

Kofa Mountains Complex Adaptive Predation Management Plan

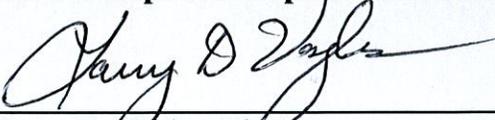
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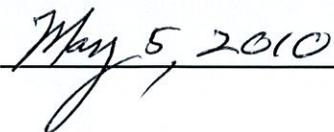


Arizona Game and Fish Department
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APPROVED: 
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DATE: 

Introduction

In April 2007 the Kofa National Wildlife Refuge (Kofa NWR) and the Arizona Game and Fish Department jointly issued a report entitled “Investigative Report and Recommendations for the Kofa Bighorn Sheep Herd” (USFWS and AGFD 2007). That report was prepared in response to an observed decline of approximately 50% in the population of desert bighorn sheep on the Refuge. The stated purpose of the report was to provide an analysis of the probable causes of the decline and a strategic approach to a management program intended to lead to the recovery of the bighorn sheep herd. Several factors were identified that could potentially be inhibiting recovery of the sheep population, such as drought, water availability, disease, predation and human disturbance. Recommendations were made for management actions to address each of these factors.

This Adaptive Predation Management Plan is a response to the recommendations made in the Investigative Report and is a step-down plan from it. It addresses predation by mountain lions only; there are other management programs in place to address the other limiting factors identified in the Investigative Report. The current plan is a revision of the Kofa Mountains Complex Predation Management Plan that was approved in April 2007. Predator management plans must be dynamic over time to incorporate changes that occur from environmental biotic and abiotic factors, in addition to new data and technologies. This plan was initially developed to address mountain lion predation on a depressed desert bighorn sheep population located in the Kofa Mountains Complex of southwest Arizona. This complex includes the Kofa, Castle Dome, New Water, South Plomosa, Tank and Little Horn mountains (Figure 1). The majority of the area under consideration falls within the boundaries of the Kofa National Wildlife Refuge (Kofa NWR). This plan follows the spirit and guidance of the Arizona Game and Fish Commission Predation Management Policy and the Arizona Game and Fish Department Predator Management Team Report. Since much has been accomplished in the 3 years since the original predation management plan was adopted, this update has been written to incorporate new information that has been learned. A parallel adaptive management approach will be implemented to better inform management decisions related to this predation management plan, but also to use research approaches to continue expanding the knowledge base of mountain lion populations over a broader area of these lower desert habitats.

Specifically, the Arizona Game and Fish Commission Predation Management Policy states:

“Actions by the Arizona Game and Fish Department (department) should be based on the best available scientific information. Mountain lions and coyotes will be managed to ensure their future ecological, intrinsic, scientific, educational, and recreational values, to minimize conflict with humans, and to minimize adverse impacts on other wildlife populations.

The department will develop site-specific management plans when either of these two species is considered to be inhibiting the ability of the Department to attain management goals and objectives for other wildlife species.”

Furthermore, the Department’s Predator Management Team Report states that “Predators and their prey cannot be managed separately” and that “as a Department we must strive to develop the biological and social data necessary to manage predators with a program that is biologically sound and publicly acceptable.”

The recent development and approval of Department Policy 11.6, Adaptive Management Practices; Approval of Management Plans, offers new opportunities to use research tools and approaches to

expand the knowledge base relative to predator/prey relationships of mountain lions and desert bighorn sheep in and around the management area. Following the policy guidance, managers will enhance efforts to monitor bighorn sheep and mountain lion populations in a broader geographic area, to better understand this relationship in a biologically meaningful geographic context. This ongoing monitoring and research will allow the department to take an adaptive approach, and to address the primary question of whether mountain lion management guidelines in this report are effectively facilitating the recovery and maintenance of bighorn sheep in the management area as a source population for future translocations. Having a better understanding of lion population dynamics in this larger landscape is a critical component of effective management of mountain lions and bighorn sheep on the Kofa NWR. Managers will monitor lion movements across a broader area, determine movement corridors, prey selection and use, and use genetic analysis to estimate total population and relatedness to other lion populations. We hope to determine the source(s) of lion immigration and to better understand the metapopulation dynamics of lions on and in proximity to the Kofa complex.

Area Description

The predation management project area consists of portions of Game Management Units (GMU) 41, 44BS, and the entirety of GMU 45A, B, and C (Kofa NWR) in the Yuma Region of the Arizona Game and Fish Department (Figure 1). These units cover approximately 1400 square miles in the Basin and Range province of southwestern Arizona. Topography is generally composed of vertical cliff faces, rugged canyons, mesas, boulder-strewn terrain, rolling hills, and broad alluvial valleys. Elevations range from less than 1,000 feet asl in the King Valley to approximately 4877 feet asl on Signal Peak in the Kofa Mountains. The predominant vegetation type ranges from lower Sonoran Desert Scrub to Chaparral-grassland on the highest peaks.

Predation management decisions will continue to be made based on impacts to desert bighorn sheep herds within the predation management area described above, but data collection and monitoring will expand to the surrounding bighorn sheep metapopulation area bounded by the Colorado River to the west, State Highway 85 to the east, Interstate 10 to the north, and Interstate 8 to the south (Figure 2).

Statement of Need

The Arizona Game and Fish Department normally conducts bighorn sheep surveys on a rotational basis every 3 years. Population estimates based on the Kofa Group Size Estimator methodology (Hervert et al. 1998; Appendix 1) demonstrate that a decline in bighorn sheep numbers occurred in the Kofa Mountain Complex, and especially on the Kofa NWR (GMU 45), between 1994 and 1997, from which it seemed to recover by 2000, and then again between 2000 and 2006 (Table 1). The most recent decline has reduced bighorn sheep numbers on the Refuge by 50%. Since 2006, population surveys on the Kofa NWR have been held annually and sheep numbers have remained stable but depressed relative to historic numbers.

Range conditions in the Kofa Mountains Complex have been affected by low rainfall in recent years, based on data recorded at the Kofa Mine Weather Station (Table 2). From 1995 to 2003 most years posted below the long-term (54 year) average annual precipitation of 6.9 inches, and 2 years (1996 and 2002) had severe drought. Though calendar year 2002 had 3" of rain, the 12-month period from September 2001 to August 2002 had only 0.8". This 9-year period of drought likely had a negative impact on plant communities, water distribution, and animal populations and possibly contributed to the observed bighorn sheep decline. However, the area experienced well above average rainfall in

2004 and 2005, but bighorn sheep numbers continued to decline. Since 2003, 5 of the past 7 years have had near average or above average rainfall

Documentation of mountain lions in the area began around 2001, a factor which may help explain continued depressed, even declining, bighorn sheep numbers. Mountain lions have historically been only a transient visitor to the Kofa NWR. There are no verified records of mountain lions on the refuge between 1944 and 2001. During a research project conducted in the Kofa Mountains from 1993 through 1996, 50 bighorn sheep were radio collared and 17 mortalities were investigated. None of the 17 could be attributed to lion predation. From 1995-1997, Germaine et al. (2000) conducted surveys for lions in 18 mountain ranges and along the Colorado and Gila Rivers in southwestern Arizona, including the Kofa NWR. They confirmed the presence of only 3 individual lions (in the Mohawk and Growler Mountains) believed to be males, and suggested that a distinct, self-sustaining mountain lion population did not currently exist in southwestern Arizona. They found no evidence of lions on the Kofa NWR. Beginning in 2001, visitors to the refuge started reporting sightings of lions or sign, a confirmed lion killed deer was discovered at a waterhole, and 2 lions were sighted during an aerial wildlife survey.

Beginning in 2004, Kofa NWR staff placed 8 active infrared and 2 passive digital remote cameras at water holes. The refuge documented at least 5 lions on the refuge in 2006. The actual population density is unknown, but photographs of spotted juveniles or females with kittens have been obtained in successive years, suggesting a local breeding population. The best population estimate for the project area is 5-10 lions (Naidu 2009). This estimate is based on discussions with federal wildlife officials, local mountain lion experts and an extensive DNA analysis of scat and tissue samples from the project area.

Although predation may not be the primary cause of the initial decline in bighorn sheep numbers, the recently established lions have the potential to further depress or inhibit recovery of a sheep herd that is already depressed, particularly on Kofa NWR. Research indicates that mountain lion predation can have significant population-level effects (Hoban 1990, Wehausen 1996, Creeden and Graham 1997, Ross et al. 1997, Rubin et al. 2002, Hayes et al. 2000, Sawyer and Lindzey 2002). Variables influencing mountain lion predation might include relative availability of alternate prey and escape terrain, vulnerability of individual prey, weather (including seasonal variation), and behavior of individual predators (Leopold and Krausman 1986, Ross et al. 1997, Krausman et al. 1999, Hayes et al. 2000, Ballard et al. 2001). Hayes et al. (2000) proposed that sustained high levels of lion predation may impede recovery of Federally listed bighorn sheep in the Peninsular Ranges in California, and Wehausen (1996) attributed declines in another Federally listed population (in the Sierra Nevada of California), at least in part, to mountain lion predation. The San Gabriel Mountains population, also in California, declined from over 500 animals to less than 90 during 1989-1995, with the decline hypothesized to be due to lion predation, possibly associated with habitat changes associated with lack of wildfires (Holl et al. 2004; Holl and Bleich 2009). Because a single mountain lion may kill on average one big game animal per week (Anderson and Lindzey 2003), even a small number of lions can inhibit the recovery of bighorn sheep on the Kofa NWR. Five to ten lions have the potential to not only take most recruitment but significant portions of the adult breeding population as well.

We conclude that any amount of predation on bighorn sheep by lions in the Kofa Mountains Complex is significant and represents additive mortality in these GMUs that have exhibited recent unexplained declines in the bighorn sheep population. Removal of individual offending lions known to be killing

multiple bighorn sheep is deemed necessary to reduce any further population declines and will aid the recovery of the Kofa Mountains Complex bighorn sheep population.

Management Goals and Strategies

The primary goal of this adaptive predation management plan is to aid the recovery of the Kofa NWR bighorn sheep population. The goal is to reverse the decline and ensure a bighorn sheep population level that can once again support an active transplant program. This will be accomplished by determining appropriate mountain lion populations in the area, and then, if found necessary, reducing predation on the bighorn sheep by removing repeat-offending mountain lions in the affected area.

Ballard et al. (2001) found several factors common in case studies that dictated when predator reductions were effective and prey populations increased. These factors included:

- Predator control is implemented when the prey populations are below habitat carrying capacity
- Predation is identified as a limiting factor
- Control efforts reduce predator populations enough to yield results
- Control efforts are timed to be most effective (just prior to predators or prey reproduction)
- Control takes place at a focused scale (generally <400 mi²).

There are several actions that could be used to reduce mountain lion numbers within the project area. A sport hunt for lions has already been authorized for the area adjacent to the Kofa NWR. Since its inception the lion sport hunt has not resulted in the removal of any lions. While this strategy may have potential, its effectiveness is limited. Including the Kofa NWR in the sport hunt has been proposed but like the surrounding hunt area, a sport hunt will probably be ineffective in removing lions. Other measures that could be used to remove mountain offending lions in the target area include snares, leg-hold and box traps, aerial gunning, shooting, and hunting with the aid of hounds or other approved methods. Snaring has proven to be an effective method to trap lions in the Kofa Complex, and it, together with radio tracking, facilitates selective removal of repeat offenders, whereas some methods such as sport hunting do not. The use of live traps (box traps) will continue to be investigated. Initial attempts to use box traps have had some success, and these efforts will continue.

The strategy for lion predation reduction will be to remove offending lions that are known to be killing bighorn sheep within the mountain complex formed by the Castle Dome, Kofa, Little Horn, Tank, Plomosa and New Water mountains. Predator control is most effective when problem individuals can be identified and removed (Sawyer and Lindzey 2002). There is evidence that some mountain lions in bighorn sheep habitat may kill multiple sheep within a year, some may kill only one sheep within a year, and some may kill no sheep at all (Ernest et al. 2002). This concept is supported by our own data and that of Ross et al. (1997). Collared lion KM04, in 6 months, made 89% of his ungulate kills on bighorn sheep and only 11% on mule deer. In contrast, lion RM01's diet, during 19 months, was 20% bighorn sheep and 80% mule deer. Collaring lions and bighorn sheep can provide the necessary data for selective predation management. Tracking individual lions and their kills will allow for the removal of offending lions that are regularly preying on bighorn sheep as opposed to a less-discriminate landscape removal of lions.

Active efforts to remove offending lions will be guided by the following criteria/triggers. Estimates of the bighorn sheep population on the Kofa NWR will be the primary trigger. These estimates will be based on standard fall aerial surveys, and include all sex and age classes of bighorn sheep. Trigger

points have been set with the assumption that a population of approximately 800 bighorn sheep is the long term average population size and is therefore the recovery goal. This estimate is based on data from aerial surveys conducted during a 20-year period from 1981 to 2000 (Figure 3).

1. When the Refuge bighorn sheep population estimate is below 600 animals, active mountain lion control would occur, absent any significant mitigating circumstances. Active mountain lion control is the removal of radio-collared mountain lions found to kill two or more bighorn sheep within the Predation Management Area (the Kofa Mountains Complex) within a 6 month period, as determined by investigation of predation sites. These sites are often identified by a cluster of GPS locations received from the satellite collar on the mountain lion. These mountain lions would be designated as “offending” mountain lions. Our definition of an “offending” mountain lion was modified from a management strategy suggested in Ernest et al. (2002) and designed to target only offending mountain lions that establish a pattern of killing multiple bighorn sheep. Box traps, foot snares, or hounds may be used to assist in the removal of offending lions. Helicopters may be used to transport biologists to very remote locations to investigate possible kill sites or to facilitate capture efforts. Aerial darting or net-gun capture of mountain lions may take place. Removal would be carried out in the most efficient and humane way available, and can be carried out wherever the offending lion may move to.
2. When the Refuge bighorn sheep population estimate is at or above 800 animals, active mountain lion control would not occur, absent any significant mitigating circumstances. Mountain lions on the Refuge may continue to be captured and fitted with satellite GPS collars to aid in continuing research.
3. When the Refuge bighorn sheep population estimate is between 600 and 800 animals, active mountain lion control may or may not be employed based on the totality of the circumstances at the time. Though approximately 800 total bighorn sheep is the long term average population size, the population has fluctuated between 600-800 sheep during times when no lions were documented on the refuge. In order to meet the bighorn sheep population objectives while minimizing the necessary impacts to mountain lions, some flexibility is warranted when the bighorn sheep population is at this stage. Decisions regarding whether active mountain lion control is necessary will be based on an adaptive management approach and based on the following factors:
 - a. The current bighorn sheep population estimate.
 - b. The current bighorn sheep population trend (an increasing or decreasing population trend of the bighorn sheep on Kofa NWR based on the prior 3 surveys [annual or triennial as funding allows]).
 - c. The level of lion predation rates on radio collared bighorn sheep.
 - d. Bighorn sheep lamb survival and recruitment.
 - e. The minimum population estimate for mountain lions using the Refuge.
 - f. The level of predation by individual mountain lions currently using the Refuge. Offending mountain lions could continue to be removed under the existing criteria, or less stringent criteria could be used where mountain lions found to kill four or more bighorn sheep annually could be removed, depending on factors a-i.
 - g. Current and forecasted habitat conditions based on field observations and precipitation data.
 - h. Available funding and manpower.

i. Level of criticality of anticipated translocations

Offending lion removal should be accompanied by frequent monitoring of bighorn sheep with surveys and/or collared sheep survival estimates to determine if predator control is achieving the desired protection of bighorn sheep.

A variety of methods will be used to gather data on mountain lions. Remote cameras will be used to monitor for lions throughout the area, allowing managers to generate a minimum estimate of the lion population size and to generate use patterns. This data will also allow managers to adapt their focus and efforts based on current lion activity. Snares will be used in and around the management area to capture lions that will be fitted with GPS tracking collars. The collaring and tracking effort will provide data on lion condition and real-time use patterns. The tracking data will also allow managers to locate and identify lion kills to inform management decisions about whether an offending lion should be removed. Genetic analysis of collected lion scats has proven to be an effective technique for determining how many individual lions are using the Kofa area (Naidu 2009). This work will be expanded to the larger metapopulation area. The long term collection of this data will allow managers to compare lion data to population and mortality data being collected on the bighorn sheep population, and assess the effectiveness of predation management efforts, predation management techniques, and the predation management plan itself. This approach is considered an adaptive management approach, and complies with the Department's Adaptive Management Policy (DOM II.6).

Efforts to trap and radio collar lions on the refuge began in 2006. It has proven difficult to capture lions in the desert habitat of Kofa. Trained dogs were used initially, but proved ineffective. Better success was obtained with snares. An adult male (KM01) was finally captured in February 2007 and lethally removed in June 2007 after it met the offending lion criteria that was established in the Investigative Report (having killed at least two bighorn sheep within a six month period). A second younger male (KM02) was captured in the Castle Dome Mountains in June 2007, but lost his collar 2 months later while off the refuge. A larger male (KM03) was captured in October 2007 and lethally removed in March 2008 after he reached offending status. A fourth male (KM04) was captured in the Kofa Mountains in February 2009. In the following 6 months, he was documented to have killed 16 bighorn sheep and 2 mule deer. Since he far surpassed the offending lion criteria, he was removed in September 2009. Adult male lion RM01 was captured and collared in August 2008 in the Gila Bend Mountains. Monitoring shows that this animal ranged mostly to the east of the Predation Management Area. In April 2010, it became an offending lion having killed two bighorn sheep inside the KPMA within three months. During the 20 months of monitoring (Aug. 2008-Mar. 2010) this lion killed a minimum of 52 mule deer and 14 bighorn sheep (2 in the management area), and was lethally removed from GMU 39 in April 2010. So far only 4 offending lions have been removed in 4 years of trying. Annual surveys on the Kofa NWR have shown that the bighorn population has approached stability, though the 45A portion continues to show a slow decline.

Completed and Planned Actions

The Region and Department has conducted the following management actions:

- One presentation to the Arizona Desert Bighorn Sheep Society to provide up-to-date information on current status of the bighorn sheep situation.

- Worked with the U.S. Bureau of Land Management (BLM) on grazing management actions within the New Water Mountains that may affect forage availability for bighorn sheep. While this has not been documented as occurring within the Kofa Mountains Complex domestic livestock may also act as a buffer species maintaining lion populations at a level higher than the habitat would normally support (Rominger et al. 2005).
- Worked with BLM to implement burro removal efforts to reduce burro numbers to meet Appropriate Management Levels (AMLs) approved in the Yuma Resource Management Plan.
- Directed sport hunters to areas open to lion hunting.
- Worked unsuccessfully with Kofa National Wildlife Refuge (KNWR) staff to open the Refuge to sport hunting of mountain lions.
- Region IV Staff and lion expert surveyed areas for lion sign.
- Maintained water developments and hauled water to all developments determined to be critical in the Kofa Mountains complex.
- Responded to questions from the public at the “Meet the Commission” forum in January 2007.
- Worked with the KNWR staff to prepare an executive briefing on options for the recovery of the Kofa bighorn complex herd.
- Delineated critical waters on Kofa and monitored them to prevent them going dry.
- Redeveloped Yaqui Tank in the Kofa Mountains and McPherson Tank in the Castle Dome Mountains.
- Placed an experimental water source in Engesser Pass.
- Captured mountain lions, placed satellite GPS collars, and monitored their movements daily. Investigated location clusters to identify prey and determine predation rate.
- Captured 42 bighorn sheep and placed satellite GPS collars to determine causes of mortality.
- FWS initiated and AGFD assisted with research project to determine condition and productivity relationships of bighorn sheep.
- Implemented annual bighorn sheep surveys on the Kofa NWR.

In addition, the following actions are being considered or continued:

- Springtime surveys to monitor lamb survival and population status.
- Continue our existing action plan process.
- Continuation of research opportunities regarding lion/bighorn sheep interaction, and other development impacts to the bighorn sheep population.
- Continue radio marking and monitoring of bighorn sheep and mountain lions.

Intensity and Duration of the Actions

Predator control targeted at offending mountain lions will continue until the bighorn sheep population recovers, or until predation by lions is no longer being documented, or no longer limits bighorn sheep population growth. The bighorn sheep population will be considered “recovered” when the population approaches the approximate long-term average of 800 sheep, as described in the Management Goals and Strategies section above.

It is difficult to predict how long it will take to meet recovery objectives, especially considering how difficult it has proven to capture lions. The population targets for the bighorn sheep population discussed above have been established to function as triggers for implementing different management approaches.

Measurable Objectives

Measurable objectives include recovery of the bighorn sheep population within the project area based on population parameters. Sheep surveys will be conducted in the fall to monitor population parameters. Kofa NWR will be used to monitor recovery of the bighorn population as it lies in the center of the project area and has experienced the largest decline in sheep population to date. The first objective involves an indication that the sheep population on Kofa NWR has recovered to long-term average levels, which is estimated around 800 sheep. Sheep surveys on the Kofa NWR should be done annually to better estimate any progress made as a result of removing offending lions. However this effort will depend on continuing to secure additional funds to conduct annual rather than tri-annual helicopter surveys.

Adaptive Management

The predation management area sits within a broader geographic area that is the adaptive management area. The adaptive management area identifies a metapopulation for bighorn for which the population in the Kofa is a subpopulation. Metapopulations are defined as a group of sheep subpopulations that are geographically separated, and even though it is limited, there is still genetic exchange between the subpopulations. Association of bighorn sheep with mountainous terrain appears to define the separate subpopulations in the Complex, with bighorn sheep, especially females, exhibiting limited movement across flat terrain. Lion movement, in contrast, is not restrained by flat terrain. The adaptive management area, for lions, is likely one population and restraints to lion movement (interstates north and south, state highways on the east and west) separate this population from other populations. The lion metapopulation is much larger, and likely covers a significant portion of the state between the Colorado River and the Phoenix metropolitan area.

The desired future state for the area is sustainable populations of wildlife. However, bighorn sheep in the Kofa NWR have declined as previously described in this plan, and they play a critical role in the restoration of threatened and extirpated populations around the state. The lion population has recently expanded and may be a sink population from other source populations. Therefore the management priority is the preservation and restoration of the Kofa sheep population.

The primary management decisions revolve around how predation management is implemented in the predation management area. The current proposed level of offending lion removal and the triggers that are in place for implementing predation management are conservative and based on the best available information from the management area and the literature, but there is a recognized need to assess the effect of management actions within the predation management area on the larger lion population and vice versa. As biologists track the Kofa NWR bighorn sheep population response to offending lion removal over time, they can begin to understand impacts and effects of (and to) the larger lion population.

Under this adaptive management approach, biologists will attempt to collar as many lions as possible within the adaptive management area (this will include lions in the predation management area), and as management decisions are made to remove offending lions, the response of and impacts to other lions can be observed. Biologists will identify movement corridors, any territorial changes post removal, areas that are used most heavily by lions, potential movement in and out of the adaptive management area, and prey selection. The data collected after an offending lion removal and during changes in prey populations may also allow biologists to identify the most preferred habitat areas for lions. Incorporating genetic data from this area and other lion populations will allow biologists to determine the source populations that provide dispersers into this lion population (this assumption can also be

tested). Genetic data have also proved useful in identifying individual lions and minimum population sizes.

The data collected across the entire adaptive management area will provide managers a clearer picture of the lion population, and allow evaluation of the effectiveness of predation management decisions related to the Kofa Complex. Questions of concern include: is the current approach feasible or will a vacant lion territory be immediately filled by another lion; are triggers too conservative or not conservative enough; and is the amount of effort adequate to reduce predation enough to facilitate recovery of the sheep population or is more effort needed? Any changes to the predation management approach that results from the analysis of the data will be captured in future revisions to the predation management plan in accordance with Commission policy.

The intent of the research component of this plan is to increase knowledge and to evaluate management actions across a broader area, and not to expand the predation management area defined in the introduction. However, any collared research lion that subsequently moves into the predation management area and becomes an offending lion, will be managed under the predation management portion of this plan. Its value as a source of data will be considered when determining if it should be removed in accordance with the identified triggers (i.e., its research value may be a mitigating factor if the bighorn sheep population is over 600 animals).

Outreach Plan

Routine public information coordination for this plan will include the Public Information Officers (PIOs) of Region IV, the Information & Education Division (IED) of the AZGFD in Phoenix, the Kofa National Wildlife Refuge (NWR), Region 2 Headquarters of the U.S. Fish & Wildlife Service (USFWS) in Albuquerque, the Yuma Field Office of the Bureau of Land Management (BLM), and the Yuma Proving Ground (YPG).

- Upon approval, the revised plan will be posted on the AZGFD website, and copied to Department PIOs.
- A talking point paper for use by AZGFD customer service personnel should be prepared. The purpose of the paper will be to equip front counter personnel to answer the bulk of routine customer questions about the plan.
- Federal agencies involved, in accordance with their own internal policies, may make their own releases and website postings.
- The Department will consider all requests from the public for presentations on the plan.
- Given the continued emotional nature of the reaction to predator management in the southwest, we should expect continued media interest of the plan revision.
- Absent contrary guidance from IED, any media queries on the plan received by AZGFD should be forwarded to Region IV.
- We should seek opportunities to periodically publicly highlight progress in the execution of this plan as appropriate.
- For specific events where public notification is required or recommended, only those agencies directly affected will be required coordination contacts for information release.

Figure 1. Map of the Kofa Mountains Complex.

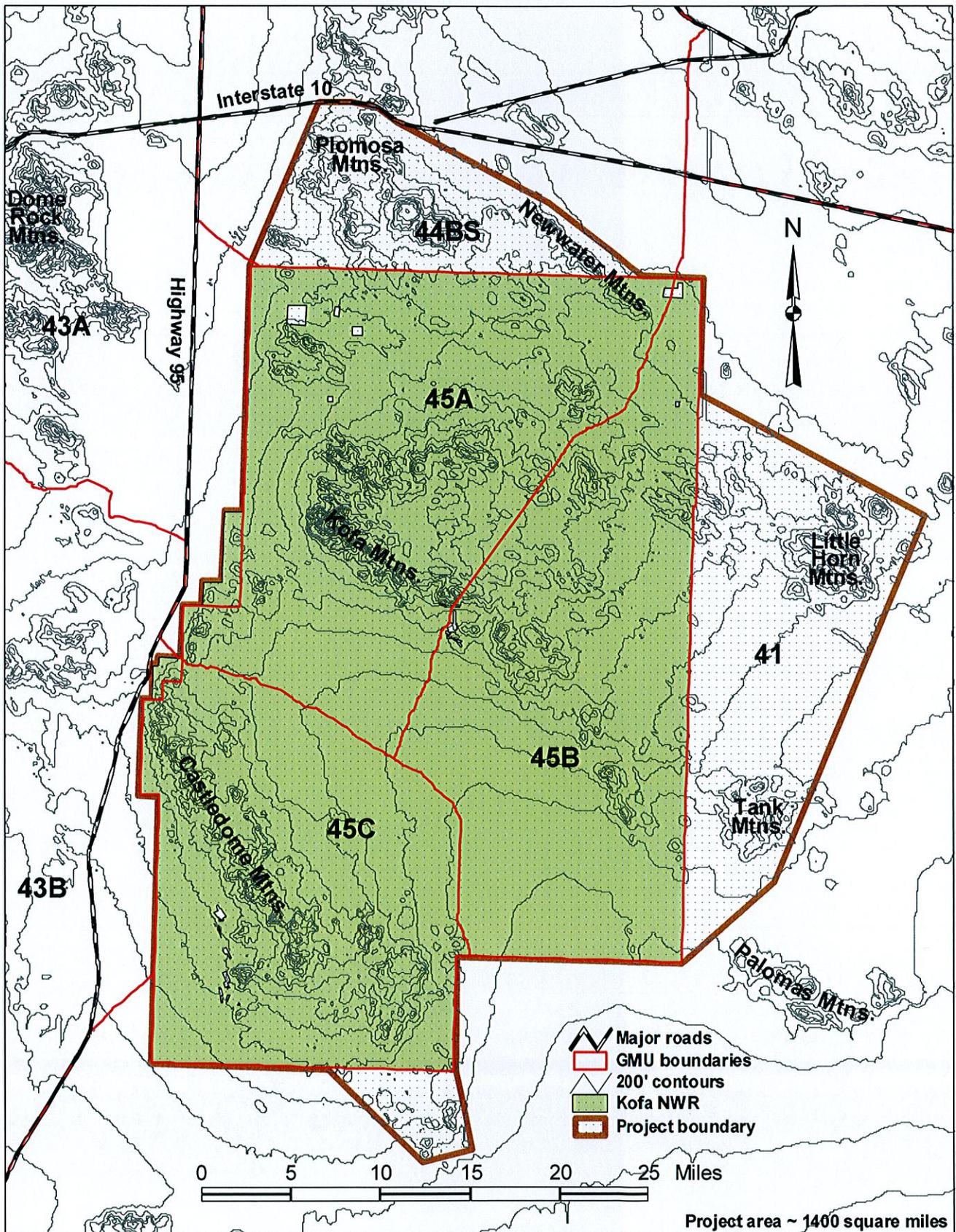


Figure 2. The adaptive management area where lions and sheep will be monitored using a research approach; delineated by the Colorado River on the west, State Highway 85 to the east, Interstate 10 to the north, and Interstate 8 to the south.

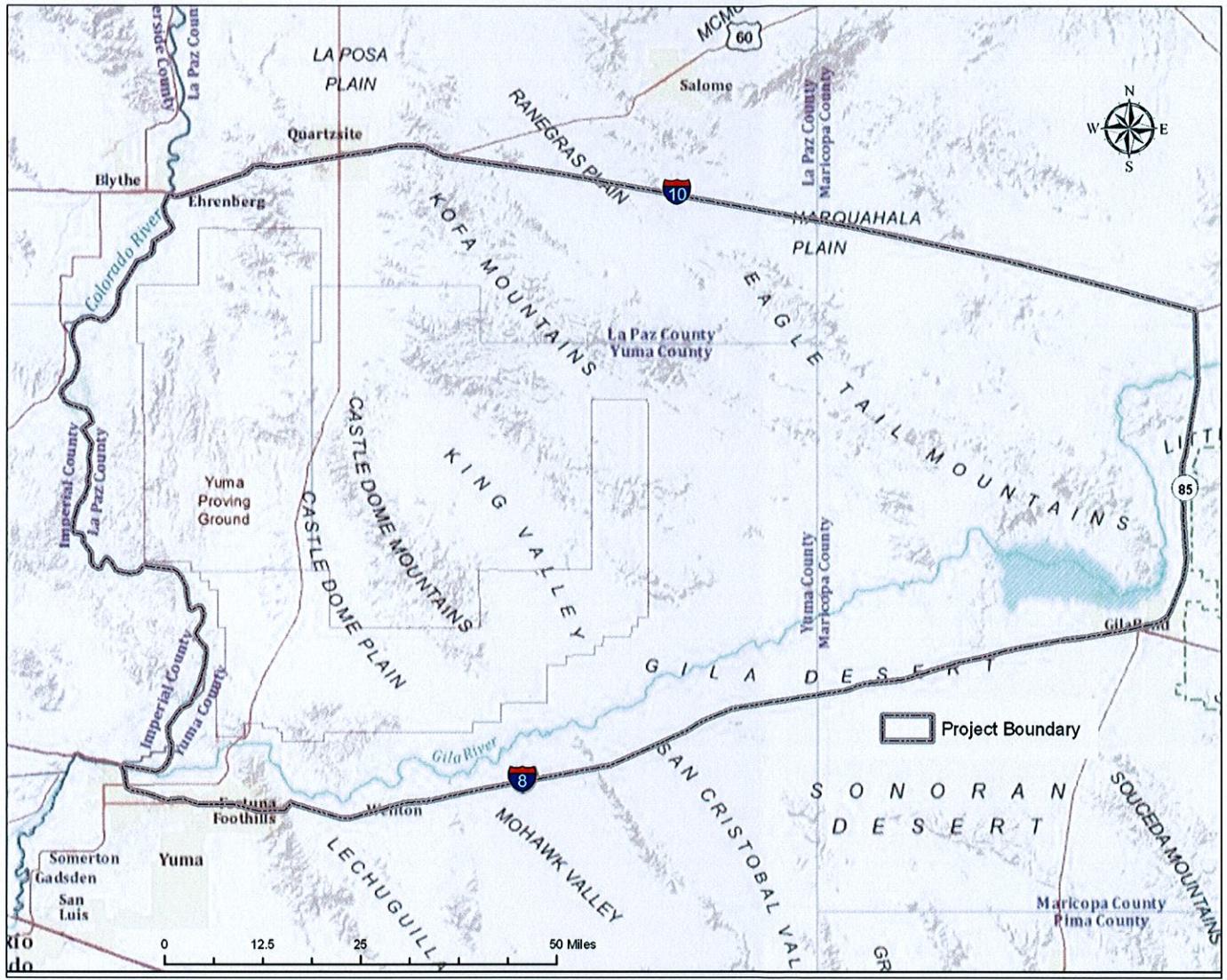


Figure 3. Bighorn sheep population estimates for Kofa NWR (Unit 45), 1981-2009. The years 1981 to 2000 were used to determine a long-term average bighorn population size. The recent decline of 50% occurred from 2000 to 2006. The population has been relatively stable from 2006 to 2009. Data are from standardized fall aerial surveys.

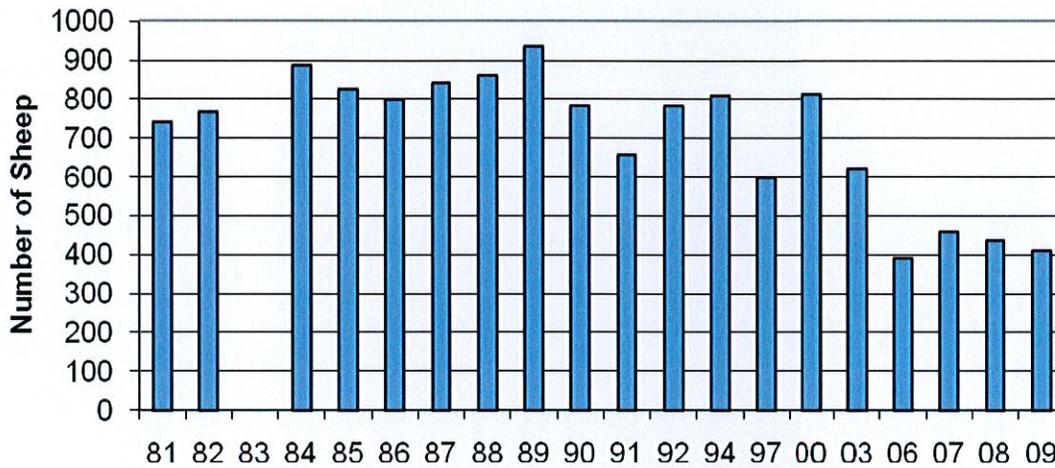


Table 1. Bighorn population estimates for 1993 through 2009 in the Kofa Mountains Complex (GMUs 45, 44BS, and 41W) and in a GMU immediately to the west of the Kofa Complex. Population was increasing in an area near the Kofa (GMU 43B) at the same time that the population was decreasing in parts of the Kofa Complex (2000-2006). Data from Arizona Game and Fish Department, Region IV, Yuma.

	43B [W of Kofa]	44BS	Kofa Mountains Complex		(Kofa
			41W	45ABC NWR)	
1993		116			
1994			93	811	
1995	209				
1996		102			
1997			108	600	
1998	207				
1999		116			
2000			107	812	
2001	190				
2002		123			
2003			119	620	
2004	250				
2005		71			
2006			101	390	
2007	336			460	
2008		42		436	
2009			92	410	

Data are derived from standardized aerial (helicopter) surveys.

Table 2. Monthly precipitation data from the Western Regional Climate Center for the Kofa Mine from 1990 to 2009. Annual average is 6.9” (n = 54 years).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
1990	0.88	0.18	0.11	0.10	0.14	0.00	0.55	1.41	2.99	0.15	0.04	0.09	6.64
1991	0.58	0.44	1.58	0.00	0.00	0.00	0.08	1.04	0.48	0.19	0.17	0.26	4.82
1992	1.16	2.05	2.56	0.27	0.62	0.00	0.06	0.73	0.00	0.38	0.00	2.49	10.32
1993	4.51	3.06	0.44	0.00	0.10	0.00	0.00	0.99	0.02	0.60	0.71	0.00	10.43
1994	0.07	0.83	1.45	0.07	1.57	0.00	0.63	0.96	0.96	0.09	0.15	1.28	8.06
1995	1.90	1.28	0.45	0.80	0.00	0.03	0.65	0.46	0.05	0.00	0.04	0.00	5.66
1996	0.00	0.16	0.01	0.00	0.00	0.00	0.06	1.54	0.10	0.05	0.01	0.01	1.94
1997	0.99	0.04	0.00	0.33	0.05	0.05	0.89	0.54	3.16	0.00	0.07	2.73	8.85
1998	0.43	3.38	0.47	0.02	0.06	0.00z	1.26	0.28	0.75	0.00	0.75	0.39	7.79
1999	0.16	0.77	0.05	0.85	0.00	0.17	1.19	0.18	0.44	0.00	0.00	0.00	3.81
2000	0.04	0.28	0.64	0.00	0.00	0.15	0.00	0.54	0.00	2.37	0.20	0.00	4.22
2001	1.01	0.85	0.73	0.06	0.00	0.04	0.76	1.15	0.05	0.08	0.10	0.39	5.22
2002	0.00	0.00	0.03	0.01	0.00	0.00	0.16	0.00	2.73	0.14	0.13	0.04	3.24
2003	0.67	1.61	0.74	0.05	0.00	0.00	0.60	1.22	0.22	0.00	0.85	0.08	6.04
2004	0.43	0.53	0.54	0.15	0.00	0.00	0.09	0.92	0.19	3.20	3.48	1.75	11.28
2005	1.65	3.46	0.30	0.39	0.00	0.00	1.05	2.72	0.00z	0.95	0.00	0.00	10.52
2006	0.00	0.00	0.38	0.13	0.10	0.43	0.88	1.15	0.93	0.30	0.00	0.00	4.30
2007	0.20	0.15	0.72	0.13	0.00	0.00	2.46	0.58	0.66	0.03	0.24	0.98	6.15
2008	1.24	0.08	0.00	0.00	0.76	0.00	0.84	0.59	0.37	0.00	1.76	1.83	7.47
2009	0.00	0.83	0.00	0.06	0.10	0.00	0.49	0.04	0.78	0.00	0.00	0.35	2.65

Appendix 1. Kofa Group Size Estimator Model used to determine bighorn sheep population numbers and harvest permit numbers.

The goal of the survey program for bighorn sheep is to obtain absolute size estimates for all populations in the Region. The number of hunting permits issued is based on the actual number of mature males in the population. Estimates previously were calculated using a simultaneous double count estimator as described by Graham and Bell (JWM:1989 54(4):1009-1016). Region IV completed a study entitled "Sighting Rates of Bighorn Sheep during Helicopter Surveys on the Kofa National Wildlife Refuge" (Arizona Game Investigations 1996-97). From this study department personnel derived a new estimator to calculate bighorn population estimates. It uses different observation rates (to correct for visibility bias) for different group sizes of surveyed sheep. It tends to be somewhat more conservative than our earlier estimation procedure.

Regional biologists and wildlife managers conduct surveys using a methodology developed to ensure a systematic approach to estimating populations of bighorn sheep. The same method is applied to all of the Region's bighorn populations. The use of this method minimizes survey effort and produces estimates of bighorn numbers and sex-age ratios. Because of budget and time constraints, surveys are conducted only once every three years.

Surveys will be conducted using the sampling methodology outlined in "Surveying Bighorn Sheep" (Remington and Welsh 1993, in The Desert Bighorn Sheep in Arizona, edited by R.Lee). Helicopters will be used to do complete surveys of selected sample blocks.

Permit recommendation should be based on the calculation worksheet. Fill it out as follows:

1. Fill in the table using the survey numbers for the past 3 years. In most cases there will have been only 1 survey during that time. If the whole area was not surveyed, then extrapolate the survey numbers to the whole area before putting them in the table (only do this extrapolation if a substantial portion of known occupied habitat was not surveyed).
2. Calculate means for the past 3 years (not past 3 surveys).
3. Calculate a population estimate using the "Kofa Group Size Estimator". The formula for this is:

$$\text{Total Pop.} = (\text{Number of groups of size } 1/0.433 \times 1) + (\text{groups of size } 2/0.507 \times 2) + (\text{gps of } 3/0.581 \times 3) + (\text{gps of } 4/0.654 \times 4) + (\text{gps of } 5/0.728 \times 5) + (\text{gps. of } 6/0.802 \times 6) + (\text{gps of } 7/0.875 \times 7) + \dots(\text{gps of } n/0.949 \times n)$$

This gives a total population estimate. Use the ratios of the different classes of sheep in the survey data to calculate the portion of the total population for each of the sheep classes.

4. Calculate permit numbers. The permit recommendation should be based on 20% of estimated class 3 and 4 rams.

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