Species Management Report and Plan ADF&G/DWC/SMR&P–2024-1

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

Report Period 1 July 2015–30 June 2020, and

Plan Period 1 July 2020–30 June 2025

Jeffrey J. Wells

2024

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 areas, 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 Jason Caikoski, Management Coordinator for the Division of Wildlife Conservation.

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Purpose of this Report

This report provides a record of survey and inventory management activities for moose (*Alces alces*) in Game Management Unit 20E for the 5 regulatory years 2015–2019 and plans for survey and inventory management activities in the next 5 regulatory years, 2020–2024. A regulatory year (RY) begins 1 July and ends 30 June (e.g., RY22 = 1 July 2022–30 June 2023). This report is produced primarily to provide agency staff with data and analysis to help guide and record agency efforts but is also provided to the public to inform it of wildlife management activities. In 2016 the Alaska Department of Fish and Game's (ADF&G, the department) Division of Wildlife Conservation (DWC) launched this 5-year report to more efficiently report on trends and to describe potential changes in data collection activities over the next 5 years. It replaces the moose management report of survey and inventory activities that was produced every 2 years.

I. RY15–RY19 Management Report

Management Area

Unit 20E is in east central Alaska bounded by the Canada border on the east and is centered on lat 64°16′N, long 142°20′W. Major drainages within the unit include the Fortymile, Charley, Ladue, and Seventymile river drainages. Unit 20E encompasses 10,680 square miles, of which 9,750 square miles are at or below 4,000 feet in elevation, and generally considered suitable moose habitat. The unit was described in detail by Gasaway et al. (1992) and generally consists of hills with elevations ranging from 1,000 feet to 5,000 feet. However, more mountainous areas, with elevations exceeding 6,000 feet, are found in the northwestern portion of the unit, and lowland areas (2,000–2,500 feet; Mosquito Flats) are found in the southwestern portion of the unit. Vegetation types include lowland shrub and sedge meadows, mature black spruce (*Picea mariana*) forest, recently burned areas dominated by shrubs and early successional forest species, subalpine shrub, and alpine tundra. The climate is typical of Interior Alaska, where temperatures frequently reach 80°F in summer and −40°F in winter.

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

Similar to other areas in Alaska, the Unit 20E moose population experienced wide fluctuations in size from the 1950s to the 2020s. Gasaway et al. (1992) summarized the history of the Unit 20E moose population from the 1950s through the 1980s, which included a rapid population increase during the 1950s through early 1960s and a rapid population decline during the mid-1960s through mid-1970s. The moose population increased within some portions of the unit between the 1980s and early 2020s, especially within the southern portion of the unit. However, the unitwide population was likely still below the intensive management (IM) population objective of 8,000–10,000 moose during RY10–RY14 (Wells 2018).

Since the early 1980s ADF&G has initiated several predator management programs targeted at reducing wolf (*Canis lupus*) and grizzly bear (*Ursus arctos*) numbers in order to increase the moose population in Unit 20E, with the most recent program in place during RY04–RY13. The response of the Unit 20E moose population during this predator control program was summarized in Gross (2008, 2010, 2012) and Wells (2014). In addition to potentially benefiting from the predator management program, Unit 20E moose also likely benefited from large wildfires during 2004–2005, which burned approximately 1,958 square miles mostly within the southern portion of the unit.

Unit 20E has had a 15-day bulls-only fall moose season since RY91, although in RY01 most of Unit 20E was changed to a registration moose hunt with a split season divided into a 5-day late August season (residents only) and a 10-day September season (residents and nonresidents). There has also been a limited winter draw moose hunt (bulls-only) within a portion of the unit since RY95. Total harvest and numbers of hunters increased between RY00 and RY14, although total annual reported harvest during RY10–RY14 remained below the IM harvest objective of 500–1,000 moose.

Management Direction

Existing Wildlife Management Plans

Unit 20E plans for moose survey and inventory management activities for RY15–RY19 were outlined in Wells (2018). Other than Wells (2018), no other wildlife management plans specific to Unit 20E moose exist for this reporting period. Direction in the Yukon-Tanana, Charley River, and Sixtymile Butte moose management plans (ADF&G 1976) has been modified by Alaska Board of Game regulatory actions and ADF&G moose management reports over the years.

Goals

During RY15–RY19 (and since RY89), the Unit 20E moose management goals were as follows:

G1. Protect, maintain, and enhance the moose population in concert with other components of the ecosystem.

G2. Continue sustained opportunity for subsistence use of moose.

G3. Maximize sustained opportunities to participate in hunting moose.

G4. Maximize opportunities for nonconsumptive use of moose.

Codified Objectives

Amounts Reasonably Necessary for Subsistence Uses

C1. The Unit 20E moose population has a positive customary and traditional use finding, as determined by the Board of Game, with an amount reasonably necessary (ANS) for subsistence uses of between 50 and 75 moose (5 AAC 99.025 (8)).

a. During this reporting period, this objective was considered met if 4% of the midpoint unitwide prehunt moose population estimate (estimated once during the 5-year report period) is greater than or equal to the lower threshold of ANS (50 moose; Wells 2018).

Intensive Management

The Unit 20E moose population is identified by the Board of Game as important for providing high levels of harvest for human consumptive use and has the following intensive management (IM) objectives:

C2. Population objective of 8,000–10,000 moose.

a. This objective was considered met if the midpoint unitwide prehunt moose population estimate (estimated once during the 5-year report period) was greater than or equal to the lower threshold of the IM population objective (8,000 moose; Wells 2018).

C3. Harvest objective of 500–1,000 moose annually.

a. This objective was considered met if the 3-year average reported harvest or 4% of the midpoint unitwide prehunt moose population estimate (estimated once during the 5-year report period) was greater than or equal to the lower threshold of the IM harvest objective (500 moose; Wells 2018).

MANAGEMENT OBJECTIVES

During RY15–RY19, the Unit 20E moose management objectives were as follows:

M1. Maintain a posthunting ratio of ≥30 bulls:100 cows within the Taylor Corridor survey area and ≥40 bulls:100 cows in all other survey areas.

a. This objective was considered met if the midpoint bull-to-cow ratio estimate (determined annually for each area surveyed) was greater than or equal to the objective (Wells 2018).

M2. Allow for population growth in southern Unit 20E (within the Taylor Corridor, Tok West, and Tok Central survey areas) when the 3-year average twinning rate is >20% and manage for population stability or reduction when the 3-year average twinning rate is ≤20%, contingent on a secondary measure of nutritional status (e.g., short-yearling weights or browse removal).

Additional information on the recent history and modifications of these objectives can be found in Wells (2018).

MANAGEMENT ACTIVITIES

1. Population Status and Trend

ACTIVITY 1.1. Conduct GeoSpatial Population Estimator (GSPE) surveys to estimate population abundance and composition (objectives C1, C2, M1).

Data Needs

Estimates of population abundance and composition are important components of moose management. Population abundance estimates are necessary to track progress towards meeting

IM population objectives, estimate sustainable yield, and monitor the population in response to different management actions. Composition estimates are used to assess the influence of harvest on the male component of the population (bull-to-cow ratio) and to assess the bull-to-cow ratio management objective. Furthermore, the composition data are used to assess calf recruitment to fall (calf-to-cow ratio), which can be an indication of predation pressure if production is also measured.

Methods

GSPE surveys

Moose abundance and composition were estimated in portions of Unit 20E during RY15–RY19 using the GSPE method (Ver Hoef 2001, 2008; Kellie and DeLong 2006). The specific areas surveyed within each year generally followed the plan as outlined in Wells (2018), although funds were not available to survey the portion of northern Unit 20E that had not previously been surveyed. Areas surveyed included the 2,241-square-mile Taylor Corridor Survey Area (TCSA) during RY15 and RY17–RY18 and a 5,051-square-mile area in RY19 that encompasses the combined Tok West, Tok Central, and Taylor Corridor survey areas (Fig. 1). In addition, the National Park Service (NPS) surveyed a 1,044-square-mile portion of northwest Unit 20E within Yukon-Charley Rivers National Preserve (YCNP) in RY15 and RY19. Approximately 4,585 square miles, or 43%, of Unit 20E was not surveyed during RY15–RY19.

The desired relative precision (RP) for TCSA and the combined Tok West/Central survey areas for observable moose population estimates was within 15–20% of the average at a 90% confidence interval (CI). The desired RP for composition estimates (calf-to-cow and bull-to-cow ratios) was within 20–30% of the average at the 90% CI. For the uncombined Tok West and Tok Central survey areas, the desired RP for observable moose population estimates was within 15–25% of the average at the 90% CI. The desired RP for composition estimates was within 20–35% of the average at the 90% CI. When corrected for sightability, the desired RP for the Taylor Corridor and combined Tok West/Central survey areas for population estimates was within 20–25% of the average at the 90% CI and for the uncombined Tok West/Central survey areas within 25–30% of the average at the 90% CI. Population trend was analyzed by fitting a population growth model in a Bayesian framework to the density and abundance estimates and associated uncertainty.

Sample units (SU) in all survey areas were stratified as high stratum if they were likely to contain >3 moose. During each survey, survey conditions for each SU completed were rated as either poor, fair, good, or excellent based upon snow (age and cover), light (intensity and type), and wind (strength and turbulence). Unless noted otherwise, all surveys were completed using PA-18 Piper Super Cub aircraft. The target search intensity was 6.8 minutes/mi^2, or approximately 40 minutes of survey time, in SUs with 100% moose habitat. Survey crews recorded Global Positioning System (GPS) waypoints for all groups of moose observed, and these waypoints were primarily used to assess SU stratification following the completion of each survey. Population and ratio estimates (along with 90% confidence intervals) were calculated using ADF&G's Wildlife Information Network (WinfoNet) GSPE software (DeLong 2006), with the exception of population estimates corrected for sightability.

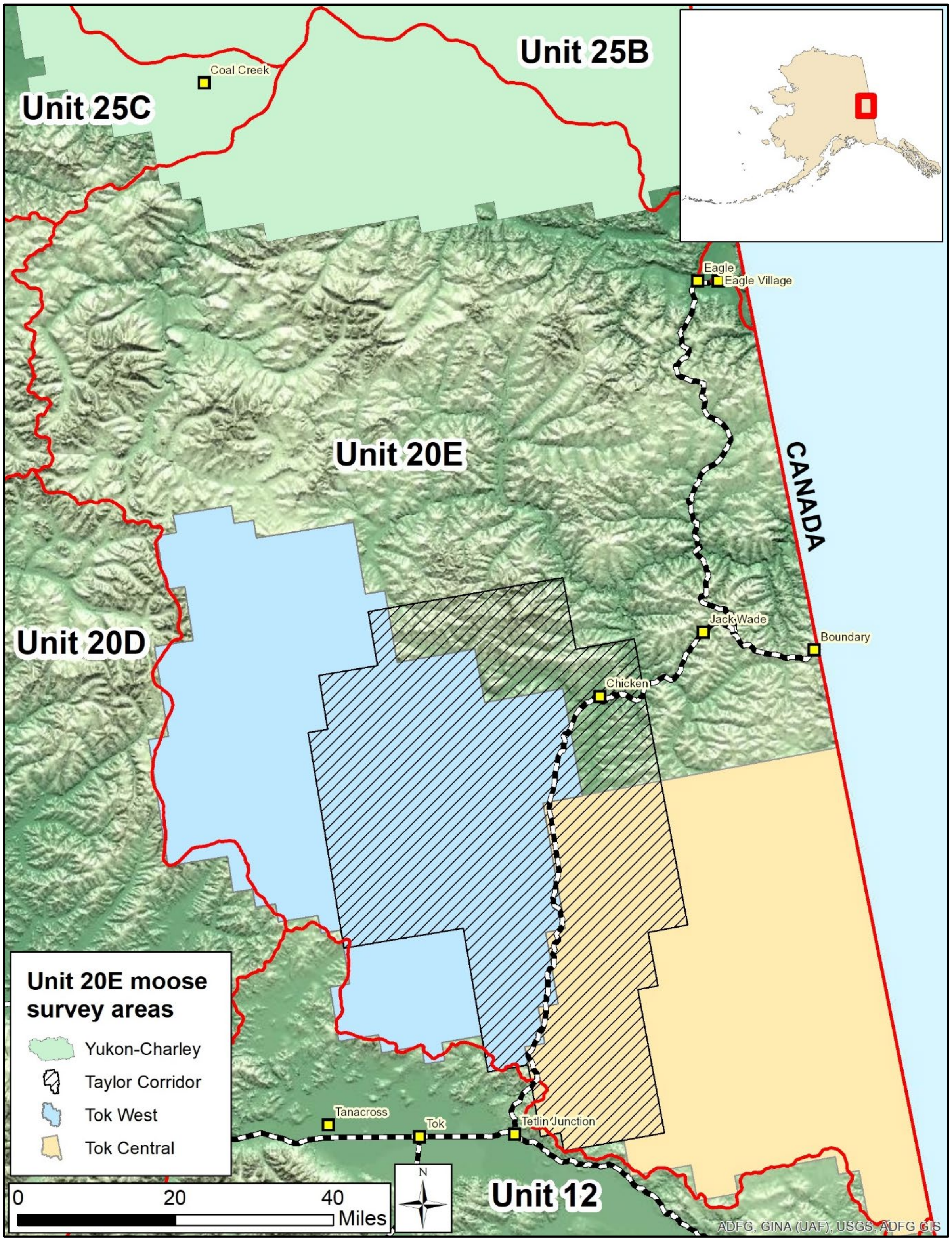

Figure 1. Moose survey areas in Unit 20E, Interior Alaska, regulatory years 2015–2019.

Sightability

Sightability was assessed during the RY17–RY19 surveys by using radiocollared adult cows. The goal during each of these surveys was to complete a minimum of 20 sightability trials in both low- and high-stratum SUs. SUs completed for the sightability trials were not part of the GSPE survey and were not included in the population and composition estimates. In addition to distributing the sightability trials between strata, the goal was to distribute the trials temporally both throughout the day (e.g. different light conditions) and throughout the survey (e.g. different survey conditions on each day of the survey) and evenly between pilot/observer teams.

Following completion of each SU, survey crews contacted the radiotracking crew and reported on a secondary frequency if a radiocollared moose was observed. A secondary frequency was used to prevent other survey teams from overhearing which SUs contained radiocollared moose because some SUs were used multiple times by different survey teams (on different days) for sightability trials. If a radiocollared moose located within an SU was not observed, the radiotracking crew communicated with the survey team to assess whether it was possible that the marked cow was observed but the collar itself was missed. If not, the radiotracking crew located the collared moose to determine if it had moved and verified whether the radiocollared moose was missed. Other data recorded for each sightability trial included whether the marked cow had a calf or calves, total group size and composition of the group associated with the marked cow, and the time that the SU survey began.

Detection probabilities were calculated separately for the low- and high-stratum SUs according to the following equation:

Detection probability = Observed/Trials, where

Observed = number of trials in which the radiocollared moose was successfully observed

Trials = total number of trials conducted

The variance of the detection probability was calculated via a simple binomial proportion variance formula.

Detection probabilities were further investigated according to whether the cow had a calf or calves at heel and according to the grouping status of the cow during the sightability trial. A cow was classified as being grouped if it was located with ≥1 other adult (noncalf) moose and ungrouped if it was not located with any other adult moose. Population estimates corrected for sightability by grouping status were calculated for 2017–2019 and were compared to the corrected estimates obtained using the stratum-based method described above. Population estimates were corrected for sightability by group status according to the following method. First, the per-SU number of grouped and ungrouped observed moose were totaled using the survey data sheets, and a GSPE was calculated for each category (grouped and ungrouped). Second, the annual sightability by group status was applied to the estimated grouped and ungrouped abundance estimates. When correcting for detection, the correlation between the grouped and ungrouped abundance predictions was accounted for. Grouped and ungrouped abundance are not independent of each other, since more grouped moose in a unit likely means more ungrouped moose as well. This correlation is not present in a by-stratum sightability correction, as stratum independence is assumed.

Moose distribution

In order to assess the boundaries of TCSA in relation to moose movements between the fall hunting season and the moose survey, radiocollared moose locations from September immediately following the closure of the state moose hunting season were compared to locations obtained in November during the RY15 and RY17–RY19 moose surveys.

The following includes more specific information by regulatory year for each survey conducted.

RY15

The GSPE method was used to survey 80 (50 high stratum and 30 low stratum) of 381 SUs in TCSA during 14–23 November. A simple random sample of 64 SUs (40 high stratum and 24 low stratum) were selected using Microsoft Excel software, and an additional 16 SUs (10 high stratum and 6 low stratum) were selected to fill gaps in randomized coverage. Overall, survey conditions were excellent with good snow cover, relatively fresh snow (approximately 1–2 inches, as estimated by ADF&G staff, fell throughout the survey area on 12 November), and heavy frost covering trees and brush. Snow cover generally decreased going from north to south and from high-to-low altitudes, and heavy frost was present for the majority of the survey. Survey conditions were reported as excellent (76%) or good (24%; survey conditions were not reported for 4 SUs). Search time per SU with 100% moose habitat (n = 63) averaged 7.0 min/mi^2 and overall search time after considering the estimated proportion of moose habitat in each SU averaged 7.2 min/mi^2. Total flight time, including ferry time, was 80.3 hours.

The NPS conducted a GSPE moose survey within a portion of Yukon Charlie National Preserve (YCNP) during 10–15 November (Sorum and Joly 2016). The NPS estimated the moose density in the entire 3,096-square-mile YCNP survey area, and this density estimate was applied to the approximately 1,044-square-mile portion of the survey area located within Unit 20E to estimate the observable moose population in that area.

RY16

No surveys were conducted due to inadequate survey conditions (lack of snow cover).

RY17

The GSPE method was used to survey 80 (48 high stratum and 32 low stratum) of 381 SUs in TCSA during 18–24 November. A simple random sample of 68 SUs (43 high stratum and 25 low stratum) were selected using Microsoft Excel software, and an additional 12 SUs (5 high stratum and 7 low stratum) were selected to fill gaps in randomized coverage. The ratio of high-to-low stratum nonrandomly selected SUs was similar to the ratio of high-to-low stratum SUs in the study area as a whole (45% high stratum and 55% low stratum). Overall, survey conditions were excellent with good and relatively fresh snow cover and good frost on trees and brush. Fresh snow fell during 16–17 November with total snow accumulation varying from approximately 8 inches in Tok to 2 inches in the northern portions of the survey area, as estimated by ADF&G staff. Total snow depth in the locations where landings took place (Mosquito Flats, Dennison

Fork, and Chicken) ranged between approximately 6–8 inches, while snow cover at higher elevations was likely deeper. Survey conditions were reported as excellent (67%) or good (33%; survey conditions were not reported for 13 SUs). Search time per SU with 100% moose habitat (n = 67) averaged 7.2 min/mi^2 and overall search time after considering the estimated proportion of moose habitat in each SU averaged 7.3 min/mi^2. A total of 41 sightability trials were completed during the survey, including 19 in low-stratum SUs and 22 in high-stratum SUs. Total flight time, including ferry time, for the survey planes was 101.8 hours while total flight time for the radiotracking plane was 43 hours.

RY18

The GSPE method was used to survey 80 (48 high stratum and 32 low stratum) of 381 SUs in TCSA during 17–30 November. A simple random sample of 68 SUs (43 high stratum and 25 low stratum) were selected using Microsoft Excel software, and an additional 12 SUs (5 high stratum and 7 low stratum) were selected to fill gaps in randomized coverage. The ratio of high-to-low stratum nonrandomly selected SUs was similar to the ratio of high-to-low stratum SUs in the study area as a whole (48% high stratum and 52% low stratum). Overall, survey conditions were good with relatively fresh snow cover and good frost on trees and brush. Fresh snow fell during 11–12 November with total snow accumulation, as estimated by ADF&G staff, varying from 9 inches in Chicken to 4 inches in Tok. Total snow depth at the initiation of the survey on 17 November was 11 and 6 inches in Chicken and Tok, respectively. An additional 5 inches fell on 20 November in Chicken for a total snow depth of 16 inches. Snow cover within surveyed SUs was reported as complete (48%), some low vegetation showing (51%), or some bare ground showing (1%; snow conditions were not reported for 2 SUs). Survey conditions were reported as excellent (20%), good (77%), or fair (3%; survey conditions were not reported for 14 SUs). Search time per SU with 100% moose habitat (n = 67) averaged 7.3 min/mi^2 and overall search time after considering the estimated proportion of moose habitat in each SU averaged 7.4 min/m^2. A total of 38 sightability trials were completed during the survey, including 17 in low-stratum SUs and 21 in high-stratum SUs. Total flight time, including ferry time, for the survey planes was 111.4 hours while total flight time for the radiotracking plane was 39.5 hours.

RY19

The GSPE method was used to survey 159 (104 high stratum and 55 low stratum) of 857 SUs in the 5,051-square-mile combined Tok West, Tok Central, and Taylor Corridor survey areas during 9–27 November. Although 160 SUs were originally selected for sampling, 1 SU was accidentally sampled twice instead of a correct SU being sampled. Prior to selecting units, both the proportion of the SUs allocated to high-stratum SUs and total SU sample size was evaluated based upon a retrospective analysis of the 2011–2018 Unit 20E moose survey results. In addition, prior to selecting units, a restratification flight was conducted over a portion of the survey area including 10 SUs within the South Fork of the Ladue River drainage, 24 SUs in the upper East Fork of the Dennison River/North Fork of the Ladue River drainages, and 18 SUs in the Middle Fork of the Fortymile River/Molly Creek drainages. These particular areas were selected to restratify based upon recent wildfires and/or stratification errors that occurred during 2012 and prior surveys. Upon completion of the restratification flight, a simple random sample of 136 SUs (93 high stratum and 43 low stratum) were selected using Microsoft Excel software, and an additional 24 SUs (11 high stratum and 13 low stratum) were selected to fill gaps in randomized coverage. The ratio of high-to-low stratum nonrandomly selected SUs was similar to the ratio of high-to-low stratum SUs in the study area as a whole (44% high stratum and 56% low stratum).

Overall, survey conditions were excellent with relatively fresh snow cover and good frost on trees and brush. Fresh snow fell over portions of the survey area during 6–7 November with snow accumulation amounts, estimated by ADF&G staff, varying from 4–6 inches along the Taylor Highway between mile 9 to Chicken, except for areas around Mount Fairplay where accumulation amounts were lower at approximately 2 inches. Additional snow accumulation occurred throughout the survey area during 13–15 November. According to National Oceanic and Atmospheric Administration (NOAA), total snow accumulation during this event was 9 inches in Tok and 7 inches in Chicken (NOAA 2019). Snow depth measurements on 16 November, as reported by NOAA (2019), were 13 inches in Tok and 15 inches in Chicken. An additional 3 inches of snow fell in Chicken on 24–25 November. Snow cover within sample SUs was reported as complete (81%) or some low vegetation showing (19%; snow conditions were not reported for 3 SUs). Survey conditions were reported as excellent (38%), good (59%), or fair (3%; survey conditions were not reported for 2 SUs). Search time per SU with 100% moose habitat (n = 126) averaged 7.0 min/mi^2 and overall search time after considering the estimated proportion of moose habitat in each SU averaged 7.1 min/m^2. A total of 43 sightability trials were completed during the survey, including 21 in low-stratum SUs and 22 in high-stratum SUs. All of the sightability trials were conducted within the TCSA portion of the overall survey area. Total flight time, including ferry time, for the survey planes was 180.5 hours (including 3.3 hours of stratification flight time) while total flight time for the radiotracking plane was 33.1 hours.

The NPS conducted a GSPE moose survey within a portion of YCNP during 11–23 November (Cameron and Schertz 2020). The NPS estimated moose density for the entire 3,096-square-mile YCNP survey area, and this density estimate was applied to the approximately 1,044-square-mile portion of the survey area located within Unit 20E to estimate the observable moose population in that area.

UNITWIDE POPULATION ESTIMATE

In order to compare population estimates to the Unit 20E IM population objective, the following equation was used to estimate a probable population range for all of Unit 20E during this report period:

$Pop_{20E} = (Pop_{South20E} + Pop_{YCNP} + Pop_{NE} + Pop_{REM}) \times SCF + MeanHarvest$, where

Pop_{20E} = Prehunt moose population estimate for Unit 20E during RY15–RY19.

$Pop_{South20E}$ = Observable moose population estimate (90% CI) for the combined Tok West, Tok Central, and Taylor Corridor survey areas (5,051 square miles) from the 2019 survey.

Pop_{YCNP} = Observable moose population estimate in the 1,044-square-mile portion of the YCNP survey area that is located within Unit 20E, calculated by applying the upper and lower 90% CI of the YCNP moose density estimate from 2019 (Cameron and Schertz 2020) to the 1,044-square-mile area.

Pop_{NE} = Observable moose population estimate in the 553-square-mile portion of the Tok Northeast survey area that does not overlap with the Tok West/Central or Taylor Corridor survey areas, calculated by applying the upper and lower 90% CI of the Tok Northeast moose density estimate from 2013 to the 553-square-mile area.

Pop_{REM} = Observable moose population estimate in the remainder of Unit 20E, calculated by applying the upper and lower 90% CI of the 2019 YCNP moose density estimate to the 4,030-square-mile area of northern Unit 20E outside the Tok Central, Tok West, Taylor Corridor, Tok Northeast, and YCNP survey areas.

Sightability Correction Factor (SCF) = 1.08; the average annual sightability correction factor calculated during 2017–2019 sightability trials within TCSA.

MeanHarvest = Average annual reported moose harvest during RY15–RY19.

Results and Discussion

<u>GSPE surveys</u>

The midpoint estimated Unit 20E moose population was lower than but close to the IM population objective of 8,000–10,000 moose during RY15–RY19. The unitwide prehunt moose population estimate during RY15–RY19 was 7,617 moose with a plausible range of 6,580–8,653 moose. Although there are issues with comparing this unitwide estimate to previous unitwide estimates, largely due to different calculation methods, this is the closest the midpoint estimate has been to the lower bounds of the IM population objective and the estimated plausible range suggests the population could potentially be within the range of the IM population objective. However, given the criteria outlined in Wells (2018), this objective was not met during this report period. It is important to point out the issues associated with estimating the Unit 20E unitwide population, which affects the ability to objectively determine whether the IM population objective is met. The largest source of potential error associated with the unitwide population estimate is the extrapolated population estimate for the portion of Unit 20E that has not been previously surveyed (40% of the entire unit).

While portions of the Unit 20E moose population increased compared to 2005–2014, other portions remained stable. The most significant increase in the moose population occurred within the southcentral portion of the unit. Observable estimated moose densities within TCSA ranged from 0.91–1.36 moose/mi^2 during RY15–RY19 (Table 1), which continued a long-term increasing trend. Observable moose density estimates for the area of overlap between the Tok West/Central and Taylor Corridor survey areas (1,821 square miles; hereby referred to as the Taylor Corridor analysis area) increased from 0.68 moose/mi^2 (90% CI = 0.58–0.78 moose/mi^2) in 2005 to 1.39 moose/mi^2 (90% CI = 1.21–1.57 moose/mi^2) in 2019. The estimated annual growth rate during this time period was 5.0% (95% credible interval [CrI] = 3.4–6.6%). The cow component of the population had an estimated annual growth rate of 6.4% (95% CrI = 4.5–8.2%) compared to the estimated bull annual growth rate of 3.0% (95% CrI = 1.0–4.8%).

Conversely, population estimates from the remainder of the unit surveyed during RY15–RY19 were comparable to 2005–2014, although portions have displayed slow long-term growth. The 2019 estimated moose density from the 1,041-square-mile-portion of the Tok West survey area outside of TCSA was 0.90 moose/mi^2, similar to the 2012 estimate of 0.88 moose/mi^2. The estimated annual long-term (2005–2019) growth rate within this portion of the unit was 2.5% (95% CrI = 0.0–4.6%). However, population trend through 2019 is difficult to assess given the lack of survey data between 2012–2019. Therefore, the estimated annual growth rate was assessed for 2005–2012 when there were annual surveys and was estimated at 5.8% (95% CrI = 1.5–10.4%). The 2019 estimated moose density from the 1,531-square-mile portion of the Tok Central survey area outside of TCSA was 0.52 moose/mi^2, which is below the 2012 estimate of 0.73 moose/mi^2 but similar to the 2011 estimate of 0.49 moose/mi^2. The long-term (2005–2019) population trend within this portion of the unit is stable (95% CrI for the annual growth rate = −1.9–3.7%). However, similar to the portion of the Tok West survey area described above, this portion of the population grew during 2005–2012 at an average annual rate of 4.7% (95% CrI = 0.1–9.9%). As previously mentioned, it is difficult to assess population trend within these areas through 2019 given the lack of data between 2012–2019. For example, although the linear trend showed long-term growth in the western portion and a stable population in the eastern portion, it’s plausible that these populations could have displayed a long-term trajectory other than a linear trend. Moose densities have also been stable, albeit at lower levels, within the northwestern portion of the unit within the Yukon-Charley Rivers National Preserve (YUCH) survey area for over 30 years (Cameron and Schertz 2020).

Bull-to-cow ratios were greater than the management objective of 40 bulls:100 cows in the Tok West/Central survey areas and hovered around the management objective of 30 bulls:100 cows in TCSA (Table 2). Bull-to-cow ratio estimates averaged 32 bulls:100 cows within TCSA during RY15–RY19, and the midpoint estimates were slightly below the objective during 2017 and 2018. These estimates are lower than the RY10–RY14 average bull-to-cow ratio within the Taylor Corridor analysis area of 51 bulls:100 cows. The decreased bull-to-cow ratio during this report period was likely the result of an increasing trend in bull harvest, which likely influenced the lower bull growth rate compared to the cow growth rate that was previously mentioned.

Table 1. Moose population estimates in the Taylor Corridor, Tok West, Tok Central, and combined Tok West/Central/Taylor Corridor moose survey areas in Unit 20E, Interior Alaska, fall 2015–2019.

				Observable moose		Sightability (stratification)[a]		Sightability (group)[b]	
Survey area	Year	Size of survey area (mi^2)	Total moose observed	Density[c]	Population[c]	Density[c]	Population[c]	Density[c]	Population[c]
Taylor	2015	2,241	505	0.9 (0.2)	2,046 (368)	–	–	–	–
Corridor[d]	2017	2,241	728	1.3 (0.2)	2,811 (506)	1.4 (0.3)	3,015 (594)	1.4 (0.3)	3,135 (690)
	2018	2,241	732	1.4 (0.3)	3,040 (581)	1.4 (0.3)	3,200 (646)	1.4 (0.3)	3,116 (623)
	2019	2,241	706	1.3 (0.2)	2,946 (354)	1.5 (0.2)	3,246 (487)	1.4 (0.3)	3,208 (577)
Tok West[d]	2019	2,452	753	1.3 (0.2)	3,080 (407)	1.4 (0.2)	3,393 (543)	–	–
Tok Central[d]	2019	2,178	289	0.7 (0.2)	1,511 (409)	0.8 (0.2)	1,666 (466)	–	–
All areas combined	2019	5,051	1,138	1.0 (0.1)	5,084 (676)	1.1 (0.2)	5,603 (896)	1.1 (0.2)	5,575 (926)

Note: Sampled using the geospatial population estimator (GSPE) sampling method (Ver Hoef 2001, 2008; Kellie and DeLong 2006).

[a] Population estimates corrected for sightability using the stratification method; sightability was not assessed in 2015.

[b] Population estimates corrected for sightability using the grouped/ungrouped method; this method was not applied to the 2019 Tok West and Central estimates.

[c] 90% confidence interval half-widths in parentheses.

[d] Subset of entire area surveyed during 2019. These areas were reported individually to compare to previous years.

Table 2. Moose composition estimates in the Taylor Corridor, Tok West, Tok Central, and combined Tok West/Central/Taylor Corridor moose survey areas in Unit 20E, Interior Alaska, fall 2015–2019.

Survey area	Year	Size of survey area (mi^2)	Bulls: 100 cows[a]	Calves: 100 cows[a]	Yearling bulls: 100 cows[a]
Taylor Corridor	2015	2,241	38 (29–47)	22 (18–26)	6 (4–8)
Taylor Corridor	2017	2,241	28 (22–34)	24 (19–29)	3 (1–5)
Taylor Corridor	2018	2,241	26 (18–34)	22 (18–26)	5 (3–7)
Taylor Corridor[b]	2019	2,241	34 (27–41)	31 (28–34)	7 (4–10)
Tok West[b]	2019	2,452	47 (39–55)	26 (22–30)	11 (8–14)
Tok Central[b]	2019	2,178	44 (30–58)	25 (16–34)	8 (3–13)
All areas combined	2019	5,051	44 (36–52)	26 (22–30)	9 (6–12)

Note: Sampled using the geospatial population estimator (GSPE) sampling method (Ver Hoef 2001, 2008; Kellie and DeLong 2006).
[a] 90% confidence interval in parentheses.
[b] Subset of entire area surveyed during 2019. These areas were reported individually to compare to previous years.

Conversely, bull-to-cow ratios have consistently remained higher in the more remote portions of the unit, reflective of the lower bull harvest rates within those areas. Bull-to-cow ratio estimates were >40 bulls:100 cows in both the Tok West and Central survey areas in addition to the YUCH survey area (Cameron and Schertz 2020) during RY15–RY19.

Calf recruitment to fall (i.e., calf-to-cow ratios) during RY15–RY19 was similar to that observed during RY10–RY14 but lower than that observed during RY05–RY09. Calf-to-cow ratios within the Taylor Corridor analysis area averaged 25:100, 23:100, and 32:100 during RY15–RY19, RY10–RY14, and RY05–RY09, respectively. Despite the lower average estimated calf-to-cow ratios since RY10, the population continued to increase within this portion of the unit.

Sightability

A total of 122 sightability trials (57 in low-stratum SUs and 65 in high-stratum SUs) were conducted during RY17–RY19 surveys. The number of sightability trials conducted per year (or per survey) ranged from 17–21 and 21–22 for low- and high-stratum SUs, respectively. Estimated detection probabilities were lower and more variable in the low- versus high-stratum SUs, although the 90% CIs overlapped both within each year and for the 3-year pooled detection probability estimates (Fig. 2). The 3-year pooled average detection probabilities were very similar between the high stratum (94%) and low stratum (90%) SUs. The 2017–2019 TCSA midpoint moose population estimates corrected for detection were 5.3–10.2% ($\bar{x}$ = 7.5%) greater than the observable (uncorrected) moose population estimates (Table 1).

Detection probabilities varied according to whether a cow had a calf at heel and also more significantly by grouping status. The average pooled (2017–2019) detection probability was lower for cows with a calf or calves at heel compared to cows without a calf at heel in both low and high-stratum SUs, although the 90% CIs overlapped (Fig. 3). Furthermore, average detection probabilities were lower for ungrouped cows (0.86; 90% CI = 0.92–0.78) compared to grouped cows (0.98; 90% CI = 0.92–1.00). Based upon the evidence presented previously that detection is similar between low- and high-stratum SUs, correcting for sightability by grouping status independent of SU stratum might be a more accurate method of correcting for sightability, especially considering the different grouping tendencies for bulls, cows with calves, and cows without calves. The proportion of bulls, cows with calves, and cows without calves observed during 2017–2019 moose surveys that were located in groups was 86%, 30%, and 77%, respectively. Therefore, applying the stratum-based sightability correction to the overall abundance estimate might overestimate abundance since a higher proportion of bulls are located in groups (and hence likely have higher detection probabilities) compared to cows. The 2017–2019 TCSA midpoint moose population estimates corrected for detection based upon grouping status were 2.5–11.5% ($\bar{x}$ = 7.6%) greater than the observable (uncorrected) moose population estimates and were overall similar to the estimates corrected for sightability using the stratum-based method (Table 1). The potential impact of differing detection probabilities for cows with calves, cows without calves, and bulls according to grouping status on composition (e.g., bull-to-cow and calf-to-cow ratio) estimates was investigated, but it was concluded that the impact was likely negligible in terms of management significance and for comparisons to management objectives.

<u>Moose distribution</u>

In RY15 and RY17–RY19 the locations of radiocollared cow moose in September, shortly after the closure of the state hunting season, were compared with their locations in November, during moose surveys. Based upon these comparisons, moose population estimates obtained from within TCSA in November are likely reflective of the population during the fall hunting season. During RY15 and RY17–RY19, a total of 134 paired locations were obtained from radiocollared moose in which individual moose were located during both September and November. Of these, 111 were located within TCSA during both time periods compared to 11 located outside of TCSA during both periods. Five were located outside of TCSA in September and moved into TCSA in November while conversely 7 were located within the TCSA in September and moved out by November. However, of the 12 paired locations located outside of the TCSA either during September or November, all were located within 7 miles of the TCSA boundary. Furthermore, the average straightline distance between September and November locations for each animal within each individual year during RY17–RY19 was 6.4 miles (range 0.6–25.1). It is important to point out that these locations were obtained only from cow moose, and it is unknown if the bull movements between September and November match the cow movements.

Recommendations for Activity 1.1

- Continue GSPE surveys.
- Discontinue assessing sightability. Data collected during this report period showed that sightability was consistent during the three years sightability was assessed.
- Discontinue the assessment of moose distribution unless radio collars are deployed on bulls in the future. Data collected during this report period showed that the moose distribution is similar between the hunting season and the time frame when surveys are conducted in November.

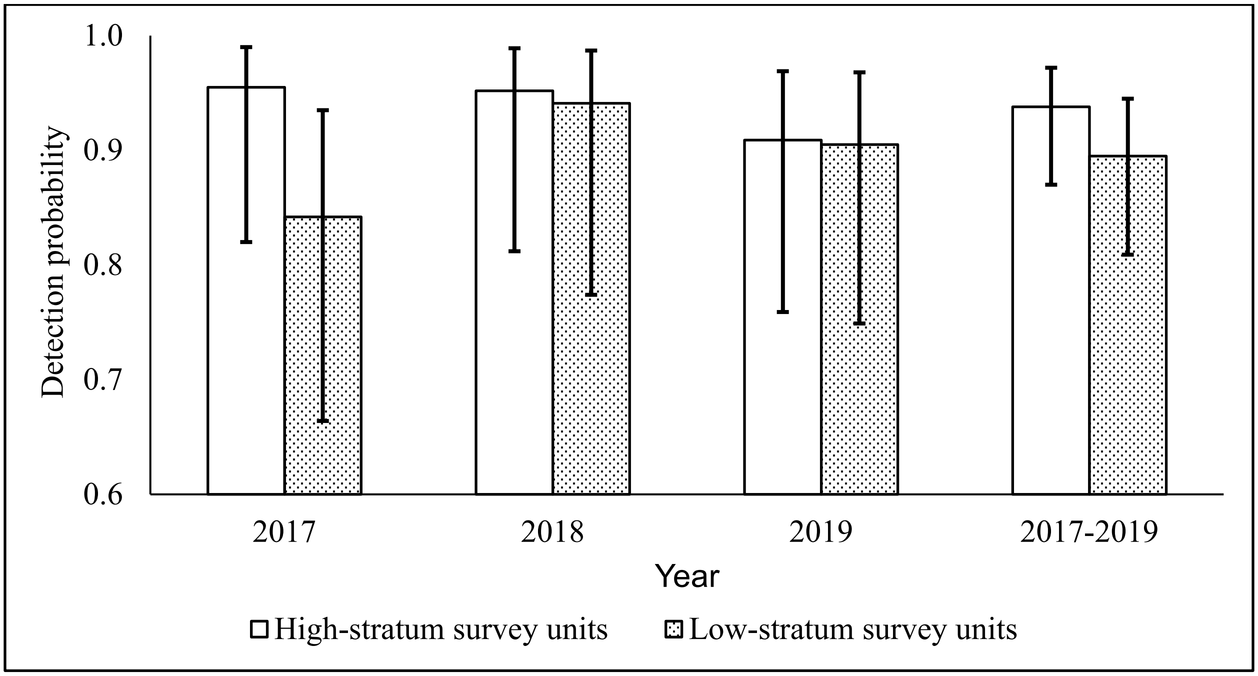

Figure 2. Detection probability estimates and corresponding 90% confidence intervals for high- and low-stratum survey units from sightability trials conducted on radiocollared adult female moose in southern Unit 20E, Interior Alaska, 2017–2019.

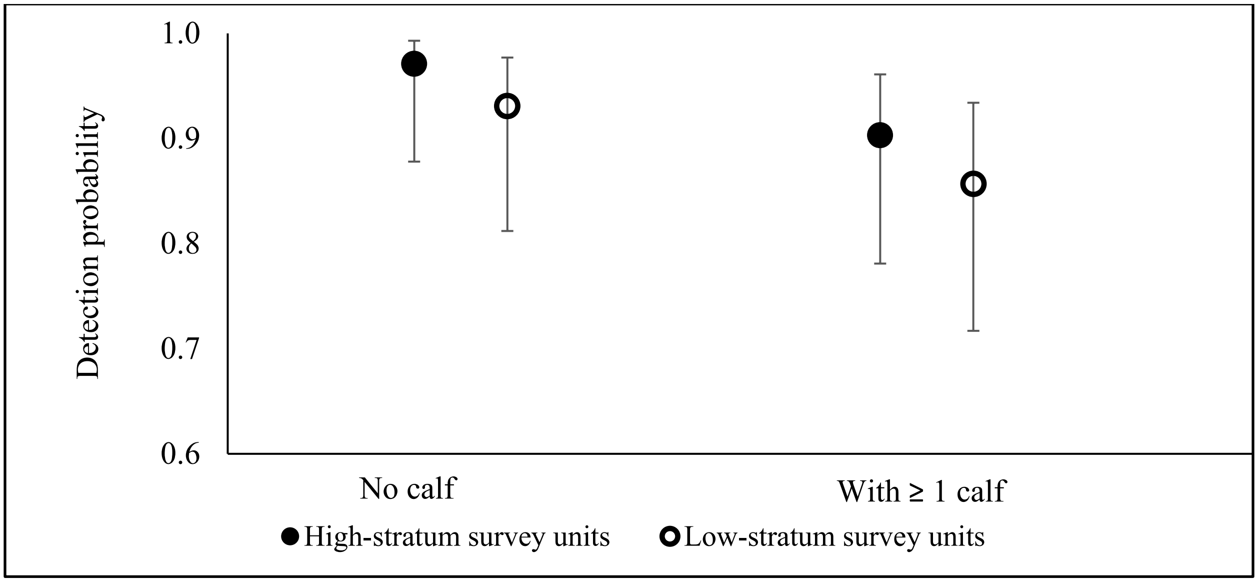

Figure 3. Detection probability estimates and corresponding 90% confidence intervals for adult females without a calf at heel (no calf) and cows with a calf or calves at heel. These detection probabilities were estimated from sightability trials conducted on radiocollared adult female moose in southern Unit 20E, Interior Alaska, 2017–2019.

ACTIVITY 1.2. Twinning surveys (Objective M2).

Data Needs

An important part of Unit 20E moose management is to ensure moose nutritional condition is maintained over time and is not reduced due to density-dependent effects. Given the long-term increasing trend in the southern Unit 20E moose population, it continues to be important to measure moose nutritional conditions within this portion of the unit. Twinning rate estimates provide a relatively inexpensive and obtainable index to nutritional condition (Boertje et al. 2007).

Methods

Twinning rates were estimated during RY15–RY19 from spring surveys conducted in southern Unit 20E and a small number of observations in immediately-adjacent, northern Unit 12. Twinning rates were estimated from observations of both radiocollared cows and random cows observed with calves. The target minimum sample size was 40 cows observed with calves distributed primarily throughout TCSA. The minimum sample size was based upon a power analysis conducted prior to this reporting period that indicated an 80% chance of detecting a change in twinning rate of ±10% at alpha equal to 0.1 with an annual sample size of 40 (Wells 2018).

Radiotracking flights were conducted annually on 2–3 separate days ranging from 21 May–6 June during RY15–RY19, while observations of random cows observed with calves within the study area were recorded during both moose radiotracking flights and spring Fortymile caribou radiotracking flights. To avoid potential duplicate observations of random cows with calves from one flight to another, the maximum straightline distance moved by radiocollared cows with calves during the RY14 twinning survey (4.4 miles) was used as a minimum separation distance between locations of random observations from different days. Any observations from different days within a single year that were located closer together than this distance were considered duplicates, and the latter observation was removed. Observations of cows with single calves and cows with twins were considered separate categories of observations. In other words, a cow observed with twins on one flight and a cow observed with a single calf on the next flight were not considered duplicate observations, even if the distance separating the locations were less than the minimum calculated distance. The maximum distance moved by the radiocollared cows with calves during the RY14 survey is likely a conservative separation distance to use because the span of time between the RY14 observations was 7 days while the span of time between observations of the randomly observed cows with calves during spring RY16–RY19 surveys ranged from 2–7 days (randomly observed cows were only recorded during 1 day in RY15). The twinning rate was calculated as the proportion of cows with twins or triplets from the sample of all cows observed with newborn calves. To account for variability that can exist between consecutive years, the 3-year average twinning rate was used to evaluate nutritional condition of the moose population according to the following guidelines:

- If the 3-year average twinning rate is ≥20%, conclude moose population has moderate to high nutritional status and is not habitat limited.
- If the twinning rate is <20% for 2 consecutive 3-year averages, conclude moose population has low to moderate nutritional status and initiate a secondary measure to estimate nutritional condition (Boertje et al. 2007). The most feasible secondary index of nutritional status for Unit 20E would most likely be either a browse survey or weighing short-yearlings.

Results and Discussion

Annual twinning rates averaged 34% during RY15–RY19, and the minimum desired sample size was achieved during each year (Table 3). There was no statistically significant linear trend in annual twinning rates during RY03–RY19 (*P-val* = 0.23), meaning that annual twinning rates were stable during that time period. The 3-year running average twinning rates (e.g., 3-year average twinning rate for RY15 would include RY13–RY15) ranged from 27% (90% CI = 20–34%) in RY15 to 36% (90% CI = 30–42%) in RY19, all of which were above the 20% threshold described above. Therefore, habitat was likely not a major limiting factor in southern Unit 20E during RY15–RY19.

Recommendations for Activity 1.2

Continue.

Table 3. Southern Unit 20E moose twinning rates, Interior Alaska, 2016–2020.

		Random cows		Radiocollared cows		All cows			
Year	Date	w/single calf	with twins	w/single calf	with twins	w/single calf	with twins	Total	% Twins[a]
2016	21 May–3 June	11	4	23	9	34	13	47	28 (17–39)
2017	24 May–6 June	10	8	22	13	32	21	53	40 (29–51)
2018	30 May–4 June	9	5	19	8	28	13	41	32 (20–44)
2019	24–31 May	14	3	17	9	31	12	43	28 (17–39)
2020	14 May–2 June	23	18	16	12	39	30	69	44 (34–54)

[a] Percentage of cows with calves that had twins. 90% confidence interval in parentheses.

ACTIVITY 1.3. Deploy radio collars on adult cows (Objectives C1, C2, M2).

Data Needs

Radio collars were deployed on adult cows in southern Unit 20E in order to 1) increase the efficiency and samples sizes obtained during twinning surveys, 2) estimate an SCF during fall moose surveys, 3) refine moose survey areas according to the movement of collared animals between the hunting season and November, and 4) identify important calving areas. The target annual sample size during RY15–RY19 was to maintain a sample of approximately 50 adult cows with radio collars.

Age and pregnancy status were determined for most of the captured cows. Known-age animals are useful in order to partially account for bias that can result from estimating twinning rates from radiocollared moose due to underrepresentation of younger cohorts (Boertje et al. 2007). In addition, known-age animals allow for the ability to include age in annual survival estimate analyses. Pregnancy determinations were made for 2 reasons: 1) to assist with determining which cows to locate during twinning surveys the following spring (there is no reason to look at nonpregnant cows during twinning surveys), and 2) to aid in determining how many of the pregnant cows are in fact observed with a calf during twinning surveys and how many are not (although it is not possible to determine whether a missed calf was due to predation, a late parturition date, or observation error). In addition, pregnancy rates provide another measure of nutritional status. Boertje et al. (2007) concluded that multiyear average parturition rates provide a nutritional ranking consistent with the ranking based on twinning rates.

Methods

Adult cow moose were captured and fitted with very-high frequency (VHF) radio collars (Telonics MOD-600NH with 3-inch wide collars adjustable from 25–43 inches) within TCSA during RY15–RY17 and RY20. All captures were conducted via darting from a Robinson R-44 helicopter using Pneu-Dart darts (2 or 3 cc with 1 inch or 1¼ inches needles) projected from a Pneu-Dart rifle using brown charges (typically on power setting #3). A canine tooth was collected from most of the cows and sent to Matson's Laboratory for age determination. In addition, blood was collected and sent to the BioTRACKING labs to assess pregnancy rates via pregnancy-specific protein B (PSPB) analysis. Specific methods by regulatory year are listed below, while more information can be found in the summary memorandum for each capture operation.

RY15

Twenty-six adult cows were captured during 11–16 March 2016. A canine tooth was collected from 25 of 26 of the cows while blood was collected from all 26. The drug dosage used for all captures was 4.5 mg carfentanil and 120 mg xylazine reversed, with 450 mg Naltrexone and either 400 mg tolazoline or 12 mg atipamezole.

RY16

Six adult cows were captured on 16 March 2017, and a canine tooth and blood were collected from all 6 animals. The drug dosage used was 8–9 mg Etorphine and 100 mg xylazine reversed with 200–225 mg Naltrexone and 10 mg atipamezole.

RY17

Five adult cows were captured on 20 March 2018. A canine tooth was collected from all 5 animals while blood was collected from 4 of the 5 animals. The drug dosage used was 8–10 mg Etorphine or 4.5 mg carfentanil and 100 mg xylazine reversed with 200–450 mg Naltrexone and 10 mg atipamezole.

RY19

Ten adult cows were captured on 23–24 March 2020, and a canine tooth and blood were collected from all 10 animals. The drug dosage used was 14 mg thiafentanil and 100 mg xylazine reversed with 140 mg Naltrexone and 10 mg atipamezole.

Results and Discussion

The radiocollared cows were used during RY15–RY19 for twinning surveys, to assess sightability during GSPE surveys, and to assess the boundary of TCSA. Location data (i.e., GPS locations) collected during twinning surveys can be used to assess important calving areas in the future. Blood was collected from a total of 70 cows during RY14–RY19, and 64 (91%) of these were determined to be pregnant based upon PSPB analysis. This pregnancy rate is relatively high and consistent with the twinning rate data, which suggests that habitat is not currently a major limiting factor for this population. The age of captured cows, determined from 59 cows captured during RY14–RY19, ranged from 1- to 14-years old ($\bar{x}$ = 6.4-years old).

Recommendations for Activity 1.3

Continue by maintaining a sample size of 40–50 radiocollared cows during the next report period. However, this activity should be considered a lower budget priority than Activities 1.1 and 1.2.

2. Mortality-Harvest Monitoring and Regulations

ACTIVITY 2.1. Monitor and analyze harvest data and other mortality (Objectives C3, M1).

Data Needs

Harvest data are needed to ensure that harvest remains within sustainable yield and determine whether the IM harvest objective has been met.

Methods

Annual harvest was estimated from mandatory harvest report cards. During RY15–RY19 this included data from the registration hunt RM865 in most of Unit 20E, the general season hunt in the upper Middle Fork Fortymile River drainage, and drawing hunts DM794 and DM796 during November–December in the Ladue River Controlled Use Area (LRCUA). Harvest by federally-qualified subsistence users was included via the joint state and federal RM865 registration permit for a portion of the unit and the general moose harvest ticket for the remainder of the unit. If timely harvest reports were not received, hunters received reminder letters (1 reminder letter for general season hunters and 2 reminder letters for permitted hunters), an e-mail (if an e-mail address was provided by the hunter), and in some situations a telephone call.

Radiocollared adult cows were used to estimate annual cow survival rates, while observations of calves accompanying radiocollared cows were used to estimate calf survival rates. During RY15–RY19, the cows were radiotracked during twinning surveys (May–June), moose surveys (November), and in some years during late winter (February–April). Annual survival of collared animals was modeled as a set of independent Bernoulli trials with distinct probability of survival for each year for adults and grouped set of years for calves. Ninety percent confidence intervals for the survival probabilities were then computed using the qbeta function in program R.

Season and Bag Limit

The fall resident moose hunting season during RY15–RY19 was 24–28 August and 8–17 September with a bag limit of 1 bull (any bull). The nonresident season was 8–17 September with a bag limit of 1 bull with 50-inch antlers or antlers with 4 or more brow tines on at least 1 side. There were 2 resident-only winter draw moose hunts in Unit 20E (DM794 and DM796) during RY15–RY19. These hunts were designed to provide additional moose hunting opportunities within the LRCUA where access is limited during the fall season. The season dates for these draw hunts were 1 November–10 December with a 1 bull bag limit (any bull). In addition to access restrictions within the LRCUA during the fall moose hunting season, access restrictions were also in place within the Glacier Mountain Controlled Use Area.

Results and Discussion

<u>Harvest by Hunters</u>

Total reported annual harvest during RY15–RY19 averaged 228 moose per year (Table 4), which is greater than the previous 5-year average harvest but is well below the IM harvest objective of 500–1,000 moose per year. The 3-year running average harvest ranged from 202–237, which is also well below the IM harvest objective. The reported harvest of 244 moose during RY15 was the highest reported annual harvest since moose seasons were reopened in RY82, following a 5-year closure in Unit 20E due to low moose population. The estimated average unitwide harvest rate during RY15–RY19, defined as the average annual harvest divided by the midpoint unitwide population estimate, was 3.0%.

Table 4. Unit 20E reported moose harvest, Interior Alaska, regulatory years 2015–2019.

Regulatory year	General and registration reported harvest				Drawing permit harvest		Total reported harvest
	Male	Female	Unknown	Total	DM794	DM796	
2015	244	0	0	244	0	0	244
2016	243	2	0	245	0	0	245
2017	206	0	0	206	0	0	206
2018	200	1	0	201	0	1	202
2019	245	0	0	245	0	0	245

Permit Hunts

The 2 winter draw hunts in Unit 20E (DM794 and DM796) were created by the Board of Game to allow for additional harvest opportunity within the LRCUA, both in areas that are difficult to access during the fall hunt, and also in areas where bull-to-cow ratios are high (i.e., >60 bulls:100 cows). Participation, success rates, and harvest were low during these winter draw hunts during RY15–RY19. Participation (permit holders who reported hunting) was 27% (4 of 15) and 29% (10 of 35) for DM794 and DM796 permit holders, respectively. Furthermore, only 1 bull was reported harvested, which equates to an overall success rate of 7%. Two bulls were harvested during these draw hunts during RY10–RY14 compared to 7 bulls during RY05–RY09. Participation and success rates were high during RY95–RY02, the first 8 years of these draw hunts, partially due to larger and more accessible hunt areas. Since then, however, both participation and success rates have declined, despite an increase in the season length of 10 days beginning in RY12. In response to this decline, the department communicated with the Upper Tanana Fortymile Advisory Committee (AC) during RY15–RY19 on the status of these hunts and potential strategies for increasing participation and/or success rates. Although these draw hunts are challenging for hunters for a variety of reasons (i.e., remote hunt areas, challenging winter conditions, difficult access, low moose densities), the department should continue to work with the public during RY20–RY24 to implement strategies to increase participation, success rates, and/or harvest to ensure the original intent of these hunts are met.

Hunter Residency and Success

Most of the moose harvested in Unit 20E during RY15–RY19 were harvested by nonlocal Alaska resident hunters (74%), while an equal proportion were harvested by both local Alaska residents (residents of Unit 12, 20E, and eastern Unit 20D) and nonresident hunters (13% each). This pattern is similar to the RY10–RY14 report period. Reported success rates averaged 25% (range = 21–28%) during RY15–RY19, which is slightly higher than the RY10–RY14 and RY05–RY09 average success rates of 23% and 21%, respectively. The number of moose hunters who reported hunting in Unit 20E increased from an annual average of 718 during RY05–RY09 to 801 during RY10–RY14 to 928 during RY15–RY19.

Harvest Chronology

Similar to prior reporting periods, since the current split season between August and September began in RY01, the majority (92%) of moose harvested during RY15–RY19 were taken during the 10-day September portion of the fall moose season.

Transport Methods

Transportation used by successful moose hunters in Unit 20E was similar to prior reporting periods. Most successful hunters used 4-wheelers (48%); followed by airplanes (17%), off-road vehicles (14%), highway vehicles (12%), and boats (9%).

Other Mortality

Radiocollared adult cow survival rate estimates were high (96–100%) during 2015–2018 and lower during 2019 (86%; Table 5). Since the average age of radiocollared cows increased during 2015–2019, a logistic regression was run to model mortality using age and a binary year predictor for 2019 versus 2015–2018 to estimate whether survival rates were statistically different between 2019 versus 2015–2018, and whether age was a contributing factor. The collinearity of year and age was accounted for during this analysis, and it was found that a significant amount of the variance in survival rates was explained by the binary year predictor that was not already included in the information provided by the age predictor. The 2019 estimated annual survival rate was statistically different from the 2015–2018 estimated annual survival rates (*P-val* = 0.006), and there was no statistically significant evidence that age was associated with the decreased estimated survival rate during 2019. However, given the relatively small annual sample sizes included in these survival estimates, the biological significance of the reduced 2019 survival rates should be further investigated after additional years of data collection.

Although determining the cause-specific source of mortality was not a primary goal of maintaining a sample of radiocollared cows, a likely cause of mortality was determined at the time the radiocollar was retrieved from the field for most of the cows that died during 2015–2019. Of the 10 radiocollared cows that died during 2015–2019, 5 were likely wolf kills, 2 were likely brown bear kills, and 3 lacked evidence to suggest a cause of mortality.

Calf survival was estimated from observations of calves accompanying radiocollared cows. Observed average calf survival from birth to November (data collected during all years) and March (data collected during 2015, 2016, and 2019) during 2015–2019 was 38% (90% CI = 32–45%) and 25% (90% CI = 18–34%), respectively. The starting combined (all years) sample size of calves accompanying radiocollared cows observed during both twinning surveys and in November was 160 and for radiocollared cows observed during both twinning surveys and in March was 84. Although these estimated calf survival rates are plausible and comparable to previous moose calf mortality studies (Gasaway et al. 1992), it is important to point out the potential sources of bias and imprecision associated with this method. First, annual sample sizes are relatively small, although the combined multiyear sample size is larger and more robust. Second, this method only estimates the survival of the calves that are observed during twinning surveys. Cows that are parturient but not observed with calves during twinning surveys could either 1) give birth to their calf or calves after the last twinning survey flight, 2) give birth to their calf or calves but they died before the cow is observed during a twinning survey flight, or 3) be accompanied with a calf or calves during the twinning survey flight but the calf or calves are missed by the survey team. These scenarios, other than calves being born after the last twinning survey flight, would bias the calf survival estimate high. Even though there are potential sources of bias and imprecision associated with this method of estimating calf survival, it likely portrays a relatively accurate picture, especially when a multiyear average is used.

Table 5. Unit 20E radiocollared adult cow moose estimated survival rates, Interior Alaska, 2015–2019.

Year[a]	*n* start[b]	Mortalities	Survival rate	Lower 90% confidence interval	Upper 90% confidence interval
2015	23	0	1.00	0.91	1.00
2016	52	2	0.96	0.91	0.99
2017	51	1	0.98	0.93	1.00
2018	44	1	0.98	0.90	0.99
2019	42	6	0.86	0.77	0.92

[a] Year is defined as 22 May–21 May (e.g., 2015 = 22 May 2015–21 May 2016).
[b] Number of radiocollared cows at the beginning of each year on 22 May.

Alaska Board of Game Actions and Emergency Orders

The Alaska Board of Game reduced the Unit 20E IM harvest objective from 500–1,000 to 250–500 during their March 2020 meeting. This reduction occurred as part of Proposal 88, although the change in the objective was not an original part of the proposal. A reduction in the objective was suggested by the department as part of the proposal presentation, while the specific range of 250–500 was suggested by the Eagle and Upper Tanana/Fortymile Advisory Committees. No emergency orders affecting Unit 20E moose were issued during RY15–RY19.

Recommendations for Activity 2.1

- Continue to monitor total harvest for comparison with the IM harvest objective.
- Continue to monitor and estimate mortality rates of calves and adult cows via monitoring of the radiocollared cows.
- Work with the public to implement strategies to increase participation, success rates, and/or harvest to ensure the original intent of the Unit 20E winter moose draw hunts are met.

3. Habitat Assessment-Enhancement

ACTIVITY 3.1. Assess habitat condition (G1).

Data Needs

Twinning rates are the primary metric used to assess nutritional health of the Unit 20E moose population. However, if twinning rates decreased to levels suggesting that the nutritional status may be low, a habitat assessment of forage plants could help determine if the moose were limited by habitat. This would be necessary in order to achieve the goal of managing the moose population in concert with other components of the ecosystem.

Methods

Refer to Activity 1.2 for twinning rate methods.

Results and Discussion

Twinning rates remained at levels suggesting adequate nutritional status during RY15–RY19. With adequate nutrition established, no habitat assessment surveys or enhancement were necessary during this report period.

Recommendations for Activity 3.1

Complete one browse survey within southern Unit 20E during RY20–RY24.

NONREGULATORY MANAGEMENT PROBLEMS OR NEEDS

There were no nonregulatory management needs during this reporting period.

Data Recording and Archiving

RECORDING

- GSPE Moose Survey Form | WinfoNet | Data Archive | Unit 20E moose (http://winfonet.alaska.gov/index.cfm).
- Moose Twinning Survey Form | WinfoNet | Data Archive | Unit 20E moose (http://winfonet.alaska.gov/index.cfm).
- ArcGIS version 10.3 (store and analyze spatial data).

ARCHIVING

- Harvest data and GSPE survey data are stored in WinfoNet | Harvest Information and Survey and Inventory Tools (http://winfonet.alaska.gov/index.cfm).
- All other electronic files such as survey memos, reports, and maps are located on the Tok server (S:\Wells\moose and S:\Wells\MAPS). All hard copy data sheets, paper files, etc. are filed in the file cabinet in the conference room in the Tok office.
- Survey memos and other pertinent electronic survey information (e.g., survey maps) are archived in WinfoNet | Data Archive | Region III Memos and Unit 20E (http://winfonet.alaska.gov/index.cfm)

Agreements

None.

Permitting

ADF&G Animal Care and Use Committee Unit 20E moose capture protocols 2016-05, 0003-2017-03, 0003-2018-13, and 0003-2020-01.

Conclusions and Management Recommendations

The IM population and harvest objectives were not achieved in Unit 20E during RY15–RY19. The midpoint estimated Unit 20E moose population was slightly lower than the IM population objective of 8,000–10,000 moose, while the upper end of the estimated plausible range overlaps with the objective. A moose survey within the northern portion of the unit that has not previously been surveyed would allow for a more accurate unitwide population estimate, and therefore a more accurate comparison to the IM objective. Unitwide reported moose harvest was well below the IM harvest objective of 500–1,000.

Bull-to-cow ratio management objectives were achieved during RY15–RY19. However, TCSA bull-to-cow ratio estimates hovered near the objective during all of the years in which it was surveyed. Bull harvest within this portion of the unit is likely near the maximum sustainable level, and although there are no recommended changes to the bull harvest structure at this point, bull-to-cow ratios should continue to be closely monitored during the RY20–RY24 reporting period to ensure harvest remains within the levels necessary to meet the bull-to-cow ratio objective.

In accordance with Management Objective M2, no management actions were taken to inhibit moose population growth in southern Unit 20E during RY15–RY19 because 3-year average twinning rates were >20%. Large portions of southern Unit 20E burned during the 2004–2005 wildfires, and these wildfires created good habitat conditions that have persisted despite a doubling of the moose population since then. Twinning rates should continue to be closely monitored during the RY20–RY24 reporting period given the increasing moose population and changing habitat conditions due to succession in the burned areas.

II. Project Review and RY20–RY24 Plan

Review of Management Direction

Management Direction

The established management direction and goals for Unit 20E moose are appropriate and will be continued. However, the RY15–RY19 goal to maximize opportunities for nonconsumptive use of moose will be removed for RY20–RY24 because no codified or management objectives are tied to this goal, and no efforts have been made to assess whether the goal has been met.

Goals

G1. Protect, maintain, and enhance the moose population in concert with other components of the ecosystem.

G2. Continue sustained opportunity for subsistence use of moose.

G3. Maximize sustained opportunities to participate in hunting moose.

CODIFIED OBJECTIVES

Amounts Reasonably Necessary for Subsistence Uses

C1. Unit 20E has a customary and traditional use finding for moose, with ANS of 50–75 moose.

a. This objective will be considered met if 4% of the midpoint of the unitwide prehunt moose population estimate is greater than or equal to the lower threshold of ANS (currently 50 moose). The estimate will be conducted once during the RY20–RY24 plan period; refer to Activity 1.1 for methods.

Intensive Management

C2. Population objective: 8,000–10,000 moose.

a. This objective will be considered met if the midpoint of the unitwide prehunt moose population estimate is greater than or equal to lower threshold of the IM population objective (currently 8,000 moose). The estimate will be conducted once during RY20–RY24 plan period; refer to Activity 1.1 for methods.

C3. Harvest objective: 250–500 moose.

a. This objective will be considered met if a 3-year average reported harvest is greater than or equal to lower threshold of the IM harvest objective (currently 250 moose). As previously stated, this objective was reduced by the Board of Game from 500–1,000 to 250–500 at their March 2020 meeting.

MANAGEMENT OBJECTIVES

M1. Maintain a posthunting ratio of ≥25 bulls:100 cows within the Taylor Corridor survey area and ≥40 bulls:100 cows in all other survey areas.

a. This objective will be considered met if the midpoint bull-to-cow ratio estimate (determined annually for each area surveyed) is above the target posthunting ratio.

b. Management action will be considered if the midpoint estimate decreases to below the objective for 2 consecutive surveys. Examples of possible management actions include shortening the season or instituting an antler restriction.

c. This objective is revised for the Taylor Corridor survey area portion from 30 bulls:100 cows during the RY10–RY14 reporting period. Following a discussion with the Upper Tanana/Fortymile AC in January 2019 regarding the Unit 20E bull-to-cow ratio management objectives, the AC recommended changing the objective from 30 bulls:100 cows to 25 bulls:100 cows within TCSA and continuing the objective at

40 bulls:100 cows within the remainder of the unit. The AC recommended changing the management objective within TCSA for the following reasons: 1) the increasing moose population (especially the cow component) within that portion of Unit 20E, 2) to better match the Unit 20E moose management goals to allow for subsistence use of moose and to maximize sustained moose hunting opportunity, and 3) to match the bull-to-cow ratio objective in the immediately adjacent portion of Unit 12 of 25:100. The Eagle AC had a similar discussion in February 2019 but decided to wait to make a change to the management objective within the northern portion of the unit until a survey could be completed within that portion of the unit.

M2. Allow for population growth in southern Unit 20E (within the Taylor Corridor, Tok West, and Tok Central survey areas) when the 3-year average twinning rate is >20% and manage for population stability or reduction when the 3-year average twinning rate is ≤20%, contingent on a secondary measure of nutritional status.

a. Management action, including the option to begin measuring a secondary index of nutritional status, will be triggered if the average 3-year twinning rate is ≤20% for 2 consecutive 3-year averages.

REVIEW OF MANAGEMENT ACTIVITIES

1. Population Status and Trend

ACTIVITY 1.1. Conduct GSPE surveys to estimate population abundance and composition (objectives C1, C2, M1).

Data Needs

No change from RY15–RY19 reporting period.

Methods

Overall, the methods used during RY20–RY24 will match those used during the RY15–RY19 reporting period. The GSPE technique will be used to complete all population and composition surveys. The desired relative precision (RP) for the Taylor Corridor and the combined Tok West and Tok Central survey areas for observable moose population estimates will be investigated and refined in collaboration with regional biometricians. As a starting point, the desired RP is within 15–20% of the average at the 90% CI, and for composition estimates (calf-to-cow and bull-to-cow ratios) within 20–30% of the average at the 90% CI. For the uncombined Tok West and Tok Central survey areas, as well as any new survey areas, the desired RP for observable moose population estimates is within 15–25% of the average at the 90% CI, and for composition estimates within 20–35% of the average at the 90% CI. When corrected for sightability, the desired RP for the Taylor Corridor and combined Tok West/Central survey areas for population estimates is within 20–25% of the average at the 90% CI and for the uncombined Tok West/Central survey areas within 25–30% of the average at the 90% CI. Biometric assistance will be used to evaluate both sample size and proportion of the SUs allocated to high stratum prior to each survey.

Although these plans are liable to change based upon management needs, available resources, etc., the general moose survey plan for Unit 20E for RY20–RY24 will be to survey TCSA annually, survey the combined Tok West/Central/Taylor Corridor 1–2 times (approximately every 3 years), and to survey the northern portion of Unit 20E outside of YUCH 1 time. To aid in assessing survey frequency, Carly Hammond (Region III biometrician) conducted a power analysis[1] exercise, exploring the ability to detect a trend in abundance assuming an exponential rate of population change. Variables explored in the exercise included rate of change, coefficient of variation (CV), number of surveys, and survey frequency (annual, biennial, or triennial). Statistical power is the probability of a statistical test, in this case linear regression, finding an effect if there is indeed an effect to be found. And inherently, there is a tradeoff between survey frequency and the ability to detect a trend, or change, in abundance (Table 6).

Table 6. Survey schedule needed to maintain at least 80% power to detect a significant linear trend, given a true annual exponential rate of reduction of 0.05 and a population estimate coefficient of variation of 0.10.

Survey frequency	Overall change in abundance[a]	Years[b]	Surveys[c]
Annual	−26%	6	7
Biennial	−34%	8	5
Triennial	−37%	9	4

[a] Estimated overall change in the population between the initial survey and when a significant linear trend is detected.
[b] Total number of years from the initial survey before a significant linear trend is detected.
[c] Total number of surveys before a significant linear trend is detected.

The power to detect a declining trend before the overall decline in abundance is <20%, assuming a true exponential reduction rate of 0.05 per year, is low unless precision is high (e.g., CV of 0.05). In addition, in order to have a power ≥80% to detect annual rates of change <0.05, the CV must be low and/or the number of years of surveys must be relatively high. It should be noted that the exponential rate of reduction of 0.05 that was assumed in the exercise presented in Table 6 is arbitrary, but the tradeoffs presented in the power analysis relate to the management goals and objectives (e.g., IM population objective) in that some overall change in abundance inevitably occurs prior to the detection of a linear trend. More precise and/or frequent surveys result in the ability to detect trends more quickly, which can result in earlier intervention actions, if such actions are desired. The tradeoffs presented in the power analysis should be considered when changing and/or determining the frequency of surveys for Unit 20E moose survey areas.

Unitwide Population Estimate

Similar to the previous reporting period, the unitwide population will not be estimated on an annual basis but will instead be estimated for the 5-year report period as a whole. This is because not all areas can be surveyed annually in Unit 20E, making annual estimates infeasible and likely inaccurate. The unitwide population estimate will be determined using the same formula used during RY15–RY19.

[1]Carly Hammond, ADF&G Region 3 Biometrician, Moose Survey Power Analysis, unpublished report archived in WinfoNet (folder Unit 20E moose), 2021.

ACTIVITY 1.2. Twinning surveys (objective M2).

Data Needs

No change from RY15–RY19 reporting period.

Methods

No change from RY15–RY19 reporting period. The annual minimum target sample size will remain at 40 cows observed with calves distributed predominantly throughout TCSA. Three-year average twinning rates will continue to be used to evaluate nutritional condition of the moose population according to the following guidelines:

- If the twinning rate is ≥20%, conclude moose population has moderate to high nutritional status and is not habitat limited.
- If the twinning rate is <20% for 2 consecutive 3-year averages, conclude moose population has low to moderate nutritional status and initiate a secondary measure to estimate nutritional condition (Boertje et al. 2007). The most feasible secondary index of nutritional status for Unit 20E would most likely be either a browse survey or weighing short-yearlings.
- With biometric assistance, estimate trend in twinning rates using logistic regression.

ACTIVITY 1.3. Deploy radio collars on adult cows (Objectives C1, C2, M2).

Data Needs

Similar to the RY15–RY19 reporting period, radiocollared adult cows will be primarily used during RY20–RY24 for twinning surveys. However, the radiocollared cows will also be used to assess calf and adult survival. A sample size of 40–50 radiocollared cows is necessary to efficiently obtain desired sample sizes during these surveys. However, given budgetary constraints, this activity should be considered a lower priority compared to Activities 1.1 and 1.2 described above.

Methods

Captures and collaring will occur as needed (i.e., annually or biennially) following the same methods as described during the RY15–RY19 reporting period to maintain a sample size of approximately 40–50 radiocollared cows during the RY20–RY24 period.

2. Mortality-Harvest Monitoring

ACTIVITY 2.1. Monitor and analyze harvest data and other mortality (Objectives C3, M1).

Data Needs

No change from RY15–RY19 reporting period.

Methods

No change from RY15–RY19 reporting period. Emphasis will be placed on the following:

- Continue to monitor total harvest for comparison with the IM harvest objective.
- Work with the public to implement strategies to increase participation, success rates, and/or harvest to ensure that the original intent of the Unit 20E winter moose draw hunts is met.
- Continue to work with the Upper Tanana/Fortymile and Eagle ACs on potential cow moose harvest strategies within portions of Unit 20E. Cow moose harvest discussions began with these ACs during RY19.
- Continue to monitor and estimate mortality rates of calves and adult cows via monitoring of the radiocollared cows.

3. Habitat Assessment-Enhancement

ACTIVITY 3.1. Assess habitat condition (G1, M2).

Data Needs

Although twinning rates are the primary metric used to evaluate nutritional condition of the southern Unit 20E moose population (see Activity 1.2), a change in twinning rate generally indicates that a change in nutritional condition, and therefore forage base, has already occurred (Seaton et al. 2011). Conversely, the proportional browse biomass removal provides a more direct and real-time range assessment (Seaton et al. 2011) and has been documented to be negatively correlated with twinning rates (Boertje et al. 2007, Seaton et al. 2011). Therefore, although twinning rates will continue to be the primary nutritional index for the Unit 20E moose population because of the fewer resources (i.e., budget) required to complete twinning surveys compared to browse surveys, a browse survey would be useful in Unit 20E in the context of maintaining the population within carrying capacity.

The most recent browse survey in southern Unit 20E was completed in 2006 and is summarized in Paragi et al. 2008 and Seaton et al. 2011. This survey was completed during spring 2006 which was 1 growing season after the large 2004 wildfires; the estimated proportional biomass removal was 21% (95% CI = 11–31%; Paragi et al. 2008). Since that browse survey, the moose population has approximately doubled, and the areas burned during 2004 have inevitably changed over time. A browse survey during this planning period (RY20–RY24) would be useful to assess range quality as it relates to current moose abundance and the 2004 fires.
Browse survey data would also be used to assess future management decisions (e.g., cow moose harvest, predator control, etc.).

In addition, a decrease in twinning rates would signal the need for a secondary measure of nutritional condition in the moose population. If the 3-year average twinning rate <20% for 2 consecutive 3-year periods, a secondary measure of nutritional condition will be initiated. A browse survey is one option for a secondary measure of nutritional status (the other feasible option being weighing short-yearlings).

Methods

Browse survey methods will generally follow those described in Seaton et al. (2011) and sampling design will be reviewed by ADF&G biometricians. Input from biometricians will be sought to verify and, if needed, refine the methods prior to conducting this activity to ensure that high scientific standards are retained in methods and interpretation of results.

NONREGULATORY MANAGEMENT PROBLEMS OR NEEDS

None identified.

Data Recording and Archiving

RECORDING

- GSPE Moose Survey Form | WinfoNet | Data Archive | Unit 20E moose (http://winfonet.alaska.gov/index.cfm).
- Moose Twinning Survey Form | WinfoNet | Data Archive | Unit 20E moose (http://winfonet.alaska.gov/index.cfm).
- ArcGIS version 10.3 (store and analyze spatial data).

ARCHIVING

- Harvest data and GSPE survey data will be stored in WinfoNet | Harvest Information and Survey and Inventory Tools (http://winfonet.alaska.gov/index.cfm).
- All other electronic files such as survey memos, reports, and maps will be located on the Tok server. All hard copy data sheets, paper files, etc. will be filed in the file cabinet in the conference room in the Tok office.
- Survey memos and other pertinent electronic survey information (e.g., survey maps) will be archived in WinfoNet | Data Archive | Region III Memos and Unit 20E (http://winfonet.alaska.gov/index.cfm)

Agreements

None.

Permitting

ADF&G Animal Care and Use Committee Unit 20E moose capture protocol 03-2023-01.

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