Status of Montana's mountain goats: A synthesis of management data (1960–2015) and field biologists' perspectives

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EXECUTIVE SUMMARY

We synthesized population survey and harvest data collected by Montana Fish, Wildlife and Parks (MFWP) staff over the past 60 years for the state's mountain goat (*Oreamnos americanus*) populations. In addition, we surveyed 18 MFWP biologists who manage goats in Regions 1–5 to learn more about the populations for which they have management responsibility. We summarized their written questionnaire responses to evaluate the current status and management circumstances of Montana's mountain goats.

Mountain goats distributions in Montana include historic ranges as well as mountainous areas into which goats have expanded from introductions of animals to non-native habitat. In 2016 an estimated 3,685 mountain goats were managed by MFWP, 2,526 (69%) in introduced populations, and 1,159 (31%) in native populations. Another 2,225 goats inhabited the Montana portions of Glacier and Yellowstone National Parks. The most important finding of this work was the dichotomy between native and introduced mountain goats. Compared with population estimates from the 1940s and 1950s, numbers of goats across native ranges (outside Glacier National Park) are 3–4 times fewer today than the 4,100 estimated from surveys during the 1940s. Our survey of MFWP biologists confirmed this decline of native goats. Many of the populations are small and isolated demographically and genetically. Furthermore, both hunting licenses issued for and annual harvests of native populations have declined nearly 10-fold from the 1960s to present. On the other hand, the majority of introduced populations are prospering, with some notable exceptions. Introduced populations now provide the majority of Montana's hunting opportunity. Total goat harvest has declined from the 1960s when 300–500 animals were harvested annually to a relatively stable ≈210 goats annually over the past 30 years. Twelve of Montana's 52 hunting districts (9 with native populations) have been closed to hunting in recent years.

Area biologists provided insights into how they survey and establish harvest prescriptions for populations. They also identified a wide range of management and research needs from which they would benefit in managing and conserving mountain goats. We provide full details of the biologists' answers to a 25-item questionnaire in the attached Appendix.

We identified multiple avenues of management and research for MFWP to consider in future planning efforts: evaluation of statistical power associated with various monitoring protocols, continued maintenance of centralized databases, design of monitoring approaches for long-term consistency, potential development of a statewide species management plan, and research into habitat factors, population dynamics, and causes of mortality of mountain goats.

INTRODUCTION

Among North American native big game species, mountain goats (*Oreamnos americanus*) present many challenges for wildlife management and conservation. They live in remote and harsh environments where traditional monitoring techniques are challenging; they often occur in small isolated populations which are, by definition, more difficult to monitor and face increased risk of declines; and they exhibit life history characteristics that make them particularly susceptible to over-harvest and slow to recover from population declines (Toweill et al. 2004, Festa-Bianchet and Côté 2008). Potentially as a result of some of these challenges, mountain goats have suffered recent population declines across much of the southern portion of the species' native range over the past 50–70 years (Côté and Festa-Bianchet 2003, Festa-Bianchet and Côté 2008, Smith 2014). For example, goat populations in British Columbia have declined by half from an estimated 100,000 in 1960 to 39,000–63,000 in 2010 (Mountain Goat Management Team 2010). Abundance of mountain goats in Washington has declined by 60 percent since 1950 (Rice and Gay 2010). Due to concerns about declines in Alberta, wildlife officials closed the entire province to goat hunting in 1987. Only in 2001 were conservative harvest quotas reinstated there (Hamel et al. 2006).

In Montana, the status of mountain goats is complicated. The western portion of the state supports native populations. To the east, additional populations were established by translocating goats into prehistorically unoccupied habitat (Figure 1). License numbers to hunt native goats have generally been reduced over the past three or four decades, indicating population declines in some areas. Carlsen and Erickson (2008) concluded, "The decline in mountain goat populations is alarming and deserves investigation by Montana Fish, Wildlife and Parks [MFWP]. When goat populations decline, it appears they don't recover."

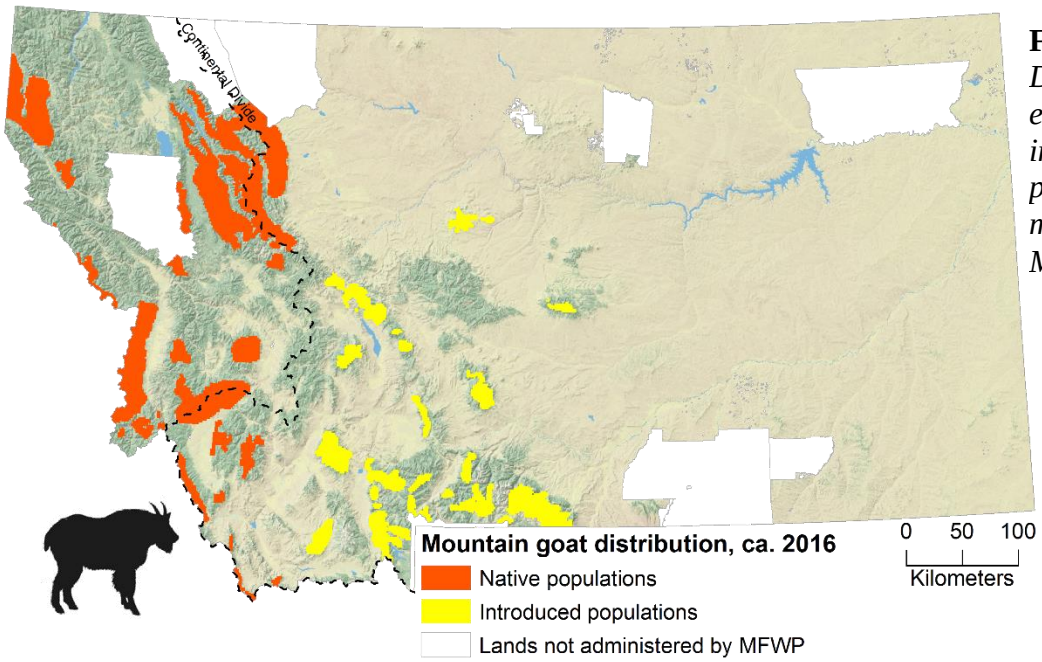


Figure 1. *Distribution of extant native and introduced populations of mountain goats in Montana, 2016.*

Concern over declines in native mountain goat populations are also supported by findings in Alberta, British Columbia, and Washington, which indicate that the mountain goat's natural history may make it particularly sensitive to harvest (and other factors, such as motorized vehicle disturbance) relative to other big game species (Gonzalez-Voyer et al. 2003, Hamel et al. 2006, Mountain Goat Management Team 2010, Rice and Gay 2010).

Contrary to the decline of Montana's native mountain goats, substantial increases have been observed in some introduced populations (Williams 1999, Lemke 2004, Flesch et al. 2016). The transplanting of goats into southwestern and central Montana began over 70 years ago. From 1941 to 2008, 495 animals were transplanted to 27 different sites, with some ranges receiving multiple introductions (Picton and Lonner 2008). Introduced herds in some locations have grown in both numbers and geographic range, while other introductions appeared to have failed, whether immediately or after a period of time.

Carlsen and Erickson (2008) reported that the statewide total goat harvest has been relatively stable over the past 30 years, although this summary may mask markedly different trends occurring among native and introduced populations. A synthesis of historic harvest and monitoring data from each hunting district (HD), and aggregated at larger scales, would elucidate potential shifts in population trends among native and introduced populations, with implications for future conservation of mountain goats and the recreational opportunities they afford.

Montana has a rich history of research into the biology, ecology, and conservation requirements of mountain goats, beginning with the work of Casebeer et al. (1950). Studies during the 1970s and '80s provided the most comprehensive biological information on Montana's native goat populations (Chadwick 1973, Rideout 1974, Smith 1976, Thompson 1980, Joslin 1986). Several studies in the Crazy Mountains provided information on that introduced population's ecology and growth during the 1950s and 1960s (Lentfer 1955, Saunders 1955, Foss 1962). Changes in numbers and distributions of other introduced populations were closely monitored in recent years by MFWP (Swenson 1985, Williams 1999, Lemke 2004). Most recently, Flesch et al. (2016) described range expansion and population growth of introduced goats in the Greater Yellowstone Area.

The aim of this study was to compile and synthesize mountain goat harvest and population information at a statewide scale across Montana over the past 50–60 years, with particular attention to comparing and contrasting dynamics of native and introduced mountain goat populations. We also developed and distributed an expert-opinion survey to solicit the insights and opinions of MFWP personnel (area biologists and/or regional wildlife managers whose jurisdictions include mountain goats) regarding population trends, limiting factors, monitoring practices, and future research and management needs. Summarized results from this survey of MFWP biologists represent the current state of knowledge about Montana's mountain goats, with potential to guide future research, monitoring, and planning efforts aimed at filling information gaps and sustaining or enhancing mountain goat populations and hunting opportunity.

Project Objectives

1. Compile and digitize historical harvest and population monitoring data from MFWP records and reports into a statewide database.

2. Assess trends in mountain goat populations and hunter harvest across Montana, with attention to differences in dynamics among native and introduced populations.

3. Use an expert-opinion questionnaire sent to MFWP personnel to assess the state of knowledge regarding population trends, monitoring practices, limiting factors, and management and research needs for Montana's mountain goats.

OBJECTIVE 1: COMPILE HISTORICAL DATA

We began this project by compiling as much historical data as we could find regarding mountain goat harvest and monitoring. Data sources included:

1. MFWP's internal website databases
    a. Wildlife Information System (WIS), aerial survey data
    b. Wildlife Information System (WIS), hunting and harvest survey data – per HD
    c. Mandatory Reporting Response Entry (MRRE), harvest data – per animal
2. Various electronic data files and reports from area biologists
3. Archived MFWP Survey & Inventory reports from regional office libraries or archives in:
    a. Kalispell
    b. Missoula
    c. Butte
    d. Bozeman
    e. Helena

We organized these data in an electronic database for our analyses. The database will be archived and/or distributed within FWP upon the project's completion. After completing the database, we sent data subsets to each area biologist for review and/or editing of hunting, harvest, and population survey data within their respective jurisdictions. Thus, nearly all of these data have been reviewed by FWP biologists with knowledge about each local area.

The compilation of mountain goat harvest data included >2,200 district-years of data concerning quantities of licenses issued, total numbers of goats harvested, and numbers harvested according to sex. Some data were available as far back in time as 1948 for some HDs. Data for most regions were more consistently available during the period of 1960–2015. Information on the sex, age, and horn measurements for >5,100 individuals was also available via mandatory checking of harvested goats, which began in 1982 and continued through 2015. Other harvest data, such as hunter-days, goats observed, and days per goat seen or harvested, were inconsistently collected over space and time and not deemed suitable for summary in this report.

Population survey data presented challenges to compile because they were not necessarily collected or summarized in reports every year in a way similar to harvest data. We were able to

compile data from many population surveys by reading regional survey and inventory reports. Review of population survey data by current FWP area biologists allowed us to fill in many data gaps, although we may still be missing data for certain areas and time periods. To date, we have compiled >700 individual goat population surveys spanning 1942–2016.

OBJECTIVE 2: TRENDS IN HARVEST AND POPULATION SURVEY DATA

Hunter harvest data

We analyzed mountain goat hunter harvest data for the period spanning 1960–2015 (Figure 2). The availability of hunting licenses during this period peaked in 1963 at 1,371 licenses, primarily for hunting of native populations (Figure 2a). Unlimited licenses were available for several native populations in Region 1 at the beginning of the study period in 1960, although regulations for these HDs were gradually switched to limited-draw-based hunting during the subsequent decade. The last unlimited hunting occurred in 1971 in a portion of the Bob Marshall Wilderness, after which only limited licenses were offered in all HDs. In 2015, 16,643 hunters applied to the lottery for 241 goat licenses, with a 1.4% chance of successfully drawing.

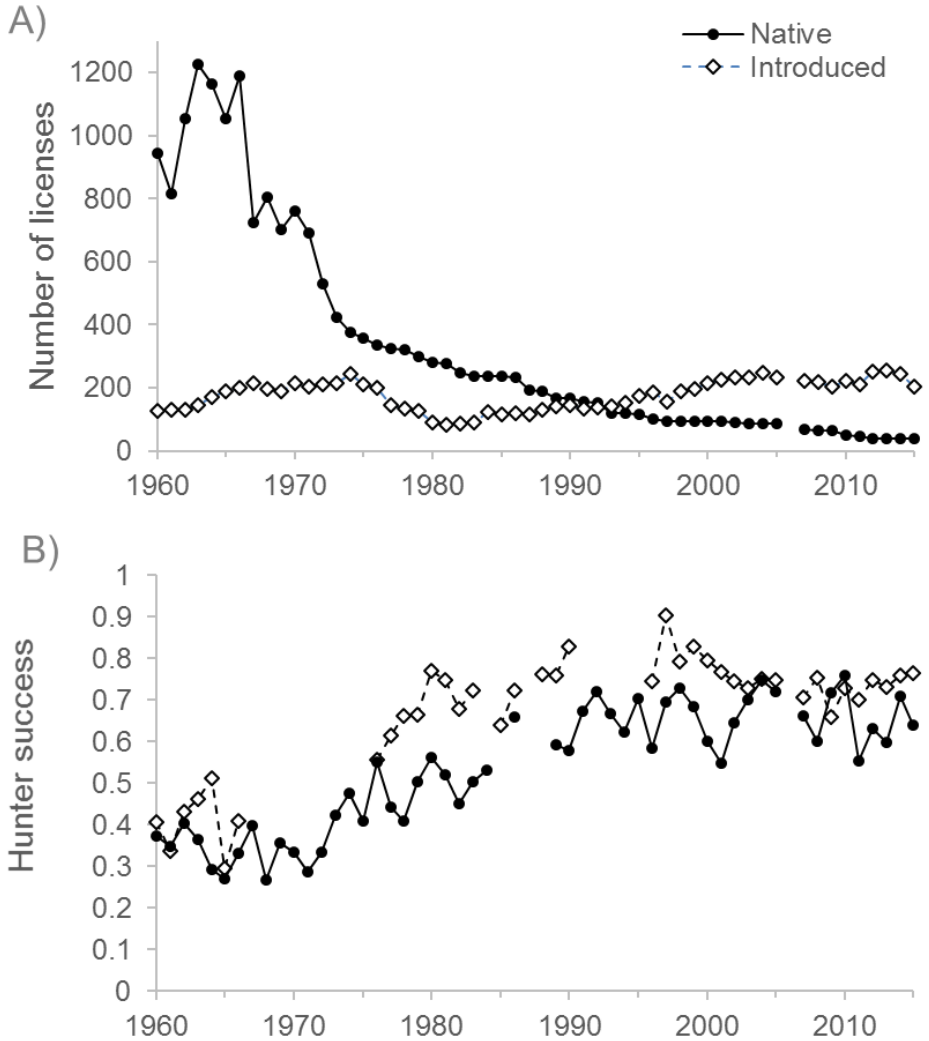


Figure 2. *Trends in A) the availability of hunting licenses and B) hunter success rates (kills per license) for native and introduced populations of mountain goats in Montana, 1960–2015.*

The success rates of hunters, measured as kills per license sold, were lowest during the beginning of this study period, averaging 34% for native populations and 41% for introduced populations during the 1960s (Figure 2b). During subsequent decades, as licenses were reduced in native ranges and increased in introduced ranges, success rates for both increased. Throughout this period, hunter success in introduced range has remained consistently higher than in native range. Thus far during the 21st century (2000–2015), success rates have averaged 65% for hunters of native populations and 74% for hunters of introduced populations. Hunter success rates are typically high and difficult to interpret for special big game species with low-odds license drawings. In such cases, we do not expect trends in hunter success to reflect those of abundance of mountain goats.

Mirroring trends in license availability, total harvest of mountain goats was highest during the early 1960s, peaking at 513 animals in 1963 (Figure 3). By the late 1970s and throughout the 1980s, total harvest became somewhat stable, averaging 216 goats per year during 1977–1989, and ranging from 170–242. Similar harvests have been achieved since, including during the 1990s (mean=212, range=197–228), the 2000s (mean=221, range=184–250), and most recently 2010–2015 (mean=198, range=174–214; Figure 3). Less visible during this 40-year period of stability in total harvest has been a dramatic shift in harvest from native to introduced populations (Figure 3). In the early 1960s, 87–88% of harvested animals were from native populations, averaging 377 native goats harvested per year compared to 55 introduced goats. Since that time, the proportionate harvest of native goats has declined substantially as a result of both reduced licenses in native populations and increased licenses in introduced populations (Figures 3, 4). In 2015, 25 goats were harvested from native ranges compared to 155 from introduced ranges.

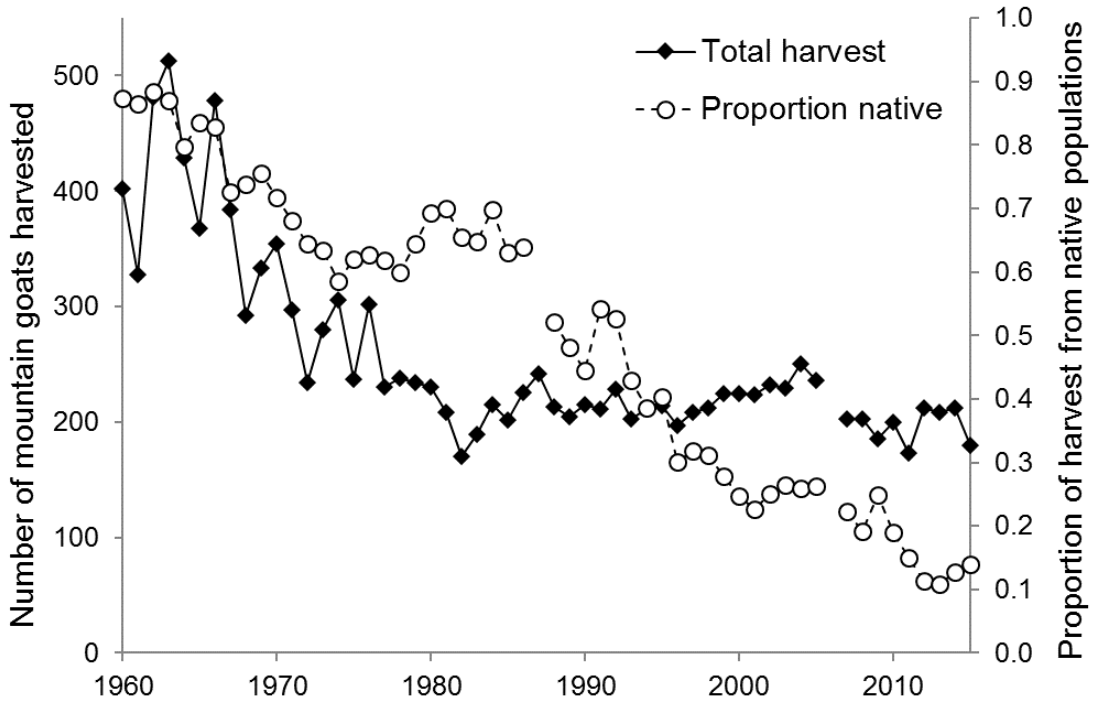


Figure 3. *Total harvest of mountain goats and the proportion of harvest coming from native populations in Montana, 1960–2015.*

When looking at trends in total harvest according to administrative region, large declines in native harvest are evident in Regions 1 and 2 of western Montana. To the contrary, substantial increases in harvest have occurred in introduced populations in Region 3 of southwestern Montana (Figure 4).

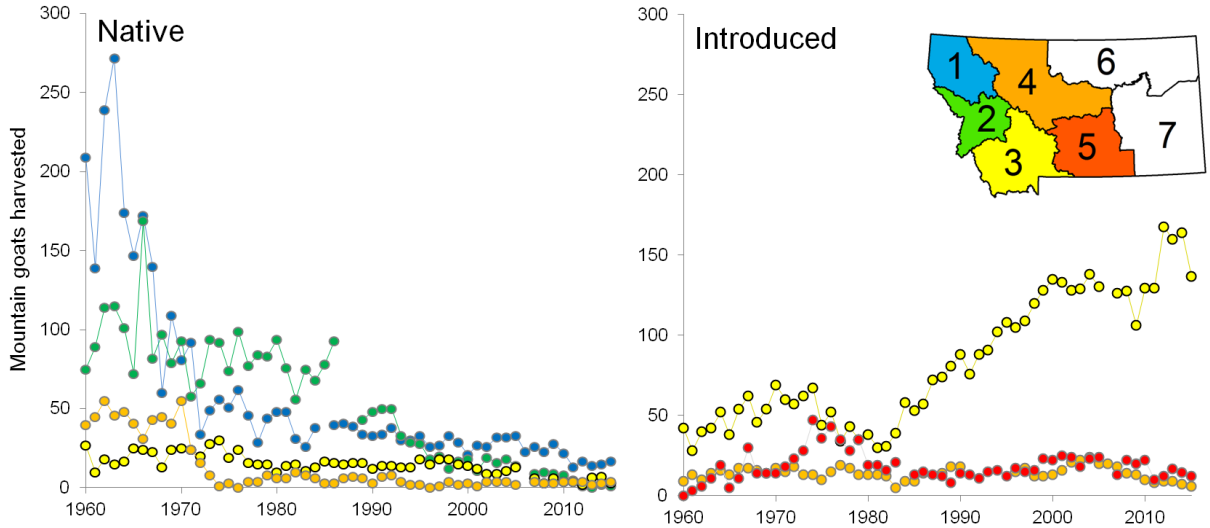


Figure 4. *Numbers of mountain goats harvested from native and introduced populations, by administrative region, in Montana, 1960–2015.*

Unlike other North American ungulates, mountain goats present a unique challenge to hunters and wildlife managers because the sexes are difficult to differentiate in the field. Male and female goats do, in fact, exhibit sexually dimorphic horn characteristics, but these and other subtle differences can be challenging for untrained observers to identify (Smith 1988a). Consequently, MFWP has consistently offered either-sex licenses that allow hunters to legally harvest either a male or female. Harvest of male goats is typically the goal for both wildlife managers (e.g., to harvest animals with lower reproductive value) and for hunters (e.g., to harvest animals with larger trophy scores). To support this goal, MFWP currently offers information and videos on their website as a voluntary educational opportunity for hunters. An exception to either-sex licenses was implemented in 2016 when 25 female-only licenses were issued in the Crazy Mountains HD313. Early indications are that hunters with these licenses were quite adept at successfully identifying and harvesting females during the 2016 season (e.g., preliminary data showed 14 of 14 harvested goats were females, K. Loveless, personal communication).

To assess how hunter education and/or selectivity may have changed in past years, we also summarized the proportion of females within the harvested sample of mountain goats during 1960–2015 (Figure 5). There was no statistical difference in proportionate harvest of females among native and introduced populations (t_{110}=0.543, P=0.588). A decreasing trend in the annual proportion of females in the harvest was evident among both native (β=-0.002, P=0.001) and introduced (β=-0.002, P=0.001) subsets of the statewide harvest, showing an average decrease of 0.2% per year. For example, an average of 42.2% of the annual harvest was females during the 1960s (excluding the outlier value of 18% from 1964), while an average of 30.7% of the harvest was females during 2010–2015.

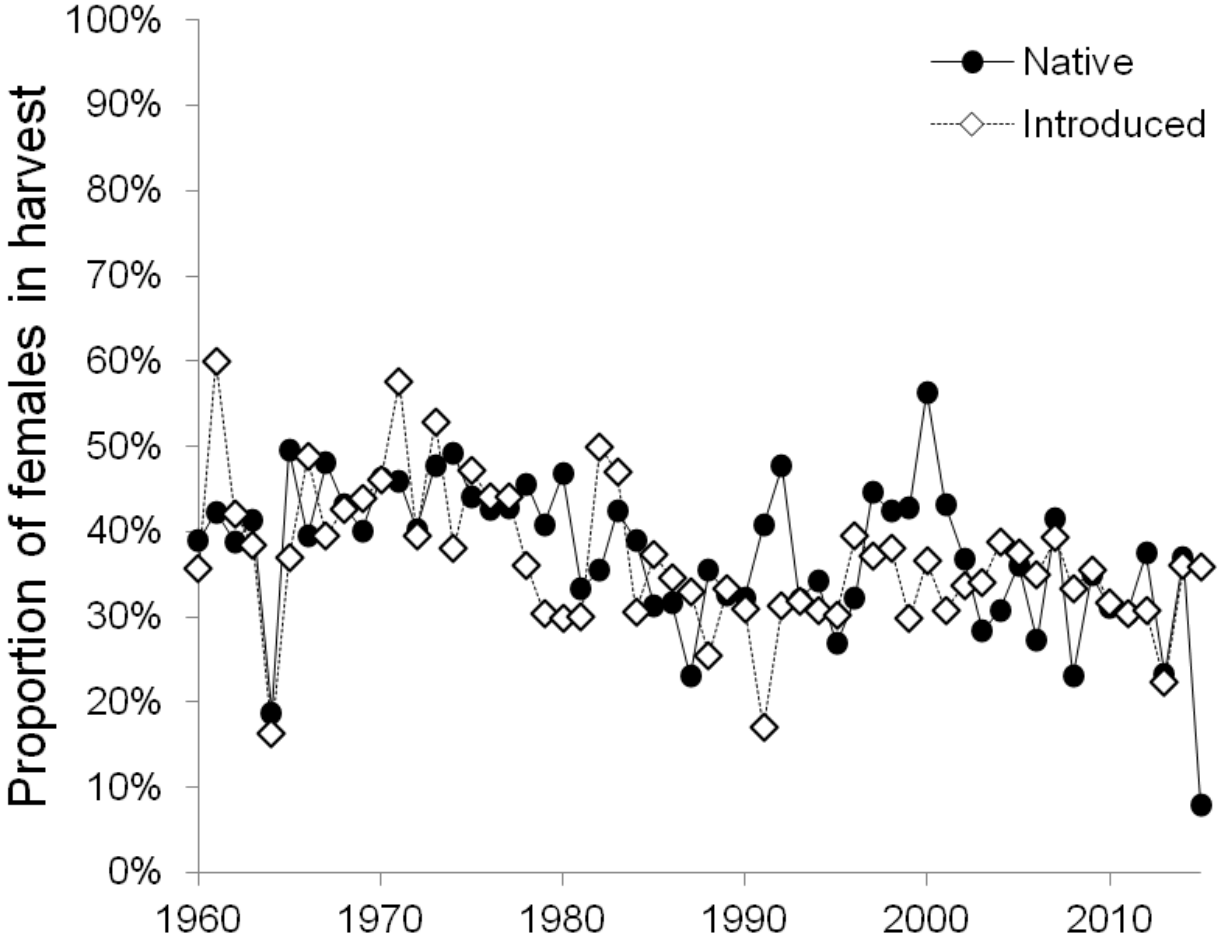


Figure 5. *Proportion of females within the annual harvest of mountain goats, among native and introduced populations, in Montana, 1960–2015.*

In order to compare trends in total harvest among regional populations, we grouped 69 different mountain goat HDs that have been used during various portions of the period 1960–2015 into 28 regional "populations" (Figure 6). The area and number of animals encompassed by each population were not consistent, although we attempted to delineate populations according to logical topographic or ecological boundaries. These groupings included 14 native populations and 14 introduced populations, and we plotted long-term trends in total mountain goat harvest for each (Figure 7). The native population in the Whitefish Range saw no harvest during this period and was eventually deemed as extirpated. Declines in harvest are evident for nearly all native populations (with the possible exception of the Cabinet Mountains) and some introduced populations, while other introduced populations show recent increases in harvest.

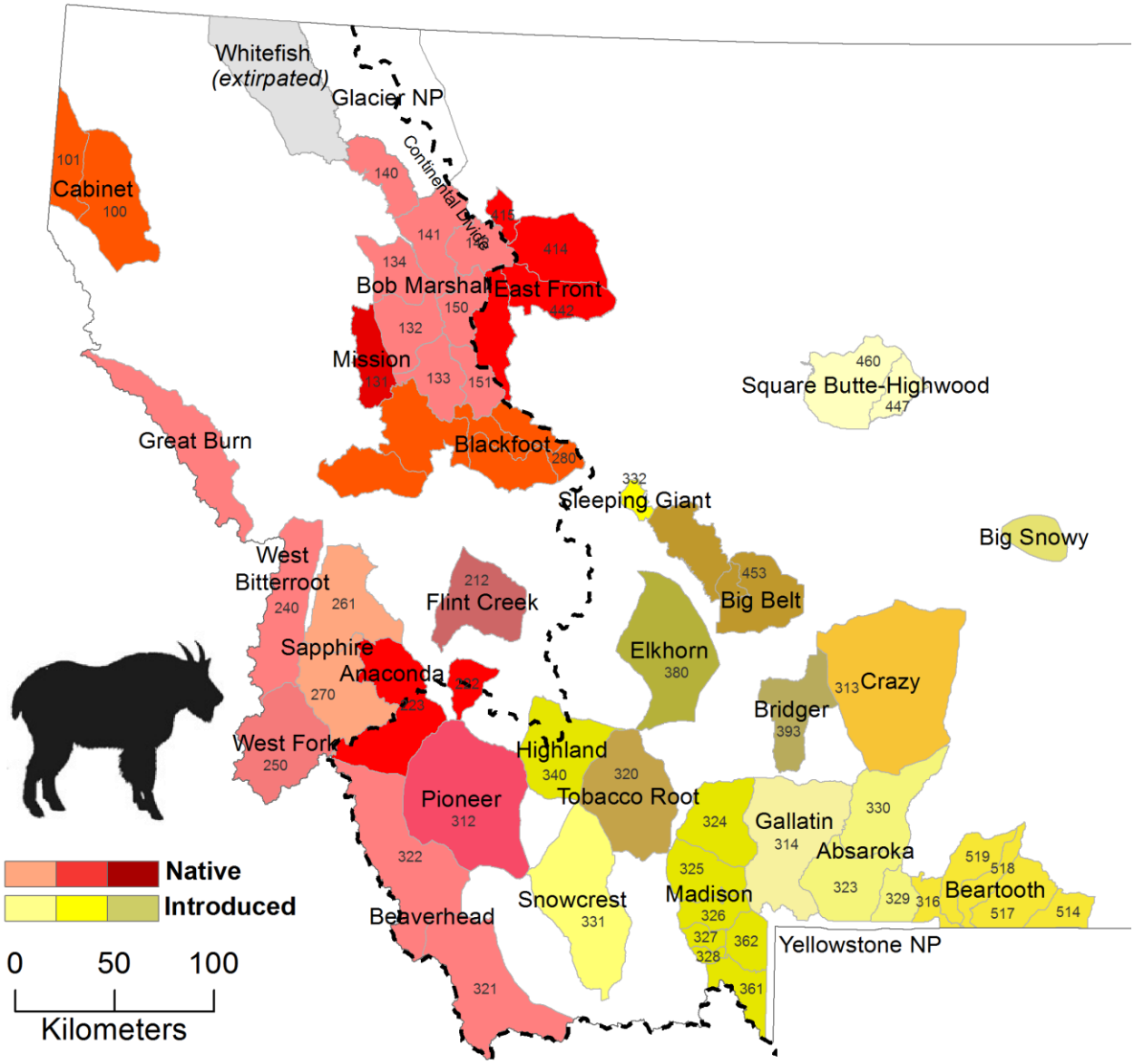


Figure 6. *Hunting districts and regional "populations" of mountain goats in Montana during 1960–2015, which were defined subjectively for purposes of summary within this report. Note: our summaries do not include popuations inside Glacier and Yellowstone National Parks.*

a) Total harvest: Native populations

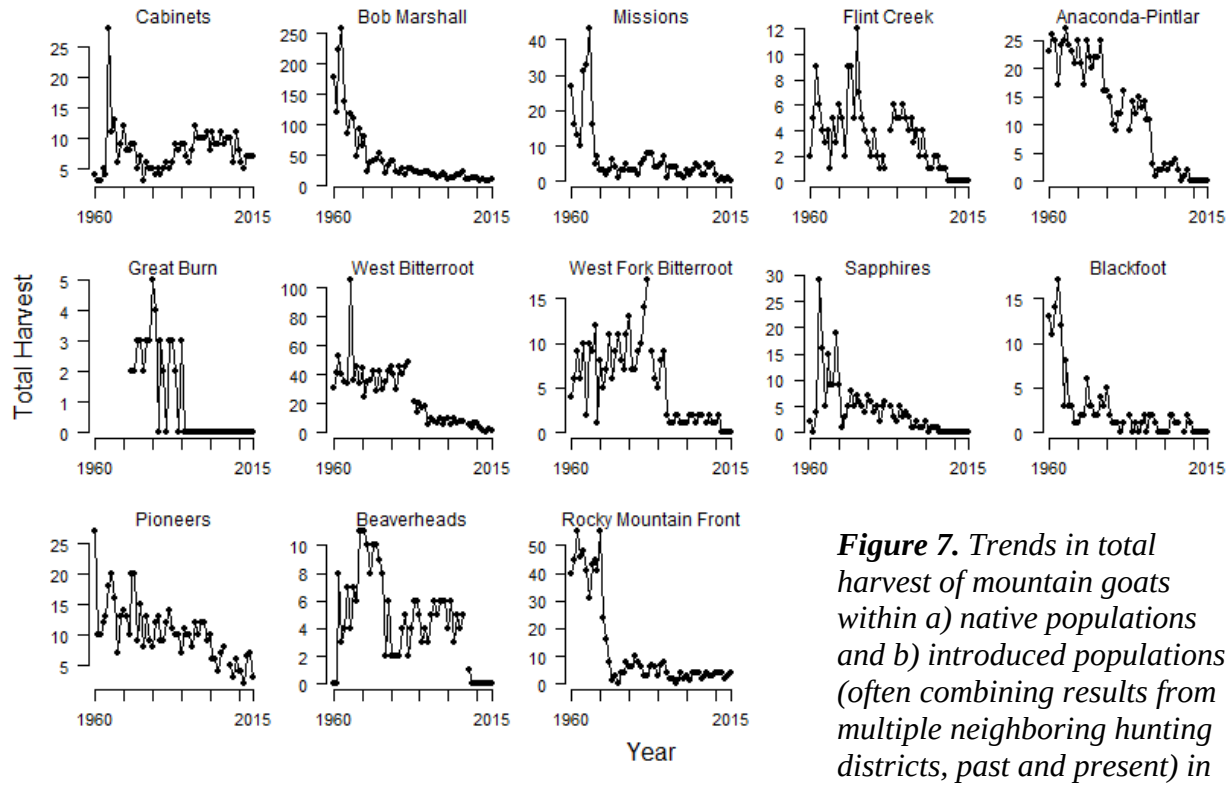
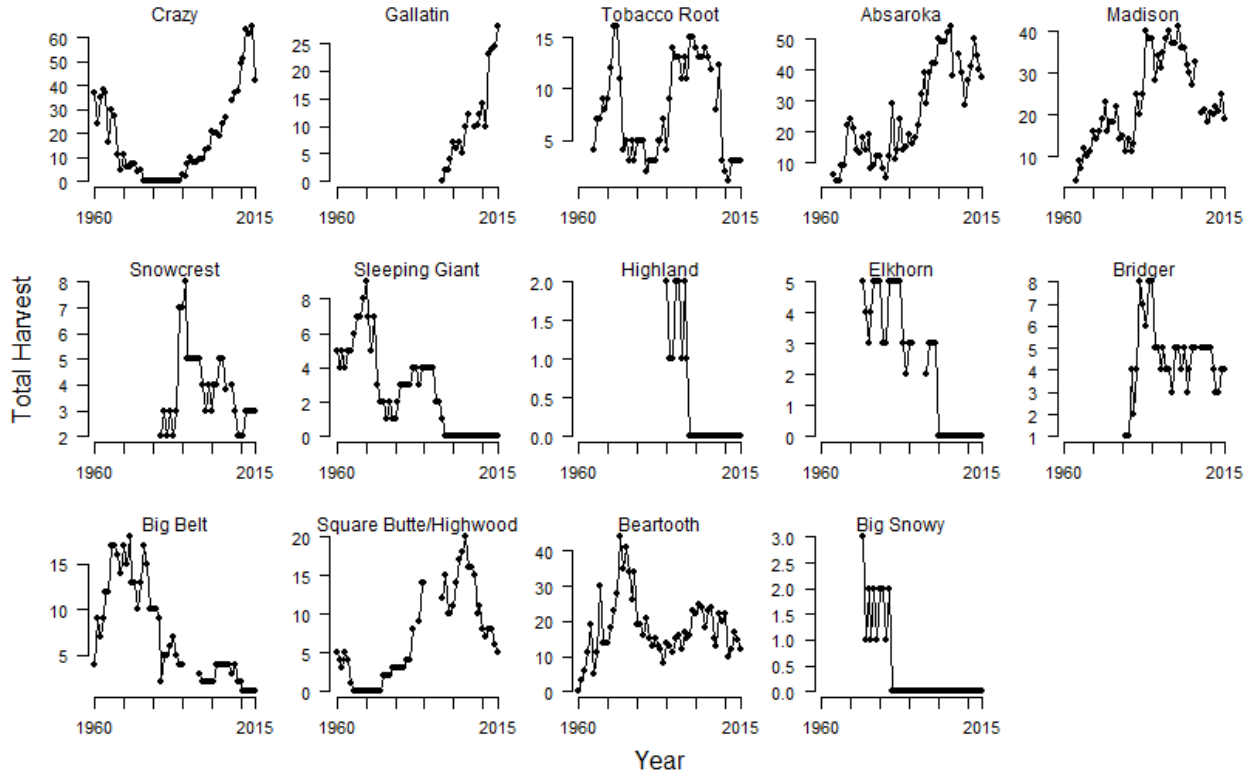


Figure 7. *Trends in total harvest of mountain goats within a) native populations and b) introduced populations (often combining results from multiple neighboring hunting districts, past and present) in Montana, 1960–2015.*

b) Total harvest: Introduced populations



Harvest rates

We estimated contemporary harvest rates of mountain goats by combining hunter harvest data presented here with population estimates developed below via questionnaires to FWP area biologists (see Objective 3). We estimated the "license rate" in 2015 as the number of licenses issued divided by the estimated population size of mountain goats within a given jurisdiction. We estimated the "harvest rate" as the 2015 estimated total harvest of mountain goats divided by the estimated population size (Table 1).

Table 1. *Population estimates, hunting licenses offered, total harvest, and estimated license rate (licenses/population size) and harvest rate (harvest/population size) of mountain goats among regional populations in Montana, 2015. See "Objective 3-Population estimates" below for more information about population estimates.*

	Regional population	Population estimate (Range)	Licenses	Total harvest	License rate	Harvest rate
Native populations	Cabinet	135 (125-155)	8	7	5.9%	5.2%
	Bob Marshall	360 (322-367)	13	10	3.6%	2.8%
	Mission	17 (16-18)	2	0	11.8%	0%
	Whitefish (extirpated)	0	0	0	--	--
	Anaconda	20 (0-40)	0	0	0%	0%
	Blackfoot	40 (20-55)	0	0	0%	0%
	Flint Creek	25 (0-70)	0	0	0%	0%
	Great Burn	23 (20-25)	0	0	0%	0%
	West Bitterroot	100 (80-120)	2	1	2.0%	1.0%
	Sapphire	10 (0-40)	0	0	0%	0%
	West Fork	30 (10-100)	0	0	0%	0%
	Beaverhead	51 (36-66)	0	0	0%	0%
	Pioneer	125 (75-150)	9	3	7.2%	2.4%
	East Front	223 (165-315)	5	4	2.2%	1.8%
Introduced populations	Absaroka	470 (355-538)	58	38	12.3%	8.0%
	Bridger	78 (56-98)	5	4	6.4%	5.1%
	Crazy	450 (330-550)	50	42	11.1%	9.4%
	Elkhorn	20 (9-30)	0	0	0%	0%
	Gallatin	250 (140-275)	30	28	12.0%	11.2%
	Highland	10 (10-15)	0	0	0%	0%
	Madison	617 (447-760)	24	19	3.9%	3.1%
	Sleeping Giant	0 (0-1)	0	0	0%	0%
	Snowcrest	48 (22-48)	3	3	6.3%	6.3%
	Tobacco Root	27 (11-44)	3	3	11.1%	11.1%
	Big Belt	105 (81-130)	2	1	1.9%	1.0%
	Square Butte-Highwood	105 (90-135)	6	5	5.7%	4.8%
	Big Snowy	1 (1-2)	0	0	0%	0%
	Beartooth	345 (290-422)	21	12	6.1%	3.5%

In 2015, MFWP issued a total of 241 mountain goat hunting licenses (39 for native populations, 202 for introduced populations). License holders harvested an estimated 180 mountain goats (25 from native populations, 155 from introduced populations). MFWP biologists estimated a total population of 3,685 mountain goats (1,159 in native populations and 2,526 in introduced populations) on MFWP-administered lands (excluding National Parks and Indian Reservations; see Objective 3). When summing estimates of harvest and goat populations statewide, the estimated statewide license rates in 2015 were 6.5% overall, or 3.4% from native populations and 8.0% from introduced populations. The estimated statewide harvest rates were 4.8% overall, or 2.1% from native populations and 6.1% from introduced populations.

We also estimated license and harvest rates specific to each regional population of mountain goats by grouping data among HDs into populations as described above for harvest trends. Among the 13 extant native populations, 7 were closed to hunting and 6 provided hunting opportunity in 2015. The average license rate among the hunted native populations was 5.5%, and the harvest rate averaged 2.0% (Table 1). Among the 14 introduced populations, 4 were closed to hunting and 10 provided hunting opportunity in 2015. The average license rate among the hunted introduced populations was 7.7%, and the harvest rate averaged 6.3% (Table 1).

Population survey data

We conducted pilot trend analyses of aerial survey data spanning 1960–2015 but found the results difficult to interpret. The availability of data varied substantially among areas and among time periods. The survey areas did not always appear consistent given small populations of goats and often challenging flying conditions, and the timing of surveys also varied in many cases. While consistent and rigorous data were available for several populations, there were many populations for which a consistent stream of data at reasonably high frequency of once per 1–5 years were unavailable within this period. For all of these reasons, we felt formal trend analyses of the survey data would be difficult to synthesize at a statewide scale in a meaningful way.

We instead focused our analysis on survey data collected during the 21st century (2000–2015), and identified 52 survey areas (typically HDs) with at least one survey during this period, for a total of 171 surveys (Table 2). To estimate annual population growth rates, λ, from survey count data, we used exponential growth state-space models developed by Humbert et al. (2009). These models have been shown to more rigorously measure uncertainty surrounding estimates of trend by accounting for process variance (i.e., biological variation) in annual growth rates as well as observation error that induces additional sampling noise around annual count data. Flesch et al. (2016) also used these methods in a recent analysis of mountain goat population trends from survey count data in the Greater Yellowstone Area. Our analysis includes some of the same populations as those studied by Flesch et al. (2016), although we focus only on a recent time period, 2000–2016. This statistical approach has been shown to perform well with a minimum of 5 data points spanning a ten-year survey period (Humbert et al. 2009, Flesch et al. 2016). For our analyses we identified a set of 21 survey areas for which at least 5 surveys for 5 unique years had been conducted. In our case, this spanned a 16-year study period.

We estimated survey-based population growth rates for 5 native populations and 16 introduced populations during 2000–2015 (Figure 8). Survey data were more limited for native than

introduced populations. For native populations, point estimates of λ were <1 for 4 of 5 populations, although 95% confidence intervals of λ overlapped 1 for all but one of these (HD 101, West Cabinet Mountains). The estimated population growth rate for the 5th native population was λ=1.0. Among introduced populations, point estimates of λ were <1 for half (8 of 16) of populations and >1 for the other half. Confidence intervals of λ overlapped 1 for 14 of 16 introduced populations, while confidence intervals for the remaining 2 populations (HD 330, North Absaroka, and HD 514, Line Creek) indicated estimates of λ that were significantly <1.

Given the wide confidence intervals surrounding most estimates of λ, little can be said with statistical certainty about trends in survey data for many of these mountain goat populations using survey data alone. Plotting the precision of trend estimates relative to the number of individuals counted per survey area suggested a positive relationship between the magnitude of counts and precision (Figure 9). Thus, statistically rigorous estimates of trends are more difficult to attain under survey conditions of small populations and infrequent surveys.

Among all mountain goat survey areas, with at least one survey during 2000–2015, the average count was 39 animals. For the subset of 21 areas with >5 surveys the average count was 56 animals. When comparing the standard error of estimates of lambda by the magnitude of these counts per area, it appears that there is potential for a high amount of uncertainty (i.e., SE estimates >0.05 would lead to confidence intervals >0.2 units wide surrounding λ) when the average number of goats counted is <100 animals. This would apply to 48 of all 52 survey areas flown during 2000–2015, unless surveys were designed such that data could be pooled among multiple survey areas prior to interpretation. However, a formal power analysis of simulated mountain goat survey data would provide an improved depiction of the precision of trend estimates under various scenarios of monitoring goats with aerial surveys.

Table 2. Mountain goat survey areas and/or hunting districts (HD), the number of surveys conducted during 2000–2015, and the average total count per survey, Montana.

	Regional population	Survey area or HD	$N_{surveys}$	Average count
Native populations	Cabinet	100	7	80 (40-113)
		101	8	36 (7-57)
		121	9	8 (2-17)
		Montanore Mine	6	15 (3-43)
	Mission	131	1	38 (38-38)
	Mission – Bob Marshall	132	2	20 (15-24)
		133	3	27 (4-48)
		134	1	26 (26-26)
		140	1	47 (47-47)
		142	2	38 (20-56)
		150	2	39 (33-44)
		151	2	9 (2-16)
	Anaconda	222 223	2	25 (9-40)
	Blackfoot	283	2	10 (10-10)
		280 (Dunham)	3	27 (24-32)
		280 (Scapegoat)	4	31 (20-37)
	Flint Creek	212	2	19 (13-25)
		213	1	0 (0-0)
	Great Burn	220	2	4 (2-5)
	West Bitterroot	240	6	66 (19-119)
	West Fork Bitterroot	250 (portion)	2	41 (38-43)
	Beaverhead	321	1	7 (7-7)
		322	4	15 (10-19)
	Pioneer	312	4	11 (0-33)
	East Front	414	1	11 (11-11)
		415	3	26 (24-27)
		442 & Sun River Game Preserve	11	46 (22-71)
Introduced populations	Absaroka	323	7	167 (120-221)
		329	7	113 (75-147)
		330	7	27 (17-38)
	Bridger	393	5	54 (25-88)
	Crazy	313	8	288 (190-371)
	Elkhorn	380	2	5 (0-9)
	Gallatin	314	4	128 (34-180)
	Madison	324	3	60 (53-71)
		325	5	33 (25-41)
		326	4	20 (13-24)
		327	5	16 (6-22)
		328	3	4 (2-7)
		362	6	35 (6-74)
	Sleeping Giant	332	5	2 (0-4)
	Snowcrest	331	1	22 (22-22)
	Tobacco Root	320	3	49 (11-84)
	Big Belt	451	8	32 (17-53)
		453	10	30 (2-49)
	Square Butte-Highwood	447	3	53 (35-62)
		460	3	40 (26-50)
	Beartooth	316	10	43 (8-76)
		514 (winter trend area)	10	48 (12-94)
		517 (winter trend area)	10	24 (4-51)
		518 (winter trend area)	10	21 (2-49)
		519 (winter trend area)	5	8 (2-24)

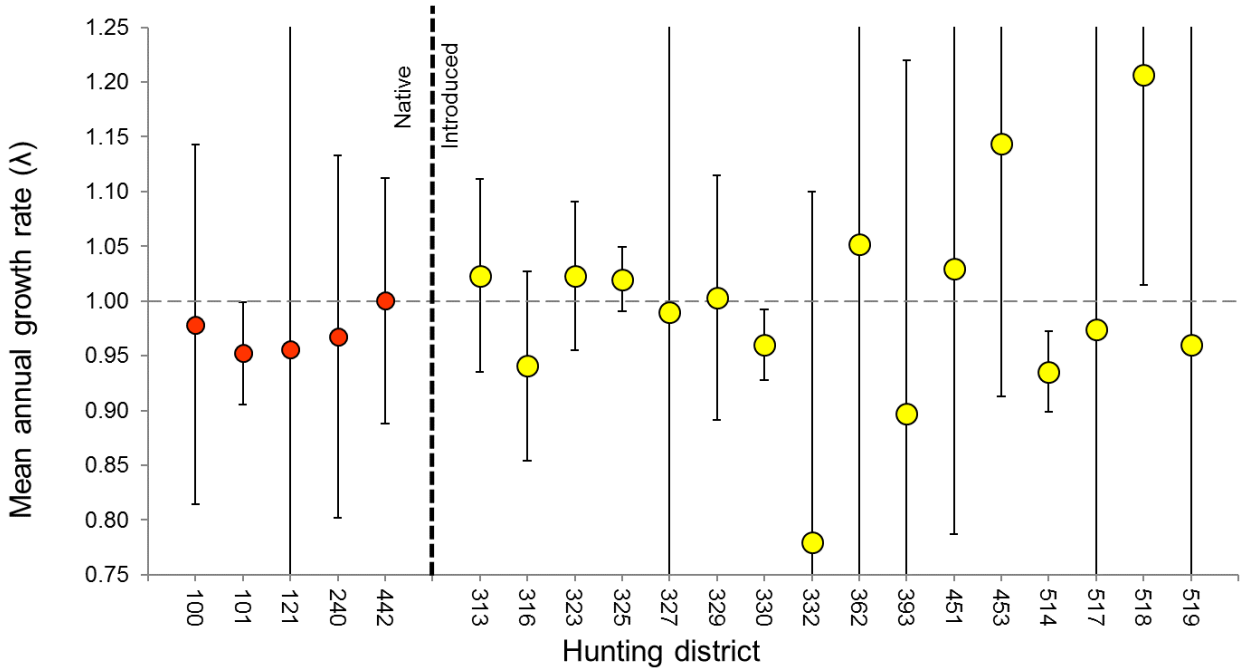


Figure 8. *Mean annual population growth rates and 95% confidence limits for 21 mountain goat survey areas in Montana, 2000–2016.*

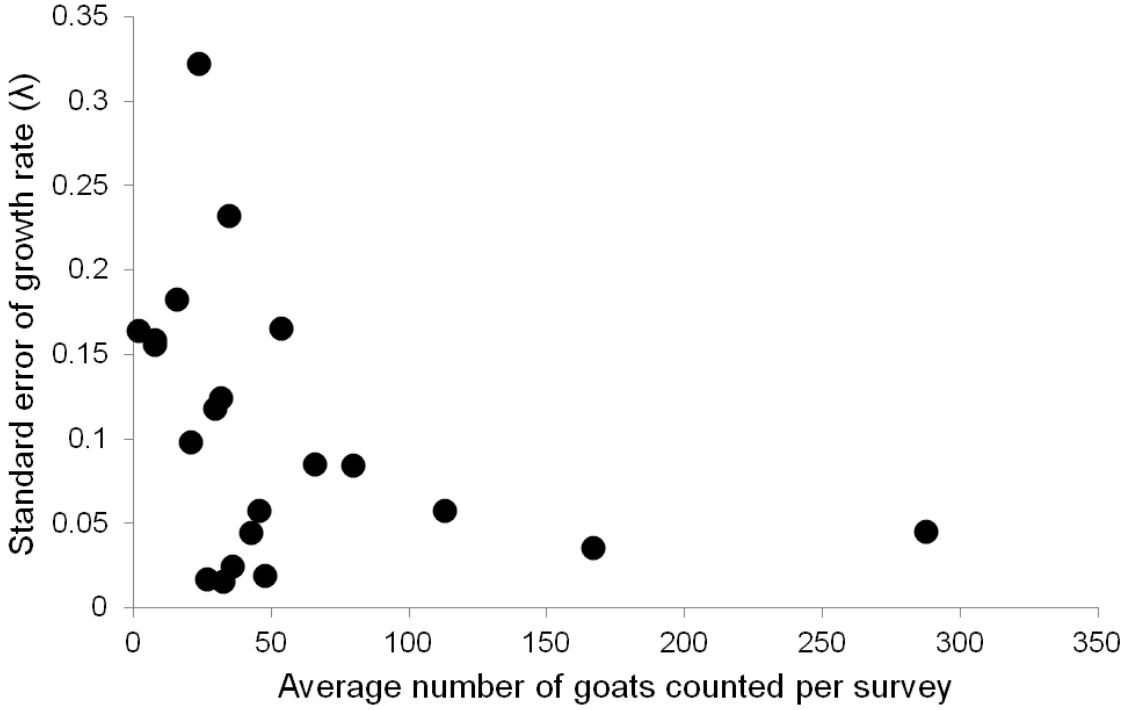


Figure 9. *The standard error of mountain goat population growth rate estimates as a function of the average number of individuals counted during trend surveys in 21 survey areas across Montana, 2000–2015.*

OBJECTIVE 3: SURVEY OF FIELD BIOLOGISTS

MFWP previously contracted a survey of population status, management practices, and research needs for another ungulate species, moose (*Alces alces*; Smucker et al. 2011). As in that project, we developed an original, standardized questionnaire for completion by MFWP area biologists whose jurisdictions include mountain goats. We emailed this 25-question survey to eighteen MFWP biologists in Regions 1–5 who have management responsibility for currently delineated mountain goat HDs. Responses were compiled and summarized separately for native and introduced mountain goat populations. We treated HDs as population sample units for summarizing results, and populations not currently within an administrative HD were included as independent samples. For a subset of questions (3, 7, 11, and 20), we asked respondents to rank a set of possible answers by their relative importance within each HD. In these cases, respondents were free to select and rank as many or as few options as were applicable, with their top choice receiving at rank of 1. We summarized answers to these questions in 2 ways: 1) first we recorded the number of times (the count) a given answer was selected, and 2) we scored rankings in reverse order such that ranks of 1 received the most points. For example, Question #3 included 7 possible answers, and a ranking of 1 received a score of 7, a ranking of 2 received a score of 6, and so on. Scores were then summed for each possible answer across all responses. Other questions were open-ended and received longer narrative responses. These responses are summarized in the following section, with complete details of responses from biologists presented in the Appendix.

Population estimates (Question 1)

We asked area biologists to provide population estimates for a total of 58 population units, including 26 HDs with native populations, 26 HDs with introduced populations, and 6 populations (4 native and 2 introduced) not currently within an HD (Appendix, Q1). These estimates were derived from the best available information from aerial and ground surveys, and applying sightability corrections and professional judgment. Several biologists provided narrative descriptions about individual HDs on their questionnaires. Along with population estimates, we also asked for a "range of confidence" of the estimate within each HD. This was not a statistical confidence interval. In some cases, a range of sightability values from the literature were used to estimate these ranges of confidence surrounding point estimates, and in other cases these were "best guesses" at the range of possible values of true abundance. When pooling estimates for summary purposes across multiple HDs, we used the sum of point estimates, low range of confidence boundaries, and high range of confidence boundaries to characterize total estimates and range of confidence boundaries for the pooled area.

The estimated total population (and range of confidence) of mountain goats in 2016 in native populations was 1,159 (885–1,537), and in introduced populations was 2,526 goats (1,842–2,958). The combined statewide population (excluding the 2 national parks) was 3,685 (2,727–4,495). An additional 2,000 (1,700–2,300) goats are estimated to live in native populations within Glacier National Park (Belt and Krausman 2012, J. Belt pers. comm.), and 225 (200–250) goats from introduced populations inhabiting northern Yellowstone National Park, either year-round or seasonally (Flesch et al. 2016). Including animals within national parks yields statewide estimates of 3,159 native goats and 2,751 introduced goats totaling 5,910 in all.

All introduced populations occur east of the Continental Divide in Regions 3–5. All native populations occur in Regions 1 and 2, west of the Continental Divide, plus three HDs in Region 3 and three HDs in Region 4 (Figure 1; Appendix Q1).

Past trends and limiting factors (Questions 2–5)

Area biologists estimated that 77% (23 of 30) of native mountain goat populations have declined over the past 50-year period of 1960–2010, including 1 extirpated population (Appendix, Q2). An additional 13% (4 of 30) were judged to be stable and 10% (3 of 30) had uncertain trends over this period. For introduced populations, biologists estimated that 43% (12 of 28) declined during this 50-year period, 11% (3 of 28) remained stable, and 43% (12 of 28) increased. Population trend was uncertain for the remaining herd of introduced goats.

The most commonly cited factors limiting goat numbers over the past 50 years were total hunter harvest followed by unknown reasons, harvest of female goats, habitat changes, and predation (Appendix, Qs 3, 4). That sequence was very similar for both native and introduced populations of goats, with ORV/snowmobile use a concern in several HDs of native goats, and predation a greater concern for introduced populations. Several respondents noted the uncertainty surrounding declines in native goat populations, sometimes as a consequence of insufficient population data needed to assess changes (Table 3).

Table 3. *Relative importance of factors limiting goat populations during past years (1960–2010) for native populations (26 HDs plus 3 populations not within current HDs) and for introduced populations (26 HDs plus 1 population not within a HD). Count data indicate the number of populations to which a limiting factor applies. Weighted scores reflect both the number of populations to which a factor applies and the relative rankings of that factor among others selected. See Appendix, Q3, 4 for detailed responses.*

		Disease	Predation	Hunter harvest (total # animals)	Hunter harvest (proportion of females)	Habitat changes (non-anthropogenic)	ORV/Snowmobile disturbance	Energy exploration	Logging and/or road construction	Non-motorized recreation	Climate change	Small population risks (inbreeding, …)	Other (describe in Q4)	Unknown
Native	Count	7	10	21	10	17	14			3	10	9		21
	Weighted score	23	49	126	70	78	79			15	13	52		123
Introduced	Count	4	12	11	10	10				1		4	5	8
	Weighted score	14	63	56	54	43				3		23	30	54
Total	Count	11	22	32	20	27	14			4	10	13	5	29
	Weighted score	37	112	182	124	121	79			18	33	75	30	177

From our compilation of hunting license records, we found that the total number of licenses issued to hunt native populations has declined over the study period (and 9 of 26 native HDs have been closed to hunting; Objective 2). When asked why licenses in their areas of management responsibility had declined, biologists most frequently indicated that licenses were

reduced in response to observed declines in goat numbers (38%) and as precautionary actions until more reliable population data become available (25%; Appendix, Q5).

Current trends and liming factors (Questions 6–8)
We also asked about the status of goat populations in recent years: 2010–present. Biologists responded that 75% of native populations declined during this time or their status was uncertain; whereas introduced populations were largely stable (54%) with a few increasing and a few others decreasing (Appendix, Q6). The most commonly cited factors currently limiting goat numbers were habitat changes, followed by harvest of female goats, total goat harvest, predation, and ORV/snowmobile disturbance (Table 4, Appendix, Q7, 8).

There were marked differences between perceived factors limiting native versus introduced populations. For introduced populations, predation, harvest of females, total harvest, and habitat changes ranked similarly as most important. For native goats, habitat changes were most important, followed by ORV/snowmobile disturbance, small population risks, and climate change concerns.

Table 4. *Relative importance of factors limiting goat populations currently or into the future for native populations (26 HDs plus 3 populations not within current HDs) and for introduced populations (26 HDs plus 1 population not within a HD). Count data indicate the number of populations to which a limiting factor applies. Weighted scores reflect both the number of populations to which a factor applies and the relative rankings of that factor among others selected. See Appendix, Q7, 8 for detailed responses.*

		Disease	Predation	Hunter harvest (total # animals)	Hunter harvest (proportion of females)	Habitat changes (non-anthropogenic)	ORV/Snowmobile disturbance	Energy exploration	Logging and/or road construction	Non-motorized recreation	Climate change	Small population risks (inbreeding, …)	Other (please describe in Q4)	Ltd Available Habitat
Native	Count	10	14	14	13	18	21			4	20	16	4	
	Weighted score	50	66	74	81	101	95			20	91	99	15	
Introduced	Count	6	13	11	11	12	3			3		3		2
	Weighted score	41	69	62	67	60	17			11		17		14
Total	Count	16	27	25	24	30	24			7	20	19	4	2
	Weighted score	91	135	136	148	161	112			31	91	116	15	14

Compared to past limiting factors (1960–2010, see Table 3), there was less uncertainty about factors currently limiting populations. For introduced goat populations, concerns about effects of harvest levels on populations (total and females), habitat changes, and predation remained high. For native populations, there was a shift away from historical concerns about harvest levels to how populations are now being affected by habitat changes (see Habitat considerations section

below), ORV/snowmobile disturbance, climate change, and small population risks. In part, this shift reflects a steep reduction in licenses issued for hunting of native populations over the years. As numbers of goats in native populations have decreased (see Questions 2–5 above), numbers of licenses and harvested goats have plummeted from an average 967 licenses and 329 harvested annually during the decade of the 1960s to an average of 50 licenses and 33 goats harvested during 2007–2015 (39 licenses and 25 goats harvested from native herds in 2015). Contrarily, introduced populations have generally prospered at most transplant sites since their introductions. Numbers of licenses and goats harvested from introduced populations have increased from an average 169 licenses and 71 goats harvested annually during the 1960s to an average of 225 licenses and 165 goats harvested during 2007–2015 (202 licenses and 155 goats harvested from introduced populations in 2015).

Regarding native goat populations, several biologists noted that the cumulative effects of specific factors listed in Table 4 may be perpetuating suppression of goat numbers that may have begun prior to 2010 (Appendix, Q8). Regarding introduced populations, biologists raised concerns about suspected predation on goats as well as the need for careful monitoring of harvest rates and potential overuse of available range by goats (Appendix, Q8).

Harvest and season setting (Questions 9–16)

Biologists managing HDs with native goats take an almost unanimously conservative approach to harvest, with the goal of minimizing impact on populations (Appendix, Q9). Nine of those 26 HDs are closed to hunting; and 8 of the 9 closed HDs are in Region 2. For HDs with introduced goats, objectives of harvest were more varied. Biologists have recommended harvest strategies to limit population growth in six HDs with introduced populations, whereas three of the 26 HDs with introduced populations have been closed to hunting.

Biologists varied in their assessment of the adequacy of survey and inventory information available to them for making management decisions (Table 5; Appendix Q10). The results suggest that, on average, more adequate survey data are collected in HDs with introduced goats. This corresponds to a greater proportion of statewide hunting opportunity being offered in HDs with introduced goats (84% in 2015), though there could be a variety of reasons for variations in survey frequency. When asked which factors were most limiting to population survey efforts, biologists identified aircraft/pilot unavailability, adverse weather conditions, and lack of funding as leading reasons (Appendix, Q12). Differences in population size may also play a role in the adequacy of information available, given our results show that larger populations yield more reliable, less variable, and thus more useful population survey data (Figure 9).

Survey minimum counts and survey recruitment ratios (e.g., kids per goat aged ≥1-year-old) are the two types of data on which biologists place the greatest reliance in setting harvest regulations (Table 6; Appendix Q11). This is true for both native and introduced populations, which underscores the importance of obtaining reliable population survey data to manage goat populations. The next two factors most relied on to set regulations were FWP harvest data (number of animals harvested relative to number of licenses issued) and hunter effort data (number of days/animal harvested). With mandatory reporting of mountain goat kills and consistent annual hunter harvest surveys, these may be the most consistently available data at biologists' disposal.

Table 5. *Tallied responses from 17 biologists regarding the quantity and quality of mountain goat survey and inventory information available for making management decisions, for those managing both native (N=10) and introduced (N=7) populations (see Appendix Question 10).*

	Adequate	Somewhat adequate	Somewhat inadequate	Inadequate
Native populations		2	4	4
Introduced populations	1	4	2	
Total	1	6	6	4

Table 6. *Relative importance of information that biologists use to set annual goat harvest regulations for native populations (26 HDs plus 3 populations not within current HDs) and for introduced populations (26 HDs plus 1 population not within a HD). Count data indicate the number of populations to which a limiting factor applies. Weighted scores reflect both the number of populations to which a factor applies and the relative rankings of that factor among others selected. See Appendix, Q11 for detailed responses.*

		FWP hunter harvest data	FWP hunter effort data (e.g., kills per unit effort)	FWP observations data (e.g., number seen/hunter)	Age and/or horn data	Anecdotal hunter reports (i.e., not in MRRE)	Survey minimum counts	Survey recruitment ratios	Other (please describe):
Native	Count	5	4	4	2	3	5	5	
	Weighted score	22	19	15	6	11	31	32	
Introduced	Count	7	6	4	6	5	8	10	1
	Weighted score	33	25	11	20	15	54	51	7
Total	Count	12	10	8	8	8	13	15	1
	Weighted Score	55	44	26	26	26	85	83	7

When asked if proposed quotas for other species, such as mountain lions, have been affected by population demographics of overlapping mountain goat populations, 16 of 17 respondents answered “no” (Appendix Q13).

We also asked biologists two questions regarding how considerations of the sex of animals entered into hunters’ decisions when targeting a mountain goat. Responses indicated that an average of 55% of hunters intend to harvest a male rather than a female (Appendix, Q14); and biologists estimated that an average of 52% of hunters can correctly identify a mountain goat’s sex under field hunting conditions (Appendix, Q15). These results suggest that over half of

license-holders may be as likely to kill a female as a male, particularly with female-biased sex ratios being typical in the adult cohort of goat populations (Chadwick 1973, Rideout 1974, Gonzalez Voyer et al. 2003). In a simulated field test, 81% of attendees of a Northern Wild Sheep and Goat Council meeting accurately identified the sex of mountain goats after being shown a 20 minute presentation describing the diagnostic characteristics of each sex. However 77% of participants in that study had prior experience censusing or classifying goats (Smith 1988b). When asked if the educational information provided to license-holders was sufficient for hunters to make informed decisions about the age and sex of the animals they choose to harvest, three biologists answered yes, six no, and six were uncertain (Appendix, Q16).

Population surveys (Questions 17–19)

We asked biologists about the methodology used to conduct population trend counts, how often surveys are conducted and during which seasons. They reported using a combination of ground and aerial survey types during all seasons and at intervals ranging from annually to never (Appendix, Q17). When asked if standardized methods should be employed to monitor mountain goats across the state, the consensus was "no" (14 of 18 responses; Appendix, Q18).

When asked to compare native to introduced goat populations, 5 of 6 biologists who responded to this question felt that Montana's introduced populations were generally healthier or more productive with higher recruitment rates. The majority of biologists surveyed said they did not have enough experience or knowledge to make this assessment (Appendix, Q19).

Habitat considerations (Questions 20–21)

There was little consensus about which, if any, habitat management programs would benefit goat conservation or increase hunter opportunity (Table 7). Among the possible management scenarios suggested in the question, 3 recreational management categories had a combined weighted score (21), larger than any other category (Table 7; Appendix, Q20). Sixteen of 17 biologists had not completed any habitat-related projects alone or in cooperation with federal land managers to improve mountain goat habitat or conservation (Appendix, Q21).

Table 7. *Relative importance of habitat management programs that would promote mountain goat conservation and hunter opportunity. Count data indicate the number of populations to which a management program applies. Weighted scores reflect both the number of populations to which a factor applies and the relative rankings of that factor among others selected.*

	None; Habitat is not a limiting factor	More fire (natural or prescribed)	Less fire (suppression of wildfire)	Weed management	Road management (i.e., more restrictive)	ORV management	Snowmobile management	Non-motorized recreation management	Unknown	Other (please describe):
Count	3	5	2	1		2	4	3	6	
Weighted score	9	15	5	1		5	11	5	15	

Management and research needs (Questions 22–25)
Biologists expressed interest in translocating animals to sustain particular native and introduced mountain goat populations (Table 8). Several cautioned that introductions should be carefully evaluated on an area-by-area (herd-by-herd) basis (Appendix, Q22).

Biologists identified a wide array of research needs that would benefit their understanding and management of mountain goat populations (Appendix, Q23 details all topics). This question was open-ended (as was Question 24 about management needs) allowing respondents to offer any number of research topics that interested them. Of the 12 topics mentioned, 3 research themes or areas of study captured 62% of all topics respondents offered: assessments of habitat condition, use, and carrying capacity (9 responses); population demographics: productivity, recruitment, kid survival, and adult survival (7); and causes of mortality (5). The other 9 topics were each mentioned 3 times or less.

Biologists also identified 8 management or monitoring needs that would assist mountain goat management (Appendix Q24 details all topics). The 2 topics most often mentioned, and constituting 68% of all responses, were: better/more frequent monitoring of populations (10 responses); and sightability correction models and improved, standardized, survey methodology (5). Ten additional topics of relevance to mountain goat management and conservation in Montana were mentioned 1 or 2 times each by questionnaire respondents (Appendix, Q24–25).

Table 8. *Biologists' responses about whether there is a pressing need for translocation of mountain goats to sustain native and/or introduced populations.*

	Yes	No
Native	2	4
Introduced	3	7
Total	5	11

DISCUSSION

Population estimates and trends
The overall goals of this project were to synthesize population and harvest trends of mountain goats in Montana over the past 50–60 years and to summarize and evaluate their current status and management circumstances. Based on the responses of FWP biologists who manage Montana's goats, there were an estimated 2,526 animals (69% of total) in introduced populations and 1,159 animals (31%) in native populations in 2016 under MFWP jurisdiction. The combined statewide population managed by MFWP was 3,685 (2,726–4,493) mountain goats. Including another 2,225 goats estimated in the 2 national parks yielded an estimated 5,910 animals within Montana's borders.

To put current numbers in historical perspective, we reviewed previous statewide population estimates of native goats. In an early comprehensive study of Montana's mountain goat population, Casebeer et al. (1950) reviewed estimates of the statewide goat population during 1919–1942, as recorded by the US Forest Service, and during 1943–1948 from estimates made by the Montana Fish and Game Department (Rognrud and Lancaster 1947). Maximum annual estimates were from the years 1943 through 1946, when 5,000–5,200 goats were estimated statewide, of which about 940 occupied Glacier National Park. Although establishment of new herds in previously unoccupied mountain ranges began in 1941 (Picton and Lonner 2008), Casebeer et al. (1950) recorded an annual maximum of only 97 goats among all introduced populations during 1943–1946. From these records it appears that about 4,100 goats occupied native ranges across Montana during 1943–1946 (excluding national parks), a figure three to four times larger than the 1,159 goats estimated by Montana's biologists in 2016. Carlsen and Erickson (2008) estimated 2,719 mountain goats in Montana in 2007, based on population survey data. Of that total, 1,517 animals were in introduced populations and 1,202 were in native populations, based upon the raw data they provided to us from that analysis. While the potential for differences in estimation methods may confound direct comparisons across years, we estimated an additional 1,000 goats to exist in introduced populations compared to that estimated in 2007 (Carlsen and Erickson 2008). However, our native goat population estimate in 2016 (1,159) is only slightly lower than theirs from a decade earlier (1,202).

The disparity between native and introduced mountain goats evidenced by these changes in population estimates was also noted by area biologists' responses concerning population trends. Of the 30 native populations, at least 23 (77%) were judged to have declined or been extirpated since 1960, with trends for 3 additional populations labeled as unknown. To the contrary, 54% (15 of 28) of introduced populations were judged as stable or increasing, though some declines are also evident. In the Beartooth Mountains, for example, trend in recent summer aerial survey data suggests declines of >40% in this introduced population since the 1980s.

Survey responses suggested a variety of causes for declines in native populations over the years. During the 50 years prior to 2010, the limiting factors most often mentioned as responsible for influencing goat numbers were total hunter harvest, female harvest, and unknown reasons. Ranking of current and future threats to goat populations indicated a shift in factors influencing populations. As licenses were reduced in HDs with native populations, habitat changes, ORV/snowmobile disturbance, climate change, and small population risks were perceived as most affecting populations. For introduced goat populations, effects of harvest levels on populations (total and females), habitat changes, and predation ranked highest in importance.

Harvest management

For native goat populations, numbers of licenses and harvested goats have plummeted from an average of 967 licenses and 329 harvested annually during the decade of the 1960s to an average of 50 licenses and 33 goats harvested during 2007–2015 (39 licenses and 25 goats harvested in 2015). Contrarily, introduced populations have generally prospered at most transplant sites since their introductions. Numbers of licenses and goats harvested from introduced populations have increased from an average 169 licenses and 71 goats harvested annually during the 1960s to an average of 225 licenses and 165 goats harvested during 2007–2015 (202 licenses and 155 goats harvested from introduced populations in 2015).

Harvest management of mountain goats has been a topic of much interest and debate in the literature. Overharvest has been implicated as a source of population declines in native mountain goats in other parts of their range. Rice and Gay (2010) used population modeling to evaluate historical trends of mountain goats in Washington and found that population declines were primarily attributable to harvest. Goat populations, numbering less than 100 animals, are generally no longer hunted in Washington (Rice and Gay 2010). Hamel et al. (2006) modeled population dynamics of mountain goats in Alberta and showed high sensitivity of population dynamics to adult female survival and a subsequently detrimental role of female harvest in affecting population trends. As a result of these findings, the authors recommended closure of hunting in populations numbering <50 total individuals, and conservative harvest rates of 1–4% for larger populations depending on the population size and proportionate female harvest (Hamel et al. 2006, Rice and Gay 2010). In our study, the average license rates were 5.5% across hunted native populations and 7.7% across hunted introduced populations, while harvest rates averaged 2.0% for native and 6.3% for introduced populations. Twelve of the state's 52 currently delineated HDs have been closed to hunting, ostensibly due to populations too small to support harvest. Additionally, it's noteworthy that during the 55 years since 1960 about 38% of the mountain goats harvested in Montana were females.

Harvest rates of introduced populations have typically been higher, including cases of harvesting as many as 7.5–20% of the population in some cases (reviewed by Williams 1999 and Côté et al. 2001). Williams (1999) noted that introduced mountain goat populations likely occur in different stages of Caughley's (1970) 4 states of an ungulate irruption, as regulated by density-dependent quality of habitat. Thus, a single optimal harvest rate prescription may not apply to all populations after accounting for other limiting factors such as density dependence or predation rates. However, all authors have recommended caution with harvest of mountain goats in particular due to the difficulties of limiting harvest to males as well as their generally modest reproductive capacity.

Population monitoring

Current monitoring practices for mountain goats vary widely among local areas in Montana. Surveys are not frequently conducted in all HDs, and vary with respect to the platform, frequency, and season among HDs. Our results suggested that current monitoring practices using aerial surveys alone have not, for the most part, been adequate to reasonably distinguish increasing vs. decreasing population trends with statistical rigor over the most recent 15-year time period. Biologists offered that better and more frequent monitoring of populations was their top management need and suggested research leading to a better understanding population demographics of goats was a high priority.

Minimum counts documented during population surveys are a valid means of monitoring trend, as long as the average proportion of individuals seen relative to those in the entire population does not change over time (reviewed by DeCesare et al. 2016). In other words, an equal proportion of the population is assumed to be within the survey area and mean sightability of those within the area is assumed to be constant. While these counts provide a means of estimating trend, they cannot be used to estimate abundance without specific estimates of sightability. Measured sightability rates of marked goats have varied from ~40% to 80% in

studies in British Columbia, Idaho, and Washington (Poole et al. 2000, Pauley and Crenshaw 2006, Rice et al. 2009). Sightability likely varies among goat populations and habitats in Montana, making it unlikely that a single sightability model would apply across the state (*sensu* Harris et al. 2015). Accounting for sightability bias across would Montana would likely require multiple studies and multiple models to fit varying conditions.

Managers of species that tend to occur in small populations commonly face an additional challenge of lacking statistical power when interpreting trend surveys. The precision of population estimates is known to decrease as the size of the population being monitored decreases (Taylor and Gerrodette 1993, Barnes 2002, DeCesare et al. 2016). For example, Barnes (2002) found that the confidence intervals for estimates for a West African elephant monitoring program were likely to be >100% of the point estimates when the population was below 600 animals. This threshold doesn't necessarily apply directly to mountain goat monitoring in Montana. Our results do suggest a positive relationship between the magnitude of counts and their precision (Figure 9). Thus, lumping subpopulations together into larger groups whether during surveys or during data analysis may increase our power to detect trends if done so consistently over time.

A formal power analysis of simulated and empirical mountain goat survey data would offer an improved depiction of how various survey sampling designs might affect the strength of results. Additionally, review of other survey techniques or monitoring practices (such as monitoring of trend via survival and reproductive rates of marked individuals or non-invasive DNA-based population estimation) may aid in evaluating current practices compared to those employed for mountain goats in other jurisdictions (Poole et al. 2011).

In addition to minimum counts, biologists indicated frequent use of recruitment ratios when monitoring mountain goat populations. These ratios are typically formulated as young/adult ratios, though the definition of the adult denominator appeared to vary across surveys depending on efforts to distinguish yearling or 2-year-old goats from older animals. Of significance to interpretation of these data is the important life history detail that the age of first reproduction for female mountain goats is 3 years of age (Rideout 1975) and primaparity can average >4 years-old for native populations (Festa-Bianchet and Côté 2008). It is likely that many of the adults counted in recruitment ratios are not in fact breeding-aged adults. Thus, variation in age structure of adults across years or populations should be expected to confound interpretation of recruitment ratio data.

Area biologists also indicated that other data, in addition to survey data, are used when managing mountain goats. These included hunter harvest data, hunter effort data, and data concerning the age and sex of harvested individuals. Statistical modeling of these forms of data is not typically employed, and it is currently unclear if catch-effort or age-at-harvest data would be sufficient to glean meaningful patterns statistically, whether as a stand-alone analysis or incorporated into an integrated population model (Skalski et al. 2007, Udevitz and Gogan 2012). Hunter success, in particular, may be of limited value in assessing the population status of mountain goats, particularly native goats in Montana. Over the past 60 years as harvest success has increased (Figure 2), we found that Montana's native goats have clearly been in decline as have the number of licenses issued annually. In HDs where only one or two licenses are issued annually,

hunter success of 100% or 50% in a HD is dicey to interpret, and potentially misleading. Fidelity of goats to preferred areas of their ranges contributes to the ability of hunters to find and harvest goats, even when populations are small (Chadwick 1973, Smith 1976, Taylor et al. 2006, Festa-Bianchet and Côté 2008). This natural history trait may predispose hunted mountain goat populations to apparent "hyperstability" when monitored with hunter statistics alone (Hatter 2001). In such cases, hunter harvest statistics may convey a deceptively stable trend even for declining populations, because hunters continue to find and harvest goats in the same areas and with the same efficiency regardless of decreased numbers overall (Hatter 2001). Survey responses suggested that Montana's goat managers recognize the limited value of harvest success compared to biological data obtained from population surveys on which they place greater importance when establishing annual regulations (Table 6). Consequently, population monitoring ranked highest among management priorities (Appendix Q24).

Population identification

Defining and sampling populations is basic to wildlife management and conservation. For analytical purposes, we grouped mountain goat HDs into 28 "regional populations" (Figure 6), but the biological significance of these delineations is unknown.

Where goats occur on an isolated mountain range, for all practical purposes those animals can be considered a biological population. In mountain range complexes, however, geographically defining a population or subpopulations of a metapopulation can be problematic. This situation arises for a number of geographic areas of Montana's mountain goats, both native and introduced. In management practice, the definition of a population often necessitates imposing arbitrary boundaries on the landscape, which may not reflect population biology of the species on the landscape. Furthermore, if seasonal distributions of populations are not well understood, and population surveys do not reflect distributions during the hunting season, disproportionate harvests of individual populations or subpopulations could occur.

Concerns about small population effects raised by several biologists are justified, given the small and potentially isolated nature of many of Montana's goat populations. Biologists estimated that 25 of the state's 52 HDs may support fewer than 50 goats. Such populations risk heightened consequences of stochastic events and inbreeding depression, compared to large populations or metapopulations (Hebblewhite et al. 2010, Johnson et al. 2011). Effective conservation of mountain goats may require additional understanding of the extent to which populations face such risks. Research on movement and yearlong distributional patterns are needed for some of Montana's larger landscapes to determine where populations may now be reproductively isolated. For some native populations in Regions 1 and 2 this seems particularly germane.

Habitat changes

Of all Montana's large mammal species, the mountain goat's distribution is almost completely on federally or state-managed lands: national forest multiple-use lands, national forest wilderness areas, two national parks, plus state lands, and some tribal lands in the Mission Mountains. Steep, rugged terrain and snow are defining features of mountain goat ranges. For some populations, mineral licks are a seasonally important resource, such as the Walton Goat Lick in Glacier National Park (Singer 1978). These habitat features and associated, preferred, food sources largely dictate distributions and movement patterns of mountain goats.

Because of their high, rugged nature, mountain goat ranges tend to be less subject to human development and alteration than habitats of the state's other big game species. Yet, the biologists we surveyed offered a range of direct or indirect effects, both natural and anthropogenic, that are either suspected or known to be affecting mountain goats. Road construction into goat habitat to facilitate mining, energy and timber extraction, and motorized recreation can alter habitat with implications for goat distributions and demography (Fox et al. 1989, White and Gregovich 2017), and increased vulnerability of goats to harvest (Mountain Goat Management Team 2010). Numerous studies in Canada and the U.S. have demonstrated that mountain goats are particularly sensitive to helicopter disturbance (Foster and Rahs 1983, Côté, 1996, Gordon and Wilson, 2004). Mountain goat management plans for Alberta, British Columbia, and Washington review how habitat threats are being addressed.

In Montana, some of the most pertinent research conducted on habitat-mediated impacts on goats includes documentation of how helicopter over-flights associated with seismic testing affects population dynamics (Joslin 1986), and how road intrusion and timber harvest alter mountain goat behavior and distribution (Chadwick 1973). However, little is known about the effects of commercial and recreational activities on most mountain goat populations in the state, or about the condition and carrying capacity of most goat ranges and how that may relate to population performance. Likewise the effects of wildfire, or contrarily fire suppression, on goats through changes in habitat structure, plant succession, and forage are little known. These are noteworthy areas of research regarding the differing status and trends we identified of native versus introduced populations generally.

Mountain goats may also be among those species most sensitive to climate change because of their cold-adapted nature and because the climate is warming (and cascading environmental changes occurring) twice as rapidly at high elevations compared to the global mean rate of warming (Beever and Belant 2011).

FUTURE DIRECTIONS FOR RESEARCH AND MANAGEMENT

Montana is unique among the 8 U.S. and Canadian jurisdictions within the native range of the mountain goat. Montana supports more introduced populations in which numbers of goats collectively now exceed those in the state's native populations. Clearly one size fits all prescriptions for management would not serve the state's goat populations well. Management and conservation efforts require consideration of the wide range of habitats Montana's goats occupy with special attention to differences between native and introduced goats. However, statewide coordination of management planning and research prioritization may serve to leverage resources to address needs and answer questions for broad landscapes and multiple populations of goats.

From our findings, important topics deserving of future attention in comprehensive planning for Montana's mountain goats include:

- Recommendations for harvest of mountain goats: These may well differ for native and introduced populations. Not only population harvest rates, but sex-specific harvest

prescriptions dependent on maintaining viable population size could be addressed. Given that mountain goats occupy habitats relatively secure from human impacts (with some exceptions) compared to other big game species, and that high natural mortality among juvenile cohorts is largely beyond managers' control, wildlife managers can influence mountain goat conservation largely through regulation of public harvest.

- Evaluation of monitoring practices: MFWP biologists rely heavily on population survey data to establish harvest levels of populations. Improved survey techniques, sightability modeling, and informed/optimal monitoring frequencies are all important management needs. Although biologists overwhelmingly felt that monitoring needed to be herd or hunting district specific because of local conditions, some consensus on data collected may be important for comparing populations and analyzing multi-year trends. The most difficult task in this study we conducted was to analyze population survey data due to inconsistencies in monitoring frequency and protocols. A formal power analysis of simulated and empirical mountain goat survey data would offer an improved depiction of how various survey sampling designs might affect the strength of results.

- Local monitoring protocols: We support area biologists' efforts to formally design, prescribe, and document monitoring protocols for mountain goats in their respective areas with the goal of detecting changes in population status that require management actions. These would greatly benefit future area biologists in their jurisdictions and synthesis efforts such as this one by ensuring comparable data streams over time.

- Species management plan: MFWP does not currently have a statewide management plan for mountain goats. Examples of such plans exist for other species in Montana, and for mountain goats in neighboring jurisdictions (e.g., Alberta, British Columbia, Idaho, Oregon, Utah, and Washington). Those state and provincial plans have brought together much of the pertinent literature and identified key planning elements, some unique to mountain goat conservation. Development of such a plan has been previously identified as a priority by MFWP, yet has not occurred in the face of limited time and resources. Relative to other ungulate species in Montana, a management plan for mountain goats may be particularly useful for a variety of reasons. First, various life history traits make them more sensitive to harvest management than other ungulates, which justifies a unique approach to harvest management of this species. Second, some of the variation in monitoring practices and/or harvest rates identified in this report might benefit from regional or statewide coordination or guidelines. Third, the reproductive isolation of many populations may render goats more vulnerable to natural and anthropogenic changes in their environment across broad areas of their distribution. Lastly, individual biologists have less funding and time to devote to gaining local experience and data with this species relative to other more abundant and/or controversial species, which might increase the value of a statewide resource for information and guidance.

- Ecological research: In addition to the monitoring-based research questions we identified above, our questionnaire indicated a variety of potential avenues for important research into mountain goat ecology. These included, but were not limited to, assessments of mountain goat foraging ecology and habitat condition, demographic vital rates and

population dynamics, and causes of mortality.

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Appendix 1. Compiled Results from the Biologist Questionnaire

The following 18 MFWP biologists completed the questionnaire during May–September 2016:
Liz Bradley, R2-Missoula
Vanna Boccadori, R3-Butte
Tonya Chilton-Radandt, R1-Libby
Jessy Coltrane, R1-Kalispell
Julie Cunningham, R3-Bozeman
Scott Eggeman, R2-Blackfoot
Craig Fager, R3-Dillon
Adam Grove, R3-Townsend
Adam Grove, R4-White Sulphur Springs (on behalf of Jay Kolbe)
Cory Loecker, R4-Great Falls
Brent Lonner, R4-Fairfield
Karen Loveless, R3-Livingston
Rebecca Mowry, R2-Bitterroot
Ryan Rauscher, R4-Conrad
Jenny Sika, R3-Helena
Shawn Stewart, R5-Red Lodge
Mike Thompson, R2-Upper Clark Fork (on behalf of Julie Golla)
Dean Waltee, R3-Sheridan

Population Estimates

Q1. Based on available data and your professional opinion, please provide an estimate of the current total number of mountain goats (*N*) within each population that you manage (including 0's for extirpated populations), as of April, 2016. Please also provide an interval showing your confidence in the range of possible values for *N* ("Range of confidence"). If needed you can lump districts together and provide a single combined estimate.

HD	Bio	Native/ Introduced	*N*	Range of confidence
100	Chilton-Radandt	N	85	80 - 95
101	Chilton-Radandt	N	50	45 - 60
131	Coltrane	N	17	16 - 18
132	Coltrane	N	33	31 - 36
133	Coltrane	N	39	36 - 42
134	Coltrane	N	14	13 - 15
140	Coltrane	N	65	60 - 70
141	Coltrane	N	62	58 - 65
142	Coltrane	N	70	67 - 73
150	Coltrane	N	61	57 - 66
151	Coltrane	N	16	16 - 16
212	Golla	N	25	0 - 50
213	Golla	N	0	0 - 20
222	Golla	N	10	0 - 20
223	Golla	N	10	0 - 20
240	Mowry	N	100	80 - 120
250	Mowry	N	30	10 - 100
261	Mowry	N	0	0 - 10
270	Mowry	N	10	0 - 30
280	Eggeman	N	30	15 - 40
312	Fager	N	125	75 - 150
313	Loveless	I	450	330 - 550
314	Loveless	I	250	140 - 275
316	Loveless	I	55	40 - 62
320	Waltee	I	27	11 - 44
321	Fager	N	20	10 - 30
322	Boccadori	N	31	26 - 36
323	Loveless	I	295	221 - 338
324	Cunningham	I	210	156 - 252

HD	Bio	Native/ Introduced	*N*	Range of confidence
325	Cunningham	I	82	57 - 103
326	Cunningham	I	37	28 - 44
327	Cunningham	I	42	30 - 53
328	Cunningham	I	6	4 - 8
329	Loveless	I	150	115 - 170
330	Loveless	I	25	19 - 30
331	Waltee	I	48	22 - 48
332	Sika	I	0	0 - 1
340	Boccadori	I	10	10 - 15
361	Cunningham	I	92	66 - 115
362	Cunningham	I	148	106 - 185
380	Grove	I	20	9 - 30
393	Cunningham	I	78	56 - 98
414	Rauscher	N	40	20 - 60
415	Rauscher	N	75	50 - 125
442	Lonner	N	40	35 - 50
447	Loecker	I	60	50 - 75
453	Kolbe	I	55	45 - 70
460	Loecker	I	45	40 - 60
514	Stewart	I	75	60 - 100
517	Stewart	I	90	80 -100
518	Stewart	I	75	60 - 100
519	Stewart	I	50	50 - 60
Fill-in other populations **(**Sun River Preserve, Rattlesnake NRA, …)				
Bradley - Rattlesnake		N	10	5 - 15
Bradley – Great Burn		N	23	20 - 25
Lonner – Sun River Preserve		N	68	60 - 80
Grove – North Big Belts		I	50	36 - 60
Taylor – Big Snowy		I	1	1 - 2
Thier – Whitefish Range		N	0	-

For 26 Native HDs, plus the Great Burn, Rattlesnake, Sun River Preserve, and (extirpated) Whitefish Range herds, the estimated total population = 1,159 (885–1,537). For 26 Introduced HDs, plus the North Big Belt and Big Snowy Mountains, the estimated total population = 2,526 goats (1,842–2,958). Total statewide population (not including the two national parks) = 3,685 (2,727–4,495).

PAST trends and limiting factors

Q2. How have goat numbers in your area changed over the past 50 years (i.e., 1960-2010)?

Native Populations (HDs) **You can provide separate answers for individual or groups of HDs, or if answer is same across your area you can just put "ALL"	**Increasing**	**Stable**	**Decreasing**	**Uncertain**
100		X		
101		X		
131			X	
132			X	
133			X	
134			X	
140			X	
141			X	
142			X	
150			X	
151			X	
212			X	
213			X	
222			X	
223			X	
240			X	
250			X	
261			X	
270			X	
280				X
312				X
321			X	
322			X	
414			X	
415		X		
442			X	
Great Burn			X	
Rattlesnake				X
Sun River Game Preserve		X		
Whitefish Range (extirpated)			X	
NATIVE TOTAL		4	23	3

Introduced Populations (HDs) **You can provide separate answers for individual or groups of HDs, or if answer is same across your area you can just put "ALL"	**Increasing**	**Stable**	**Decreasing**	**Uncertain**
313	X			
314	X			
316	X			
320				X
323	X			
324	X			
325			X	
326			X	
327			X	
328			X	
329	X			
330	X			
331		X		
332			X	
340		X		
361	X			
362		X		
380			X	
393	X			
447	X			
453	X			
460	X			
514			X	
517			X	
518			X	
519			X	
North Big Belts (no HD)			X	
Big Snowy (formerly HD 516)			X	
INTRODUCED TOTAL	12	3	12	1

For 26 Native HDs, plus the Great Burn, Rattlesnake, Sun River, and Whitefish herds, goat numbers in 23 of 30 areas were judged to have decreased over the past 50 years with numbers in 4 others stable and 3 others uncertain.

For 26 Introduced HDs, plus the North Big Belt and Big Snowy Mountains, goat numbers in 12 increased, 3 were stable, and 12 decreased over the past 50 years.

Q3. Which limiting factors do you suspect may have affected goat numbers in your area of responsibility during the past (1960–2010)? Please numerically rank for each HD those that apply, with 1 being of highest importance. Leave blank those that don't apply. Compiled by hunting district (HD) as indicated by biologists (including Great Burn, Rattlesnake, Sun River Preserve, and North Big Belts). Weighted score accounts for relative rankings.

Count of HDs per category and ranking		Disease	Predation	Hunter harvest (total # animals)	Hunter harvest (proportion of females)	Habitat changes (non-anthropogenic)	ORV/Snowmobile disturbance	Energy exploration	Logging and/or road construction	Non-motorized recreation	Climate change	Small population risks (inbreeding, …)	Other (please describe in Q4)	Unknown
Native	Ranked 1st (7 points)		1	7	10	2	4					5		15
	Ranked 2nd (6 points)	1	3	10		1	1			1	1	1		1
	Ranked 3rd (5 points)	1	3	1		3	9			1		1		
	Ranked 4th (4 points)	1		3		10				1		1		2
	Ranked 5th (3 points)		3			1					9			
	Ranked 6th (2 points)	4										1		1
	Ranked 7th (1 point)													2
	Count of HDs	**7**	**10**	**21**	**10**	**17**	**14**			**3**	**10**	**9**		**21**
	Weighted score	**23**	**49**	**126**	**70**	**78**	**79**			**15**	**33**	**52**		**123**
Introduced	Ranked 1st (7 points)		3	2	2								4[a]	7
	Ranked 2nd (6 points)	2	3	2	4	2						3		
	Ranked 3rd (5 points)		2	5	2	2						1		1
	Ranked 4th (4 points)		2	1	1	5								
	Ranked 5th (3 points)		2							1				
	Ranked 6th (2 points)				1								1	
	Ranked 7th (1 point)	2		1		1								
	Count of HDs	**4**	**12**	**11**	**10**	**10**				**1**		**4**	**5**	**8**
	Weighted score	**14**	**63**	**56**	**54**	**43**				**3**		**23**	**30**	**54**
Pooled	**Count of HDs**	**11**	**2**	**32**	**20**	**27**	**14**			**4**	**10**	**13**	**5**	**29**
	Weighted Score	**37**	**112**	**182**	**124**	**121**	**79**			**18**	**33**	**75**		**177**

[a] Other factors were ranked 1st and described in Q4 below for 4 introduced populations (HDs 313, 331, 332, 340)

[b] Other factors were ranked 6th and described in Q4 below for 1 introduced population (HDs 320)

The most commonly cited factors limiting goat numbers over the past 50 years (through 2010) were total hunter harvest followed by unknown reasons, harvest of female goats, habitat changes, and predation. That sequence was very similar for both native and introduced populations of goats, with ORV/snowmobile use a concern in several HDs of native goats, and predation a greater concern for introduced populations.

Q4. Please elaborate here on the limiting factors you marked in Question 3. For example, if you selected predators, disease, hunter harvest of females or climate change, please explain.

Following are some specific comments reported by respondents:

- "I marked "UNKNOWN" as a top factor in my areas, as I think the bottom line is that we really don't know what has been driving declining goat numbers [native herds] and therefore research is crucial."
- The percent of adult females in the harvest is disturbing/a concern, and overall harvest was probably excessive in the past (several respondents).
- Small isolated populations are potentially affected by inbreeding depression.
- Others mentioned that they suspect climate change effects on goats (or their habitats) but have no direct information.
- Too little population data to assess changes.
- There has been pneumonia complex disease in sheep which may have affected goat production.
- "We have the full complement of predators and I would very much like to know how they influence survival."
- Cumulative effects (hunting + natural mortality) may have caused declines and kept some native populations low.
- Several hunting districts have unique circumstances where trapping and removal of goats may have contributed to declines (HD442); struggling native herds were supplemented with transplanted goats (HD101 and also the Rattlesnake); bighorn sheep were reintroduced on top of a small goat population and may have competed with goats (HD332); habitat was limited where goats were introduced (HD331 and 340); a population crashed possibly due to density-dependent factors and/or disease but has subsequently recovered (HD313).

Q5. In your area of responsibility, why have licenses for <u>native</u> goats been reduced in recent decades (check all that apply)? One response per biologist with responsibilities for native herds.

- Reduced licenses in response to observed declines in goat numbers based on monitoring data (6)
- Reduced licenses as precautionary action until more reliable population data are available (4)
- Reduced licenses in response to change in the objectives or science behind harvest management (2)
- Reduced licenses to maintain higher numbers for other users (e.g., non-consumptive recreationists) (1)
- Other (3) Please describe:

Note that for 2 biologists who indicated "Other," licenses had not been reduced in recent years, and in the third case, permits have been increased.

<u>CURRENT</u> trends and limiting factors

Q6. How do you feel those same populations are doing now (i.e., 2010-present)? Some biologists indicated more than one category for a HD.

Populations (HDs) **You can provide separate answers for individual or groups of HDs, or if answer is same across your area you can just put "ALL"	**Increasing**	**Stable**	**Decreasing**	**Uncertain**
100			x	
101		x		
131			x	
132			x	
133			x	
134			x	
140			x	
141			x	
142			x	
150			x	
151			x	
212			x	
213?			x	
222			x	
223			x	
240		x		x
250				x
261				x
270	x			x
280		x		x
312		x		
321				x
322	x			
414				x
415				x
442		x		
Great Burn				x
Rattlesnake				x
Sun River Preserve		x		
NATIVE TOTAL	2	6	14	10

Introduced Populations (HDs) **You can provide separate answers for individual or groups of HDs, or if answer is same across your area you can just put "ALL"	**Increasing**	**Stable**	**Decreasing**	**Uncertain**
313		x		
314		x		
316	x	x		
320				x
323		x		
324	x			
325		x		
326				x
327/362	x			
328			x	
329		x		
330		x		
331		x		
332		No goats		
340		x		
361	x			
380		x		
393		x		
447	x	x		
453				x
460		x	x	
514			x	
517			x	
518		x		
519		x		
North Big Belts (no HD)	x			
INTRODUCED TOTAL	6	15	4	3

Goats in HDs with native populations are mostly decreasing in recent years (2011–present) or their status is uncertain; whereas introduced populations are generally considered stable with a few increasing and a few others decreasing.

Q7. What are your thoughts as to the <u>current and future</u> threats to sustaining goat numbers? Please numerically rank for each HD those that apply, with 1 being of highest importance. Leave blank those that don't apply. Compiled by hunting district as indicated by biologists (including Big Burn, Rattlesnake, Sun River, and North Big Belts).

	Count of HDs per category and ranking	Disease	Predation	Hunter harvest (total # animals)	Hunter harvest (proportion of females)	Habitat changes (non-anthropogenic)	ORV/Snowmobile disturbance	Energy exploration	Logging and/or road construction	Non-motorized recreation	Climate change	Small population risks (inbreeding, …)	Other (please describe in Q4)	Ltd Available Habitat
Native	Ranked 1st (7 points)	2	3	1	9	4	1				1	9		
	Ranked 2nd (6 points)	2	2	9		3				1	8	3		
	Ranked 3rd (5 points)	4	1		3	11	9			2	1	2		
	Ranked 4th (4 points)		5	2			10			1	1	2	3[a]	
	Ranked 5th (3 points)		2	1	1		1				9		1[b]	
	Ranked 6th (2 points)	2	1	1										
	Ranked 7th (1 point)													
	Count of HDs	**10**	**14**	**14**	**13**	**18**	**21**			**4**	**20**	**16**	**4**	
	Weighted score	**50**	**66**	**74**	**81**	**101**	**95**			**20**	**91**	**99**	**15**	
Introduced	Ranked 1st (7 points)	5	3	2	4	3	1			1		1		2
	Ranked 2nd (6 points)	1	4	4	5		1							
	Ranked 3rd (5 points)		2	4	1	4						2		
	Ranked 4th (4 points)		3	1	1	4	1							
	Ranked 5th (3 points)					1				1				
	Ranked 6th (2 points)		1											
	Ranked 7th (1 point)									1				
	Count of HDs	**6**	**13**	**11**	**11**	**12**	**3**			**3**		**3**		**2**
	Weighted score	**41**	**69**	**62**	**67**	**60**	**17**			**11**		**17**		**14**
Pooled	**Count of HDs**	**16**	**27**	**25**	**24**	**30**	**24**			**7**	**20**	**19**	**4**	**2**
	Weighted score	**91**	**135**	**136**	**147**	**161**	**112**			**31**	**91**	**116**	**15**	**14**

[a] Other factors were ranked 4th and described below in Q8 for native populations (HDs 312, 321)
[b] Other factors were ranked 5th and described below in Q8 for 1 native populations (HD 442)

The most commonly cited factors currently limiting goat numbers were habitat changes, followed by harvest of female goats, total goat harvest, predation, and ORV/snowmobile disturbance. But there were marked differences between perceived factors limiting native versus introduced populations. For introduced populations, predation, harvest of females, total harvest, and habitat changes ranked nearly equally as most important. For native goats, habitat changes were most important, followed by ORV/snowmobile disturbance, small population risks, and climate change concerns.

Compared to historical limiting factors (Question 3), there was less uncertainty about perceived limiting effects on populations. For introduced goat populations, effects of harvest levels on populations (total and females), habitat changes, and predation remain high.

For native populations, there is a shift away from concerns about harvest levels, to how impacts of habitat changes, ORV/snowmobile disturbance, climate change, and small population risks are affecting populations. In part this is because harvest levels of native populations have been slashed over the years (9 HDs with native goats are now closed to hunting). Only 38 permits were issued to hunt goats in the 26 HDs with native populations in 2015. Thus other risks to population viability have replaced earlier concerns with harvest levels.

Q8. Please elaborate here on the limiting factors you marked in Q7. For example, if you selected predators, disease, hunter harvest of females, or climate change, please explain.

Native Populations:

- Several biologists wrote that the concerns they identified in Question 7 were cumulative, perpetuating suppression of goat numbers that may have begun prior to 2010.
- Where populations are now small and isolated, inbreeding depression is a concern.
- For several populations, habitat is limited. "Forest encroachment, due to fire suppression, on some of these higher elevation ranges may be limiting available winter forage." Also noted were concerns that fire suppression has exacerbated forage competition with elk, bighorns, moose, or deer populations in places.
- Concern was expressed that hunter harvest success and effort are not good measures of how a herd is doing.
- Disease impacts (both introduced and native goat herds) are surmised, but not documented. These concerns were expressed for HDs where bighorns have experienced pneumonia die-offs, although the same has not been documented in goats. A disease die-off is circumstantially implicated in HD313 in the past.
- Harvest of adult female goats (roughly 38% of the total harvest historically) is a concern in some populations of native and introduced herds.
- Increased recreation (both motorized and non-motorized) are suspected of impacting growth of goat populations. This could result from displacement and/or physiological stress, but neither has been studied to confirm.
- Through changing plant phenology, dwindling snow in summer, and late-winter snow events, climate change probably contributes to declining viability of some herds.

Introduced Populations:

- More concerns were expressed about predation on goats in introduced than native populations, with lions stated to be of greatest concern. However, several biologists noted that predation on goats was not well documented, or only suspected (in some introduced and native HDs).
- In HDs in the Madison, Gallatin, and Crazy Mountains, harvest objectives and rates that are higher than are sustainable in native herds are being monitored to insure overharvest doesn't occur.
- Concern expressed that for herds with limited habitat, insufficient harvest could lead to overuse of available range. And transplanting bighorns into HD332 may have not only disadvantaged a small goat population but contributed to an increase in lion predation on goats.

Harvest and Season-setting

Q9. What best describes your objectives when allocating mountain goat licenses (select one)? One response per HD only for those HDs open to hunting now.

Native Populations (HDs) **You can provide separate answers for individual or groups of HDs, or if answer is same across your area you can just put "ALL"	Provide conservative number of licenses to allow opportunity with **minimal impact**	Provide **maximum sustainable** number of licenses that still maintains current population size	Provide enough licenses to **limit or decrease the current population** size	Other (please describe):
100	x			
101	x			
131	x			
132	x			
133	x			
134	x			
140	x			
141	x			
142	x			
150	x			
151	x			
212				No licenses
213				No licenses
222				No licenses
223				No licenses
240	x			
250				No licenses
261				No licenses
270				No licenses
280				No licenses
312		x		
321				No licenses
322	x			
414	x			
415	x			
442	x			
Great Burn (No HD)				No licenses
Rattlesnake (No HD)				No licenses
Sun River Preserve (No HD)				No licenses
NATIVE TOTAL	16	1		

Introduced Populations (HDs) **You can provide separate answers for individual or groups of HDs, or if answer is same across your area you can just put "ALL"	Provide conservative number of licenses to allow opportunity with **minimal impact**	Provide **maximum sustainable** number of licenses that still maintains current population size	Provide enough licenses to **limit or decrease the current population** size	Other (please describe):
313			X	
314				x
316				x
320	x			
323				x
324		x		
325		x		
326				x
327		x		
328		x		
329				x
330				x
331	x			
332				No licenses
340				No licenses
361	x			
362		x		
380				No licenses
393		x		
447	x			
453		x		
460	x			
514	x			
517	x			
518	x			
519	x			
North Big Belts (no HD)				No licenses
INTRODUCED TOTAL	9	7	1	6

Biologists managing native HDs take an almost unanimously conservative approach to harvest. For HDs with introduced goats, objectives are more varied with the "Other" responses aimed at limiting population growth.

Q10. Which of the following describes the quantity and quality of your goat survey and inventory information with respect to making management decisions (select one)? One response per biologist.

	Adequate	Somewhat adequate	Somewhat inadequate	Inadequate
Native Populations (HDs)		2	4	4
Introduced Populations (HDs)	1	4	2	
Pooled	1	6	6	4

These results suggest that more adequate survey data are collected in HDs with introduced goats. This may be because most goat permits (84% in 2015) are issued in HDs with introduced goats and therefore these goat populations are surveyed more often or thoroughly.

Q11. What information do you currently use to set annual goat harvest regulations? Please numerically rank those that apply with 1 being of highest importance, leaving blank those that don't apply. Compiled by hunting district as indicated by biologists.

Count of HDs per category and ranking		**FWP hunter harvest data**	**FWP hunter effort data** (e.g., kills per effort)	**FWP observations data** (e.g., number seen/hunter)	**Age and/or horn data**	**Anecdotal hunter reports** (i.e., not in MRRE)	**Survey minimum counts**	**Survey recruitment ratios**	Other (please describe):
Native	Ranked 1st (7 points)	1					3	2	
	Ranked 2nd (6 points)		1			1	1	3	
	Ranked 3rd (5 points)	2	1	1	1				
	Ranked 4th (4 points)		2	1			1		
	Ranked 5th (3 points)	1		2		1			
	Ranked 6th (2 points)	1				1			
	Ranked 7th (1 point)				1				
	Count of HDs	**5**	**4**	**4**	**2**	**3**	**5**	**5**	
	Weighted score	**22**	**19**	**15**	**6**	**11**	**31**	**32**	
Introduced	Ranked 1st (7 points)	2					6		1
	Ranked 2nd (6 points)		1				2	5	
	Ranked 3rd (5 points)	2	1		2	1		1	
	Ranked 4th (4 points)	1	3	2 /8				4	
	Ranked 5th (3 points)	1			3	2			
	Ranked 6th (2 points)	1	1	1		2			
	Ranked 7th (1 point)			1	1				
	Count of HDs	**7**	**6**	**4**	**6**	**5**	**8**	**10**	**1**
	Weighted score	**33**	**25**	**11**	**20**	**15**	**54**	**51**	**7**
Pooled	**Count of HDs**	**12**	**10**	**8**	**8**	**8**	**13**	**15**	**1**
	Weighted score	**55**	**44**	**26**	**26**	**26**	**85**	**83**	**7**

Survey minimum counts and survey recruitment ratios are the two types of data on which biologists place the greatest reliance in setting harvest regulations. This is true for both native and introduced populations. This emphasizes the importance of obtaining reliable population survey data.

The next two factors most relied on to set regulations were FWP harvest data (number of animals harvested relative to number of permits issued) and hunter effort data (number of days/animal harvested). With mandatory reporting of mountain goat kills, these may be the most consistently available data at biologists' disposal.

Q12. If better or more frequent survey data would help you set harvest quotas, what factors are *most* limiting to survey efforts (e.g., funding, time, aircraft availability, weather, other logistics, etc…)? Compiled by responses from each biologist (multiple factors listed by biologists are included).

The factors most frequently reported were:

- Aircraft/pilot availability (11)
- Weather (11)
- Funding (10)
- Time (6)
- Sightability Correction Model needed (1)
- Cooperation with Idaho on the border goat herd in HD322 (1)

Several biologists listed all of the top 4 factors in their responses.

Q13. Have any of your proposed quotas for other species, such as mountain lions, been affected by numbers or recruitment ratios of overlapping mountain goat populations? If so, please explain. One response per biologist.

	Yes	No
Native populations		9
Introduced populations	1	7
Pooled	**1**	**16**

Q14. Based on your conversations with hunters, what % of hunters in your area take into consideration the animal's sex (i.e., deliberately target males) when choosing to harvest a given mountain goat (circle one)? One response per biologist for those with licensed HDs.

0	10	20	30	40	50	60	70	80	90	100	Uncertain
1			2		5		2	1	2		2

The weighted average of the responses was 55%.

Q15. Based on your conversations with hunters, what % of hunters in your area would you expect correctly identify the animal's sex when choosing to harvest a given mountain goat (circle one)? One response per biologist for those with licensed HDs.

0	10	20	30	40	50	60	70	80	90	100	Uncertain
1			2		6	1		1	2		2

The weighted average of the responses was 52%. This suggests that half of permittees are as likely to kill a nanny as a billy, all other factors being equal (goat population demographics, sex-biased distribution, etc.).

Q16. Is the educational information provided to license-holders sufficient for hunters to make informed decisions about the age and sex of the animals they choose to harvest? If not, what more could be done? One response per biologist for those with licensed HDs.

[3] Yes
[6] No
[6] Uncertain

Comments offered:

- Work with other states to improve educational materials (3)
- Use Alaska education information or something similar (2)
- FWP used to send out informational letters (1)
- Mandate billy only seasons (1)
- Send hunters the brochure developed by Gayle Joslin (1)
- Hunters could be required to take in-person mandatory training (1)

Population surveys

Q17. What survey methodology do you use to assess mountain goat population size and trend? Please check all that apply. Compiled by responses from each biologist.

Populations (HDs)	Methodology			Season				Frequency				
	Fixed-wing	Heli-copter	Ground	Winter/ Early Spring	Jul-Aug	Aug-Sept	Early Fall	Annual	Every other year	Every few years	Rarely	Never
Fixed-wing	6				1	3	2	2		1	2	1
Helicopter		20		6	4	5	3	5	5	4	7	1
Ground			8		1	7		3	2	2	1	

Some respondents indicated they use multiple survey methods at differing times of the year.

Q18. Do you feel it is important that FWP monitors mountain goats using similar methods across regions of the state (e.g., timing and frequency of surveys, choice of aircraft, etc.)? One response per biologist.

Yes	No	Uncertain
2	14	2

Q19. Do you see a difference between native vs. introduced goat populations in terms of general health or productivity/recruitment? If so, please describe. One response per biologist.

Yes	No
5	1

Several biologists noted they did not have enough information to answer this question or that they only had either native or introduced goats in their area of responsibility and therefore could not judge. Several others did not respond.

Comment: "We have a health baseline for the Crazies. Maybe it would be prudent to do some health captures in other areas to compare, or at a minimum, get a hunter sampling protocol going similar to bighorns."

Habitat Considerations

Q20. What habitat management programs would promote mountain goat conservation and hunter opportunity in your area of responsibility? Please numerically rank those that apply for each population or group of populations with 1 being of highest importance. One response per biologist.

Count of HDs per category and ranking	**None;** Habitat isn't a limiting factor	**More fire** (natural or prescribed)	**Less fire** (suppression of wildfire)	**Weed management**	**Road management** (ie., more restrictive)	**ORV management**	**Snowmobile management**	**Non-motorized recreation management**	**Unknown**	**Other** (please describe):
Ranked 1st (3 points)	3	5	1			1	3	1	4	
Ranked 2nd (2 points)			1			1	1	2	1	
Ranked 3rd (1 point)				1					1	
Count	**3**	**5**	**2**	**1**		**2**	**4**	**3**	**6**	
Weighted score	**9**	**15**	**5**	**1**		**5**	**11**	**5**	**15**	

There was little consensus about which, if any, habitat management programs would benefit goat conservation or increase hunter opportunity. The three recreational management categories had a combined weighted score (21) larger than any other category.

Q21. Have you completed any habitat-related projects alone or with federal or other land managers related to the subjects in Question 20 that were geared to improve mountain goat habitat or conservation? Please explain, listing HDs for which the projects were completed. One response per biologist.

Yes	No
1	16

Comments offered:

- Would like to support more burning on USFS lands
- Have worked with BLM and USFS to remedy conifer encroachment but no projects yet
- Yes response is for comments on USFS motorized travel restrictions in goat habitat

Research & Management Needs

Q22. Is there a pressing need for translocation of mountain goats into a portion(s) of your area to sustain native and/or introduced populations? If so, would this be to reintroduce an extirpated population or augment an extant population? Please explain. One response per biologist.

	Yes	No
Native	2	4
Introduced	3	7
Pooled	**5**	**11**

Introductions need to be carefully evaluated on an area-by-area (herd-by-herd) basis, as indicated by the comments below.

Comments offered:

Native Herds:

- Need better population data to determine any needs for augmentation. (2)
- We would need to first understand what is driving population declines and get a better idea of the actual number of goats in the area. If it is disease or habitat driven, then why dump more goats into areas? (2)
- Yes, HD240 and possibly 250 to augment struggling populations.
- Yes, for augmentation in 212, and 222-223. However, the disease issue (bighorn pneumonia) is a huge unknown.

Introduced Herds:

- Yes, HD380 and North Big Belts: To augment small, extant populations.
- Yes, Boulder Baldy area and Big Baldy area of Little Belts
- Yes, Highwoods and Square Butte to improve genetic diversity of isolated populations.
- No, all habitat is occupied and goats are self-sustaining.

Q23. What are the most urgent *research* needs that would help you manage mountain goats in your area of responsibility?

- Habitat condition and use and carrying capacity (9)
- Population demographics: productivity, recruitment, kid survival, and adult survival (7)
- Causes of mortality (5)
- Animal health (3)
- Sightability correction model for survey data (2)
- Improved survey methodology (2)
- Effects of recreation on populations (1)
- Effects of climate change on populations (1)
- Better information on dispersal of introduced herds (1)
- Impacts on populations of female harvest (1)
- Competition and disease transmission of sympatric bighorns and goats (1)
- Do we know if population augmentation can overcome small population effects? (1)

Q24. What are the most urgent *management or monitoring* needs that would help you manage mountain goats in your area of responsibility?

- Better/more frequent monitoring of populations (10)
- Sightability correction model and improved, standardized survey methodology (5)
- Monitoring of health (2)
- Coordinated and cooperative management with Idaho of boundary herds (1)
- Field work to determine movements of goats between adjacent HDs (1)
- More time to devote to learning about goats to improve management (1)
- Transplant augmentation (1)
- Continue to collect harvest data and ages of harvested goats (1)

Q25. What other topics of relevance did we miss with these questions?

- Focus on predation of goats (1)
- Potential effects of goats on bighorns in the GYE, i.e. Bob Garrott's research (1)
- More FWP effort should be shifted to species that may be at risk, like goats (1)
- Need extended field studies of small goat populations to develop an understanding of how remnant native populations survive. This could help develop bigger research questions and conservation priorities. Need more first-hand familiarity via field studies (e.g. grad students) (1)