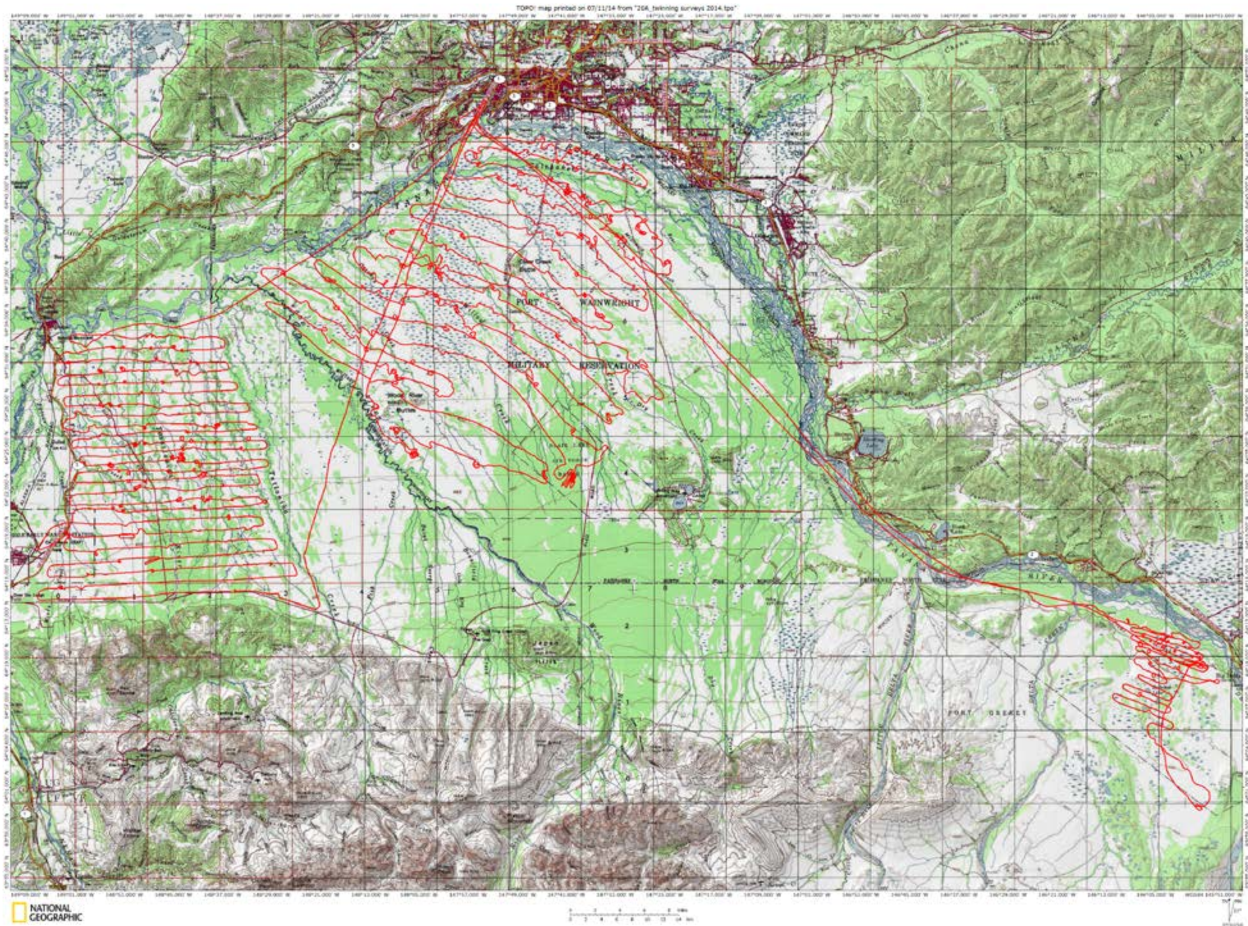

Figure 1. Northcentral Tanana Flats, Western Tanana Flats, and Eastern Tanana Flats-foothills twinning survey areas and flight paths, Unit 20A, 2014.

TABLE 1. Unit 20A moose twinning rates from transect surveys, Interior Alaska, calendar years 2006–2014.

Calendar year	Date	Cows w/Single calf	Cows w/Twins	Cows Total	% Twins[a]	Mean[b]
2006[c]	23 May	49	6	55	11	
2006[d]	24 May	32	6	38	16	14
2006[e]	25 May	30	6	36	17	
2007[c]	25 May	58	2	60	3	
2007[d]	28 May	28	9	37	24	13
2007[e]	2 Jun	36	4	40	10	
2008[c]	23 May	57	6	63	10	
2008[d]	27 May	46	14	60	23	15
2008[e]	26 May	36	5	41	12	
2009[c]	23–24 May	55	5	60	8	
2009[d]	27–28 May	52	6	58	10	10
2009[e]	30 May	32	4	36	11	
2010[c]	24, 26 May	51	3	54	6	
2010[d]	27 May	30	6	36	17	12
2010[e]	28 May	26	4	30	13	
2011[c]	24 May	45	5	50	10	
2011[d]	26 May	32	11	43	26	19
2011[e]	27 May	24	6	30	20	
2012[c]	25May	42	12	54	22	
2012[d]	26 May	37	4	41	10	12
2012[e]	27 May	31	1	31	3	
2013[c]	29May	43	5	48	10	
2013[d]	30 May	36	5	41	12	12
2013[e]	1 June	29	5	34	15	
2014[c]	24 May	39	1	40	3	
2014[d]	26 May	28	9	37	24	9
2014[e]	28 May	9	0	9	0	

[a] Percentage of cows with calves that had twins.
[b] Mean of percent twins for Northcentral, Western Tanana Flats and Eastern Tanana Flats-foothills.
[c] Northcentral Tanana Flats.
[d] Western Tanana Flats.
[e] Eastern Tanana Flats-foothills.

Appendix I. Units 20A, 20B, and 20C moose twinning survey memorandum, Interior Alaska, 2015.

STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

DIVISION OF WILDLIFE CONSERVATION

Bill Walker,
GOVERNOR

1300 College Road
Fairbanks, AK 99701-1551
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MEMORANDUM

TO: Doreen Parker McNeill, Management Coordinator RIII

FROM: D. Young and T. Hollis, Fairbanks Area biologists

DATE: 21 July 2015

SUBJECT: Units 20A, 20B, and 20C Moose Twinning Surveys, 2015

BACKGROUND

Annual twinning rate surveys are conducted to estimate twinning rates (i.e., an index to nutritional status of the moose population) and address the management objective to: Manage population levels based on 3-year mean twinning rates in conjunction with at least one of the following signals to substantiate low twinning-based nutritional status: 50% of 36-month-old moose are parturient, average multiyear short yearling mass is <385 pounds (175 kg), or >35% of annual browse biomass is removed by moose (Boertje et al. 2007):

- <10% twinning rate — reduce the moose population
- 10–20% twinning rate — maintain a stable moose population
- >20% twinning rate — manage for population growth

METHODS

UNIT 20A

Surveys were flown 21–25 May in a PA-18 Supercub with pilot Marty Webb (Tundra Air) and observers Don Young and Carl Roberts. We generally searched open habitats (i.e., open meadows, tundra, shrubfields, burns) and avoided closed canopy forest and recently burned areas. We flew roughly parallel transects 0.5-1.0 miles apart depending on the openness of the habitat. To increase statistical power, we established, a priori, a desired sample size of ≥50 cows with calves. Leaf-out was complete. Weather, turbulence and airsickness were not factors during eastern and central Unit 20A surveys, however it was windy/turbulent during the Western Unit 20A flight which likely contributed to lower sample size. Total flight time (including ferry time) was 18.3 hours ($4300.50) and total survey time was 15.77 hours. We observed 677 moose ≥ 1 year old (42.93 moose/hour); 144 (21.27%) parturient moose; 9.13 parturient moose/hour; and a 35.38% (144/407) observed birth rate (cows > 1 year old). We observed one cinnamon black bear with 2 COYs on the western Tanana Flats and a breeding pair of grizzly bears on the eastern Tanana Flats. **Mean (Northcentral, Western Tanana Flats, and Eastern Tanana Flats-foothills) observed twinning rate was 22.56% (Table 1)**.

Northcentral Tanana Flats — Surveys were conducted on 21 May south of the Tanana River, east of the Wood River, mostly west of the Blair Lakes Impact Area Trail, and north of approximately N64˚22.17′ (Fig.1). Total flight time was 6.6 hours ($1551.00) and total survey time was 6.47 hours. We observed 377 moose (≥1 year old) or 58.3 moose/hour; 84 (22.3%) parturient moose or 13.0 parturient moose/hour. **The observed twinning rate was 22.6% (19/84; Table 1).**

Western Tanana Flats — Surveys were conducted on 23 May south of the Tanana River, west of Tatlanika Creek, east of the George Parks Highway and north of the Rex Trail (Fig.1). Total flight time was 5.9 hours ($1386.50) and actual survey time was 5.12 hours. We observed 137 moose (≥1 year old) or 26.8 moose/hour; 35 (25.5%) parturient moose or 6.8 parturient moose/hour. **The observed twinning rate was 17.1% (6/35; Table 1).**

Eastern Tanana Flats-Foothills — Surveys were conducted in Eastern Tanana Flats on 25 May between Delta Creek and the Delta River, North of the Tanana River, and north of N63˚53.595′ (Fig 1). Total flight time was 5.8 hours ($1363.00) and actual survey time was 4.18 hours. We observed 163 moose (≥1 year old) or 39 moose/hour; 25 (15.3%) parturient moose or 6.0 parturient moose/hour. **The observed twinning rate was 28.0% (7/25; Table 1).**

RECOMMENDATIONS

Continue to collect twinning rate information in Units 20A and 20B to calculate 3-year running means. Discontinue twinning surveys in Unit 20C because estimated twinning rates averaged >20%, 2010-2015 (mean = 32.0, SE = 4.5). Manage the Units 20A and 20B moose populations for zero growth, and the Unit 20C population for positive growth.

Data Archiving

Field forms will be photocopied and saved as PDF’s on D. Young’s Home Drive H:\MOOSE\2015.

ECC: K. Kellie
T. Paragi
D. Brunning
A. Crawford

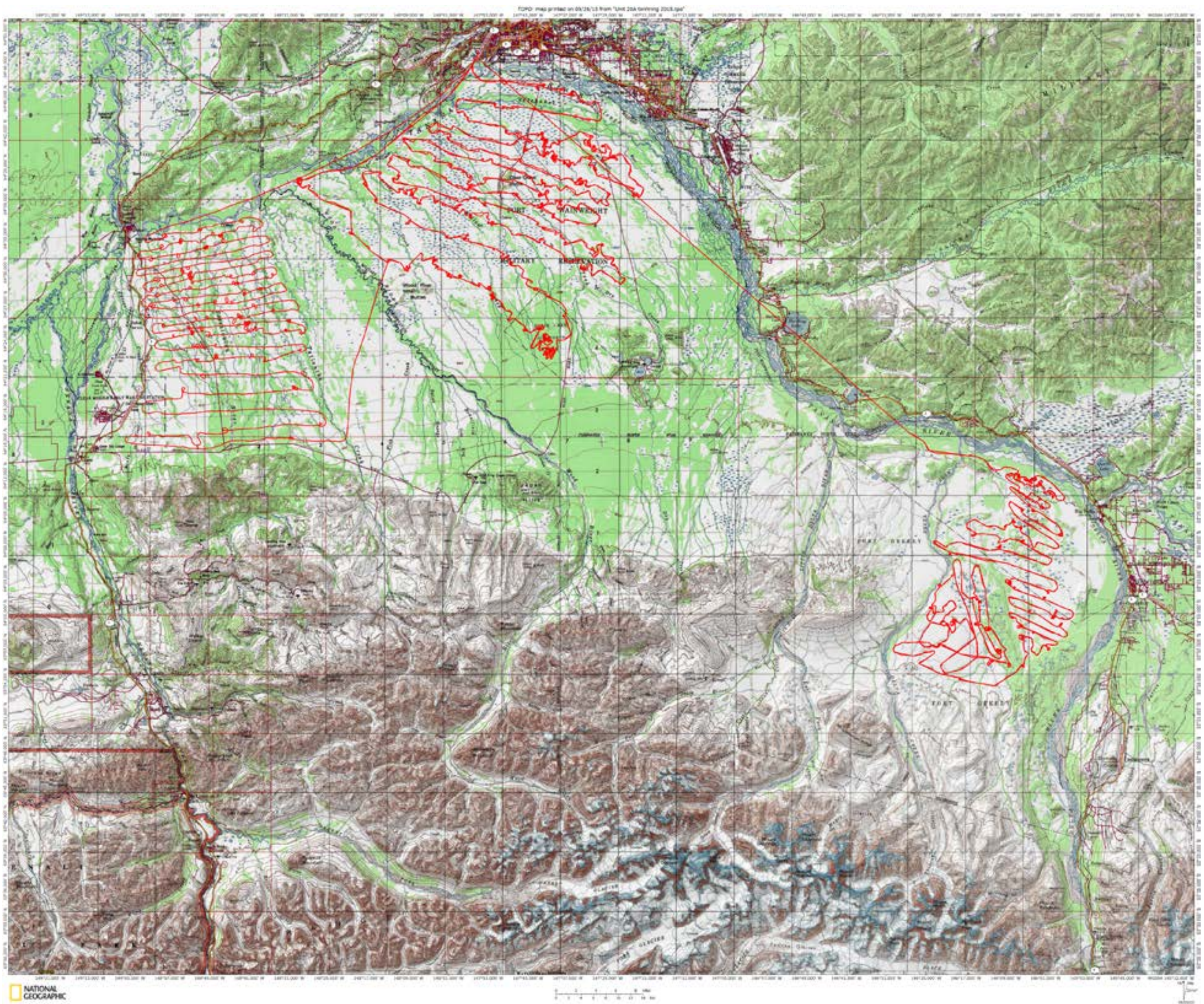

Figure 1. Northcentral Tanana Flats, Western Tanana Flats, and Eastern Tanana Flats-foothills twinning survey areas and flight paths, Unit 20A, 2015.

TABLE 1. Unit 20A moose twinning rates from transect surveys, Interior Alaska, calendar years 2006–2015

Calendar year	Date	Cows w/Single calf	Cows w/Twins	Cows Total	% Twins[a]	Mean[b]
2006[c]	23 May	49	6	55	11	
2006[d]	24 May	32	6	38	16	14
2006[e]	25 May	30	6	36	17	
2007[c]	25 May	58	2	60	3	
2007[d]	28 May	28	9	37	24	13
2007[e]	2 Jun	36	4	40	10	
2008[c]	23 May	57	6	63	10	
2008[d]	27 May	46	14	60	23	15
2008[e]	26 May	36	5	41	12	
2009[c]	23–24 May	55	5	60	8	
2009[d]	27–28 May	52	6	58	10	10
2009[e]	30 May	32	4	36	11	
2010[c]	24, 26 May	51	3	54	6	
2010[d]	27 May	30	6	36	17	12
2010[e]	28 May	26	4	30	13	
2011[c]	24 May	45	5	50	10	
2011[d]	26 May	32	11	43	26	19
2011[e]	27 May	24	6	30	20	
2012[c]	25May	42	12	54	22	
2012[d]	26 May	37	4	41	10	12
2012[e]	27 May	31	1	31	3	
2013[c]	29May	43	5	48	10	
2013[d]	30 May	36	5	41	12	12
2013[e]	1 June	29	5	34	15	
2014[c]	24 May	39	1	40	3	
2014[d]	26 May	28	9	37	24	9
2014[e]	28 May	9	0	9	0	
2015[c]	21 May	65	19	84	23	
2015[d]	23 May	29	6	35	17	23
2015[e]	25 May	18	7	25	28	

[a] Percentage of cows with calves that had twins.
[b] Mean of percent twins for Northcentral, Western Tanana Flats and Eastern Tanana Flats-foothills.
[c] Northcentral Tanana Flats.
[d] Western Tanana Flats.
[e] Eastern Tanana Flats-foothills.

Appendix J. Unit 20A short-yearling moose capture card, Interior Alaska, March 2009.

March 2009 20A **SHORT YEARLING** CAPTURE CARD **MOOSE #**______

Date: ____________ **Personnel:** ____

Location (lat, lon): ______________________ **Description:** __________________________

Study Area (circle): Fish Ck Burn Central 20A Survey Line Fire Western 20A

Times: Dart1 _______ Dart2 ________ Down ______ Reversal ________ Up __________

Collar: Freq. ________ Serial No. _______ **Darts:** #Hits ____ #Miss ____ Dart ID(s) ___________

Dart location(s): ____

Measurements (cm):

T.B.L. (from hairless nasal patch to base of tail)	______________	**FRONT TEETH:**
M.T. (hock to fetlock)	______________	(d=decid, P=perm)
Tail Bone Length	______________	__ __ __ __ __ __ __ __
Neck Circumference (min. behind ears)	______________	

Weight w/net ________

SEX: F M **BLOOD:** Yes No **CONDITION:** poor moderate good

Reversal: Naltrexone: mL ______ Vial ID _______ Tolazoline: mL ________ Vial ID _________

Remarks: ____

____

Appendix K. Decision framework for moose in Unit 20A, Interior Alaska, that links management recommendations to metrics of population trend, nutritional status, and bull:cow ratio in the context of management objectives.

Population trend	Nutritional status	Bull:cow ratios	Management action recommended
Increasing (lambda > 1.02)	High nutrition status: (3-year mean twining rate >20% and/or female 10-month mass >385 lb)	≥25 bulls:100 cows	Bull harvest rate >5% Cow harvest rate = 1-2%
		<25 bulls:100 cows	Bull harvest rate = 4-5% Cow harvest rate = 1-2%
	Moderate nutrition status: (3-year mean twining rate 10-20% and/or female 10-month mass 365-385 lb)	≥25 bulls:100 cows	Bull harvest rate = 4-5% Cow harvest rate = 2-3%
		<25 bulls:100 cows	Bull harvest rate <4% Cow harvest rate = 2-3%
	Low nutrition status: (3-year mean twining rate <10% and/or female 10-month mass <365 lb)	≥25 bulls:100 cows	Bull harvest rate >5% Cow harvest rate >3%
		<25 bulls:100 cows	Bull harvest rate = 4-5% Cow harvest rate >3%
Stable (lambda = 0.98-1.02)	High nutrition status…	≥25 bulls:100 cows	Bull harvest rate = 4-5% Cow harvest rate <1%
		<25 bulls:100 cows	Bull harvest rate = 4-5% Cow harvest rate <1%
	Moderate nutrition status…	≥25 bulls:100 cows	Bull harvest rate = 4-5% Cow harvest rate = 1-2%
		<25 bulls:100 cows	Bull harvest rate = 4-5% Cow harvest rate = 1-2%
	Low nutrition status…	≥25 bulls:100 cows	Bull harvest rate = 4-5% Cow harvest rate >2%

Population trend	Nutritional status	Bull:cow ratios	Management action recommended
Decreasing (lambda < 0.98)	High nutrition status…	<25 bulls:100 cows	Bull harvest rate = 4-5% Cow harvest rate >2%
		≥25 bulls:100 cows	Bull harvest rate = 4-5% Cow harvest rate= 0%
		<25 bulls:100 cows	Bull harvest rate <4% Cow harvest rate = 0%
	Moderate nutrition status…	≥25 bulls:100 cows	Bull harvest rate = 4-5% Cow harvest rate = 0-1%
		<25 bulls:100 cows	Bull harvest rate = 4-5% Cow harvest rate = 0-1%
	Low nutrition status…	≥25 bulls:100 cows	Bull harvest rate >5% Cow harvest rate = 0-2%
		<25 bulls:100 cows	Bull harvest rate = 4-5% Cow harvest rate = 0-2%