Nevada Department of Wildlife

Predation Management Status Report

Fiscal Year 2018

State of Nevada

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Table of Contents

Executive Summary 3
Project 21: Greater Sage-grouse Protection (Common Raven Removal) 4
Project 21-02: Common Raven Removal to Enhance Greater Sage-grouse Nest Success 6
Project 22-01: Mountain Lion Removal to Protect California Bighorn Sheep 8
Project 22-074: Monitor Rocky Mountain Bighorn Sheep for Mountain Lion Predation 10
Project 32: Mountain Lion, Black Bear and Mule Deer Interactions 11
Project 37: Big Game Protection-Mountain Lions 13
Project 38: Big Game Protection-Coyotes 14
Project 40: Coyote Removal to Complement Multi-faceted Management in Eureka County 15
Project 41: Increasing Understanding of Common Raven Densities and Space Use in Nevada 20
Project 42: Assessing Mountain Lion Harvest in Nevada 25
Project 43: Mesopredator Removal to Protect Waterfowl, Turkeys, and Pheasants on Wildlife Management Areas 26
Overall Budget and Expenditures for FY 2018 27
Literature Cited 28
Appendix 29

Executive Summary

The goal of the Nevada Department of Wildlife's (NDOW's) Predator Management Program is to conduct projects consistent with the terrestrial portion of NDOW's Mission "to preserve, protect, manage, and restore wildlife and its habitat for the aesthetic, scientific, educational, recreational, and economic benefits to citizens of Nevada and the United States." Provisions outlined in NRS 502.253 authorize the collection of a $3 fee for each big game tag application, deposition of the revenue from such a fee collection into the Wildlife Fund Account, and use by NDOW to 1) develop and implement an annual program for the management and control of predatory wildlife, 2) conduct wildlife management activities relating to the protection of nonpredatory game animals and sensitive wildlife species, and 3) conduct research necessary to determine successful techniques for managing and controlling predatory wildlife. This statute also allows for: the expenditure of a portion of the money collected to enable the State Department of Agriculture and other contractors and grantees to develop and carry out programs designed as described above; developing and conducting predator management activities under the guidance of the Nevada Board of Wildlife Commissioners; and provide that unspent monies remain in the Wildlife Fund Account and do not revert to State General Funds at the end of any fiscal year.

NDOW maintains a philosophy that predator management is a tool to be applied deliberately and strategically. Predator management may include lethal removal of predators or corvids, non-lethal management of predator or corvid populations, habitat management to promote more robust prey populations which are better able to sustain predation, monitoring and modeling select predator populations, managing for healthy predator populations, and public education, although not all of these aspects are currently eligible for funding through predator fee dollars. NDOW intends to use predator management on a case-by-case basis, with clear goals, and based on an objective scientific analysis of available data. To be effective, predator management should be applied with proper intensity and at a focused scale. Equally important, when possible projects should be monitored to determine whether desired results are achieved. This approach is supported by the scientific literature on predation management. NDOW is committed to using all available tools and the most up-to-date science, including strategic use of predator management, to preserve our wildlife heritage for the long term.

In FY 2018, 11 projects were included in the planned activities, with each project having committed funding. Included in NDOW's ongoing work is Greater sage-grouse protection (Project 21 and Project 21-02), bighorn sheep protection (Project 22-01, Project 22-074, and Project 37), pronghorn protection (Project 38), mule deer protection (Project 40) and waterfowl, turkey, and pheasant protection (Project 43).

Nevada Department of Wildlife spent $641,331 on lethal predator removal during FY 2018. This accounted for 108% of FY 2016 revenues.

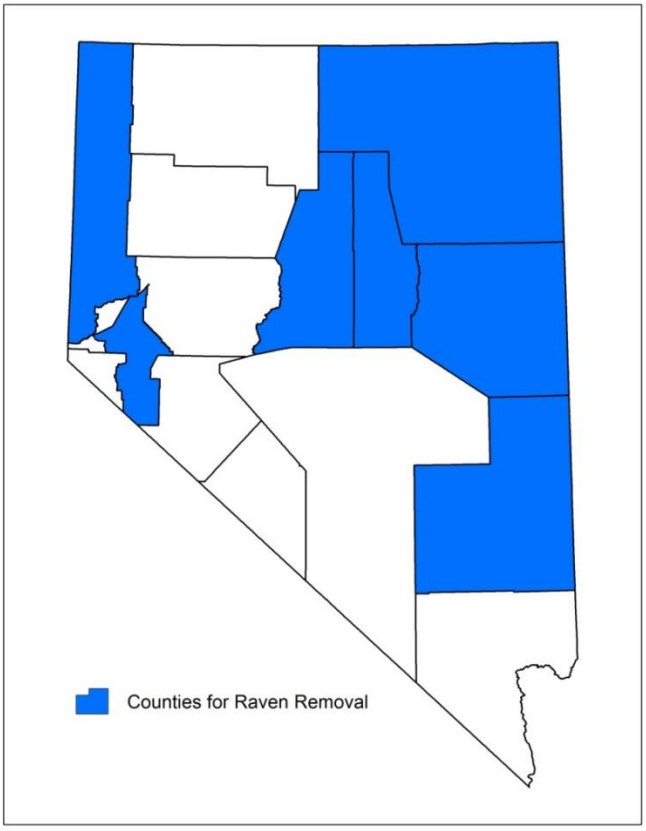
Project 21: Greater Sage-grouse Protection (Common Raven Removal)

Common raven (thereafter raven) control efforts to conserve Greater sage-grouse commenced in early March and extended throughout June 2018. The objective of this project is to increase Greater sage-grouse nest success and recruitment. USDA Wildlife Services (WS) performed raven control work through the placement of corvicide (DCR-1339) injected chicken eggs within occupied Greater sage-grouse habitats. The main treatment areas consisted of eastern and northeastern Nevada in situations where concentrations of ravens have been noted and where habitat has been compromised, potentially by wildfire or anthropogenic subsidies (e.g. landfills and transfer stations). Another treatment area, the Virginia Mountains in western Nevada, is being used as an experimental area and details of that project are reported below (Project 21-02).

Through the efforts of USDA WS personnel, an estimated 2,381 ravens were removed during spring 2018. The total number of ravens taken for Project 21, and Project 21-02 was 2,500, which is the maximum that NDOW can remove under the current USFWS depredation permit (#MB37116A-0). Ravens were removed in 11 game management areas during the spring of 2018 under Project 21 and Project 21-02.

Raven take by Management Area (MA) FY 2018.

Area	Ravens Removed
MA 3	585
MA 6	101
MA 7	217
MA 8	86
MA 10	29
MA 11	39
MA 14	214
MA 15	354
MA 20	93
MA 22	291
MA 23	372
Total Ravens	2,381



Department Comments on Project

Raven management, including lethal removal, is imperative to maintain and improve Greater sage-grouse and the ecosystems they depend on. NDOW recommends continuing Project 21 while common ravens are believed to be a limiting factor for Greater sage-grouse.

$3 Planned Expenditures	P-R Planned Expenditures	Wildlife Services Expenditures	NDOW Lethal Expenditures	NDOW Non-Lethal Expenditures	NDOW Salary, Travel, and Office	Total
$100,000	N/A	$39,151	$0	$5,848	$12,816	**$57,815**

Project 21-02: Common Raven Removal to Enhance Greater Sage-grouse Nest Success

Work was initiated during March and extended throughout May 2018 to monitor the efficacy of raven control on the resident Greater sage-grouse population within the Virginia Mountains, located in southern Washoe County. Over a 2.5-month period, USDA WS deployed corvicide-treated eggs within previously identified Greater sage-grouse nesting habitats located around Sheep Springs, Spanish Flat, and lower Cottonwood Creek. An estimated 108 ravens were removed during the spring months.

Greater sage-grouse monitoring work is being conducted by the USGS Western Ecological Research Center. Seven years of baseline monitoring work have been conducted on this population to determine various vital rates and vegetative parameters in used versus random sites across multiple life phases. The information presented below provides summaries of the USGS field crew efforts from March through July 2018.

USGS Report

RAVEN MONITORING AT VIRGINIA MOUNTAINS

Methods

- Raven point count surveys were performed at Virginia Mountains in association with sage-grouse locations, nests, broods, and random locations

Results

- 176 surveys were conducted overall. 86 of these were independent random (IR) surveys (49%) and 51 were sage-grouse nest surveys (29%).
- 62 ravens were visually observed at distances < 2000 m
- 48 ravens were visually observed at distances < 1125 m
- 5 double-blind surveys were conducted with 12 total ravens observed; double-blind surveys count as 2 in the calculation below
- Raven index for density = # ravens/survey = 0.27 (overall)
    - 0.36 (at independent random surveys)
    - 0.16 (at nests)

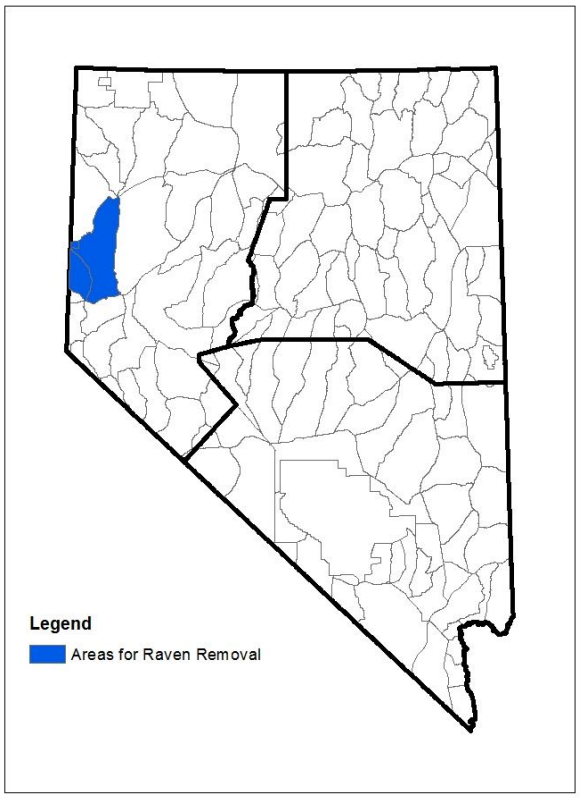
Synthesis

- Raven density appeared to remain relatively low at this site, compared to some previous years (0.5–0.96 ravens/survey; 2009–2011). Numbers are more similar compared to recent years, though raven density may have increased slightly (0.15–0.20 ravens/survey; 2013–2016).
- Raven numbers appeared to be higher at random locations (0.36) than nest locations (0.16)

Department Comments on Project

The area experienced an unplanned, large scale fire in 2017. To better understand the effects of the fire and raven removal on sage-grouse populations, NDOW supports continuing this project through FY 2020.

$3 Planned Expenditures	P-R Planned Expenditures	Wildlife Services Expenditures	NDOW Lethal Expenditures	NDOW Non-Lethal Expenditures	NDOW Salary, Travel, and Office	Total
$25,000	N/A	$16,695	$0	$0	$12,816	**$29,511**



Project 22-01: Mountain Lion Removal to Protect California Bighorn Sheep

Attempts have been made to establish a California bighorn sheep population in Area 01. Substantial mountain lion-induced mortality has been observed. California bighorn sheep populations may require a reduction in mountain lion densities to reach population viability.

Between July 1, 2017 and June 30, 2018, 7 mountain lions were removed by USDA WS in Unit 011 and 3 mountain lions were removed in Unit 013. Mountain lion removal efforts were made by a private contractor in Unit 011, 3 mountain lions were removed. The private contractor submitted the Annual Predator Management Project Reporting Form (Appendix).

Five GPS collars were deployed on bighorn sheep in Unit 011, and another 5 in Unit 013 during FY 2018.

01 Sheep Herd Health (Biologist III Chris Hampson)

Both aerial and ground surveys were conducted in 2018 in hunt unit group 011-013. The surveys located and classified a total of 65 bighorn. The sample provided a composition ratio of 15 rams/100 ewes/51 lambs. Bighorn were located in the Hays Canyon Range in unit 013 and on the Massacre and Coleman Rims in unit 011.

Observations included 6 rams (aged Yearling to 6 years of age), 39 ewes and 20 lambs. The sample provided us a good look at recruitment for this year and indicates excellent survival for the mid to late summer period. Several collared and ear-tagged animals were observed during the surveys that were animals from the previous bighorn releases in these areas.

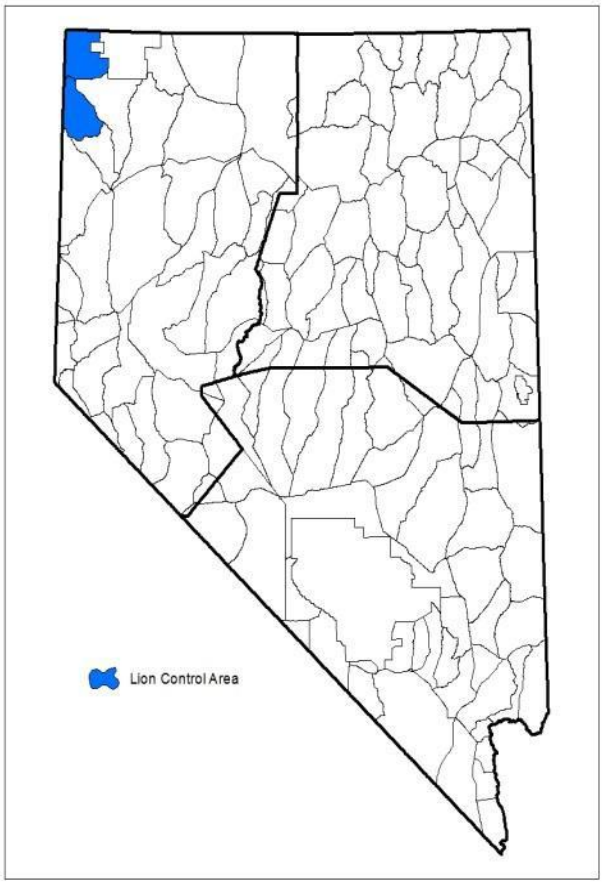
As of this writing, 9 bighorn collars (5 in Hays Canyon and 4 on Massacre Rim) are active in unit group 011,013. Additional bighorn were captured and fitted with telemetry collars in November 2017 and January 2018. The telemetry collars help keep track of important movement patterns and also help to monitor survival. If a lion kill is found to be the cause of mortality, actions can then be implemented and taken to locate and remove the offending lion.

Bighorn populations within the Hays Canyon Range of Unit 013 appear to be continuing on an upward trend with good lamb survival observed. The Massacre Rim sub herd appears to be stable at low levels and the Coleman Rim sub herd appears to be increasing and currently at moderate levels. The Coleman Rim sub herd on the Nevada side of the line is known to move back and forth between Oregon and Nevada and interchange and mixing between the two subpopulations of California bighorn is known to occur.

Department Comments on Project

NDOW supports continuing Project 22-01 until the local bighorn sheep populations reach viability as defined in the annual Predator Plan.

$3 Planned Expenditures	P-R Planned Expenditures	Wildlife Services Expenditures	NDOW Lethal Expenditures	NDOW Non-Lethal Expenditures	NDOW Salary, Travel, and Office	Total
$90,000	N/A	$95,341	$27,800	$0	$12,816	**$135,957**


Lion Control Area

Project 22-074: Monitor Rocky Mountain Bighorn Sheep for Mountain Lion Predation

Unit 074 Rocky Mountain bighorn sheep herd experienced a die-off in 1999. Two years following the die-off, the lamb recruitment was low, remaining consistent with typical bighorn sheep die-offs. Since then the average lamb recruitment has been 48 lambs:100 ewes. This level of recruitment should have resulted in an increasing bighorn sheep herd; however the population rebound has not occurred.

The Contact Area is a major deer winter range. It is possible that mountain lions following the deer herd from summer range in the Jarbidge Mountains to winter range switch their diet to bighorn sheep when deer return to their summer range. Some mountain lions may be staying in the area on a yearlong basis with their primary food source being Rocky Mountain bighorn sheep.

No mountain lion removal efforts were conducted during FY 2018.

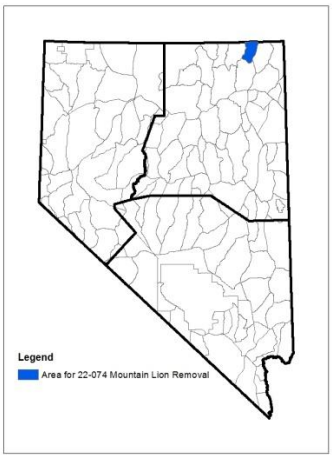
Bighorn Sheep Herd Health (Biologist III Kari Huebner)

On October 17, 2017 26 bighorn were classified in the Contact herd. Observations included 12 ewes (3 yearlings), 3 lambs, and 11 rams (3 yearlings). On October 26, 2017, five additional bighorn (4 ewes and 1 ram) were collared to determine if there are any mountain lion related predation events. The population is most likely between 25-30 sheep. Recruitment remains low, but improving. No known mountain lion mortalities have been observed since FY 2016.

Department Comments on Project

NDOW supports continuing Project 22-074 until the local bighorn sheep reaches population viability as defined in the annual Predator Plan.

$3 Planned Expenditures	P-R Planned Expenditures	Wildlife Services Expenditures	NDOW Lethal Expenditures	NDOW Non-Lethal Expenditures	NDOW Salary, Travel, and Office	Total
$90,000	N/A	$0	$0	$4,900	$12,816	**$17,716**



Project 32: Mountain Lion, Black Bear and Mule Deer Interactions

NDOW technicians collected kill site data on 6 mountain lions, and visited 126 kill sites. Below is an exert from the Wildlife Conservation Society. The entire report can be found in the appendix of this document.

Existing Data in Hand

35,000+ GPS locations from 10 cougars collared under Project 32

60,000+ GPS locations from 30 bears collared under Project 32

600+ predation events (i.e. kill sites) for cougars visited by NDOW and WCS biologists with data on prey items, date, location, bear interactions recorded

Deer densities by habitat type in three mountain ranges of study site for 2015, 2016, and 2017

Feral horse counts in Virginia Range from NV Dept of Ag for 2015, 2016, and 2017 and BLM counts of horses for Pinenut Range for each year

Bighorn sheep population estimates for Virginia Range for 2015, 2016, and 2017

Necessary data likely needed to complete analyses

We are still trying to access 800+ kill sites data from 21 collared cougars from Alyson Andreasen's PhD work (Andreasen 2014). These data would allow us to examine impact of an increasing bear population on bear-cougar interactions over a longer period of time (8-10 years vs 3 years of Project 32). We can and are addressing all questions of Project 32 without those data, but they would be really nice to include in the analyses to increase sample sizes and to get a complete picture of how cougars are responding to bear re-colonization over a much longer time-frame.

Expected publications and estimated timeline

Dr. Jon Beckmann at WCS is teaming with Dr. Julie Young to Co-Advise a PhD student at Utah State University (Kristin Engebretsen) to complete these analyses and publications along with NDOW staff.

1) Publication using multi-variate analyses to model cougar kill rates and prey selection to disentangle the impact of varying densities of bears, bear scavenging rates, habitat features, prey availability (i.e. deer, bighorn, and horse densities by habitat type), cougar sex, body condition (body mass) and reproductive status (i.e. kittens present or not). This paper will include analyses to understand how bears and their interactions with cougars are impacting predation rates and prey item selection by cougars, along with any potential changes in livestock predation across time and as bear densities change. These analyses should be completed by summer 2019 and submitted to a peer-reviewed journal following review by all co-authors, including NDOW staff.

2) Publication on cougar and bear RSPF models. This paper will compare cougar-bear interactions (i.e. cougar kill rates, kill sites, bear scavenging rates at cougar kill sites, and cougar prey selection) across the various habitats that bears use based on the RSPF models to further understand impact of habitat use by bears on cougar kill rates and prey selection (estimated completion date of late 2019 to early 2020 for models and manuscript following review by all co-authors, including NDOW staff).

$3 Planned Expenditures	P-R Planned Expenditures	Wildlife Services Expenditures	NDOW Lethal Expenditures	NDOW Non-Lethal Expenditures	NDOW Salary, Travel, and Office	Total
$40,000	$120,000	$0	$0	$80,274	$12,816	**$93,090**

Department Comments on Project

End Project 32. Begin a project, passive in nature, to estimate the black bear population throughout the inhabited portions of Nevada.

Project 37: Big Game Protection-Mountain Lions

In some circumstances, culling of top predators is beneficial for protection of newly translocated big-game populations, small and isolated big-game populations, or big-game populations held below carrying capacity by predation (Hayes et al. 2003, Rominger et al. 2004, McKinney et al. 2006). The geographic range of mountain lions is larger than any big-game mammal in North and South America (Logan and Sweanor 2000), and specific areas may benefit from removal efforts that may target more than a single mountain lion.

USDA Wildlife services removed 4 mountain lions under this project, 3 in Unit 252 and 1 in Unit 041. A private contractor lethally removed 1 mountain lion from the Jackson Mountains and another 2 mountain lions in the Delamar Mountains. Another private contractor removed 5 in the Snowstorm Mountains. The Annual Predator Management Project Reporting Forms for Project 37 may be found in the Appendix of this document.

Five GPS collars were purchased to deploy on mountain lions in areas surrounding the Delamar Range. 6 GPS collars were deployed by a private contractor. These data will increase understanding of mountain lion space use and prey selection, allowing for more efficient future lethal removal.

Department Comments on Project

NDOW supports continuing Project 37 until local bighorn sheep populations become viable as defined in the annual Predator Report. NDOW supports the ability to remove mountain lions quickly.

$3 Planned Expenditures	P-R Planned Expenditures	Wildlife Services Expenditures	NDOW Lethal Expenditures	NDOW Non-Lethal Expenditures	NDOW Salary, Travel, and Office	Total
$175,000	N/A	$40,932	$134,285	$21,627	$12,816	**$209,660**

Project 38: Big Game Protection-Coyotes

Coyotes face an increase in caloric need when raising pups, both through an increase in parent energetic output and feeding growing pups (Till and Knowlton 1983, Sacks et al. 1999, Seidler et al. 2014). Parent coyotes and their pups may consume a drastically different diet than their non-parent counterparts at the same time of year; this difference in diet likely requires larger prey, including mule deer fawns. Removing coyotes may increase mule deer fawn and other wildlife species reproductive output.

Upon approval of Project 38, game biologists with pronghorn management responsibilities were asked whether or not their pronghorn herds may be underperforming due to coyote predation. Areas where predation by coyotes could be a factor limiting pronghorn populations received removal efforts from USDA WS. From March through June USDA WS conducted coyote removal, primarily with helicopter for the benefit of pronghorn. Two hundred thirty-nine coyotes were removed.

Area	Coyotes Removed
MA 7	74
MA 10	18
MA 16	54
MA 20	17
MA 22	5
MA 23	71
Total	239

Department Comments on Project

NDOW supports continuing Project 38 pending available funding.

$3 Planned Expenditures	P-R Planned Expenditures	Wildlife Services Expenditures	NDOW Lethal Expenditures	NDOW Non-Lethal Expenditures	NDOW Salary, Travel, and Office	Total
$125,000	N/A	$133,720	$0	$0	$12,816	**$146,536**

Project 40: Coyote Removal to Complement Multi-faceted Management in Eureka County

Mule deer populations in Diamond Mountains in Eureka County are believed to be underperforming due to competition with feral equids, pinyon-juniper expansion, and predation. To alleviate pressure on resources, the BLM conducted a feral horse round-up in the Diamond Mountains in January 2013, removing 792 horses. Eureka County and the Eureka County Advisory Board to Manage Wildlife directed the removal of pinyon and juniper trees on private range lands in the Diamonds and Roberts Mountains in 2008, 2009, and 2011. USDA WS removed coyotes in the area in 2011 and 2012. A private contractor removed coyotes in 2014. On-going removal of coyotes may assist mule deer population recovery.

From July 2017 until June 2018 USDA WS conducted aerial gunning and trapping of coyotes in Area 14, removing 319 coyotes and 5 mountain lions.

NDOW had a contractor conduct 3 Forward Looking Infrared (FLIR) surveys (1 in FY 2017, 2 in FY 2018). The purpose of these surveys was to located collared mule deer does, and determine the presence/absence of fawns. Preliminary results suggest this is a viable method to accurately and quickly monitor and estimate mule deer fawn survival during the first 3 months of a mule deer fawn's life.

144 Deer Herd Health (Biologist III Clint Garrett)

This project takes place mainly in the Diamond Range (hunt unit 144) within management area 14 (MA14: 141–145) and contains the majority of the mule deer for this hunt unit grouping. The project focus is on deer wintering and fawning grounds to reduce the effects of potentially high concentrations of coyotes that may be suppressing mule deer below carrying capacity. The project response variable stated within the NDOW predator plan uses spring fawn:adult ratios of 50:100 or higher for 3 consecutive years in hunt unit 144 before the project will be altered or discontinued. Other potentially affected game species within the project area include sage grouse and although no response variable is identified within the predator plan for sage grouse, the table below lists peak male attendance for the Diamond population management unit (PMU). Along with coyote removal Wildlife Services also actively pursues and removes mountain lions from the project area.

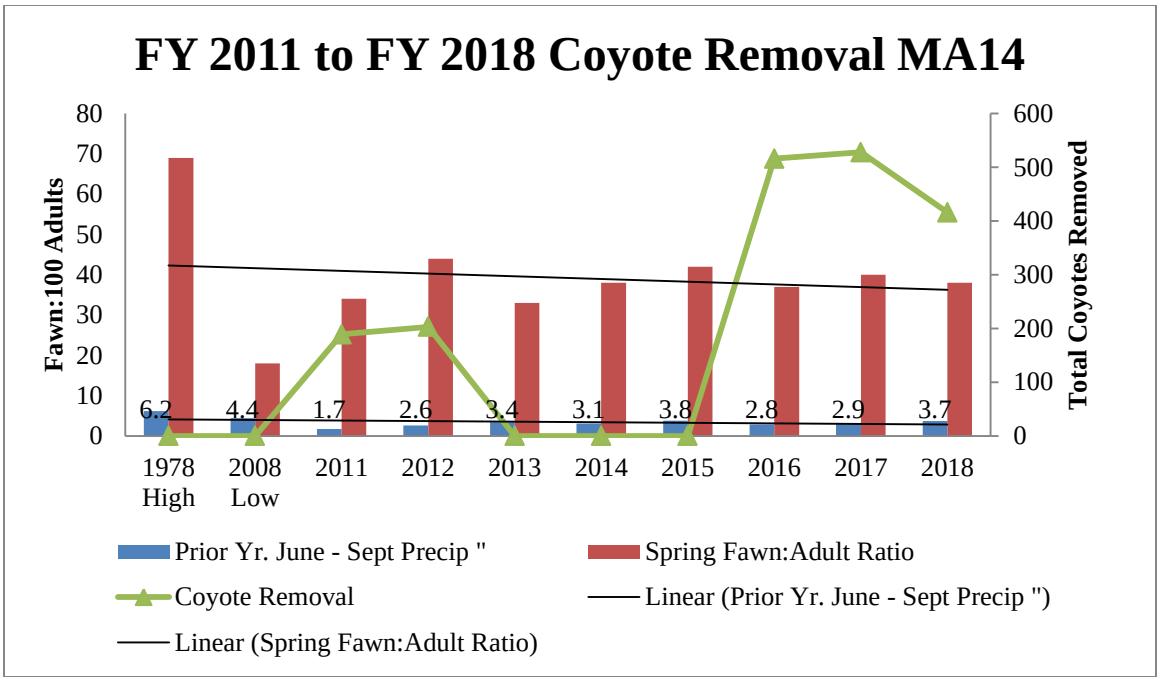
Deer were collared in January 2017 (10 collars) and 2018 (3 collars) to help understand the connectivity between the 144 hunt unit and surrounding hunt units. This collaring effort has given us a better understanding of limiting factors and seasonal use patterns of the deer herd within the Diamond Range. To date there have been 7 of the 13 collared does killed by mountain lions within the Diamond's which have occurred in varied locations and times of the year.

Current deer modeling is done for MA14 as a whole. For MA14: The September populations levels where at a high in 1985 (9,300) and a low in 1976 (3,100). The 2018 spring survey of 39 fawns:100 adults is slightly above the previous 5-year average of 38 fawns:100 adults. The previous 5-year population estimate (2013–2017) is 4,100 deer with the 2017 and 2018 estimates being 4,400 and 4,500 respectively showing an increase in population and a slight

increase in fawn recruitment. The tables and charts below give numbers for MA14, Unit 144 and the Diamond PMU.

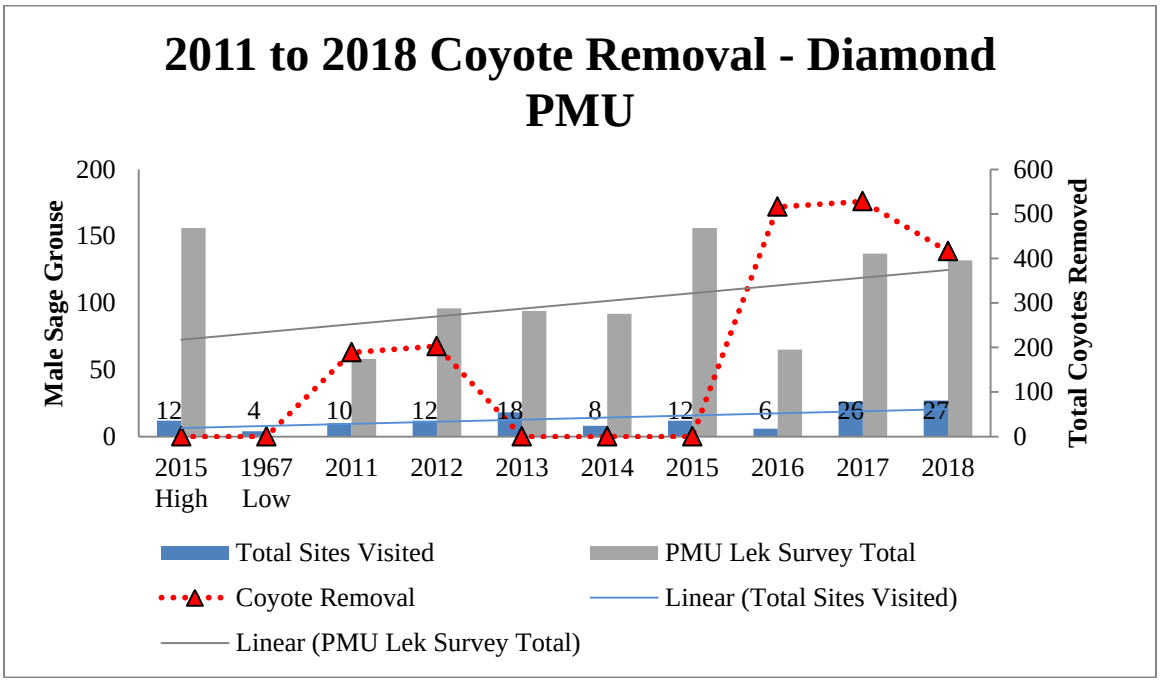
Deer Survey Year	HU 144 Fawns	HU 144 Adults	HU 144 Fawn/Adult Spring Ratio	June Thru Sept. Precip.	% Fawn Loss		WS Total Removed		Removal Season
					HU 144	MA 14	Coyotes	Mt. Lions	
Lowest Ratio Spring 2008	109	621	18/100	4.4	41%	43%	-	-	?
Highest Ratio Spring 1978	375	544	69/100	6.2	18%	12%	-	-	-
+Spring 2011	291	861	34/100	1.7	NFS	23%	189	0	FY11
Spring 2012	255	574	44/100	2.6	0%	11%	*203	0	FY12
Spring 2013	217	652	33/100	3.4	21%	18%	0	0	No NDOW/WS Removal
Spring 2014	333	877	38/100	3.1	1%	3%	0	0	No NDOW/WS Removal
+Spring 2015	369	876	42/100	3.8	NFS	14%	0	0	No NDOW/WS Removal
+Spring 2016	384	1,050	37/100	2.8	NFS	23%	516	0	FY16
Spring 2017	435	1,086	40/100	2.9	0%	10%	528	1	FY17
Spring 2018	422	1,111	38/100	3.7	0%	7%	319	5	FY18

+ No fall surveys (NFS) were conducted in 2014 or 2015 for MA14. Fawn loss could not be calculated for hunt unit 144 individually.
Survey/model information goes back to 1974 for MA14 but 1977 – 1978 was the first year a representative survey size was observed.
***** Coyote removal was conducted prior to Project 40 implementation – NA4W 10-26: Eureka County and Project 22 Unit 144.
Coyote and Lion removal information is obtained from Nevada USDA-APHIS-WS
Precipitation information is obtained from https://wrcc.dri.edu Eureka, NV



Sage Grouse Survey year	Diamond PMU - Individual Complex						PMU Totals	Total Sites Visited
	West Diamond Valley	East Diamond Valley	South Eureka	Newark Summit	Antelope Valley	Newark Valley		
Low Spring Count (yr)-# Sites 1955-2018	0 (1967)-4	10 (2002)-2	0 (00/01)-2	6 (2001)-1	0 (9 yrs.)-1	0 (1957)-4	0 (1967)-4	0 (6 yrs.)-0
High Spring Count (yr)-# Sites 1955-2018	21 (2012)-1	102 (1979)-1	28 (2015)-2	61 (2015)-4	23 (1985)-1	104 (2000)-6	156 (2015)-12	132 (2018)-27
Spring 2011	11	15	NS	NS	0	32	58	10
Spring 2012	21	15	1	28	NS	32	96	12
Spring 2013	11	19	0	38	0	26	94	18
Spring 2014	3	46	18	NS	NS	25	92	8
Spring 2015	12	35	28	61	NS	20	156	12
Spring 2016	7	42	NS	NS	0	16	65	6
Spring 2017	5	*54	19	*32	0	27	137	26
Spring 2018	3	*29	21	*50	0	*29	132	27

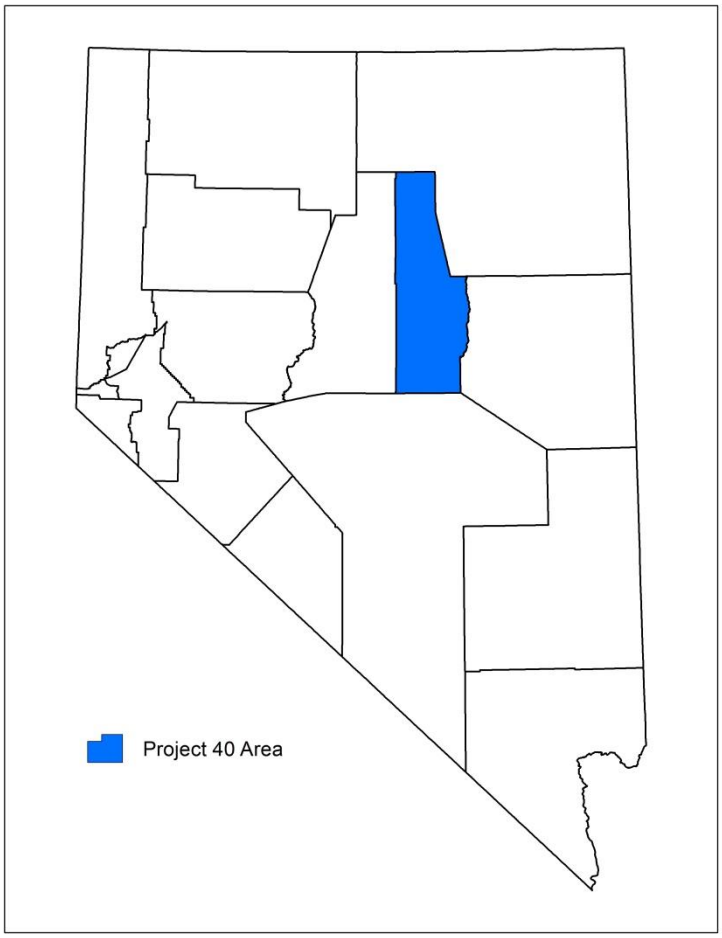
*Includes recently added and pending active lek sites.



Department Comments on Project

NDOW supports continuing Project 40 until mule deer populations reach levels defined in the annual Predator Plan.

$3 Planned Expenditures	P-R Planned Expenditures	Wildlife Services Expenditures	NDOW Lethal Expenditures	NDOW Non-Lethal Expenditures	NDOW Salary, Travel, and Office	Total
$100,000	N/A	$110,960	$0	$20,343	$12,816	**$121,430**


Project 40 Area

Project 41: Increasing Understanding of Common Raven Densities and Space Use in Nevada

The common raven (*Corvus corax*) has been identified as the most common nest predator of Greater sage-grouse (*Centrocercus urophasianus*) (Coates et al. 2008, Lockyer et al. 2013). Although the raven is a natural predator of Greater sage-grouse nests (Schroeder and Baydack 2001), human subsidies, including food sources (e.g., roadkill (Kristan III et al. 2004, Coates et al. 2014*a*, *b*), landfills (William III and Boarman 2007, Peebles 2015) and artificial nesting structures (e.g., power and utility lines (Knight et al. 1995, Coates et al. 2014*a*, *b*, Howe et al. 2014), dramatically increased raven abundance as much as 1600% in some areas (Boarman 1993, Sauer et al. 2017). Increased raven abundance coupled with Greater sage-grouse habitat loss (Schroeder et al. 2004) and degradation (e.g., invasive species invasion (Commons et al. 1999, Baruch-Mordo et al. 2013, Coates et al. 2016), wildfire (Crawford et al. 2004, Lockyer et al. 2015) resulted in reduced or decreased Greater sage-grouse population growth in portions of its range (Klebenow 2001, Stiver 2011).

Raven Transmitters

Between October 2017 and September 2018 we captured and radio-tagged 36 ravens: 1 hatch year, 4 adults and 31 juveniles. We started the season tracking 14 ravens radio-tagged during previous capture efforts resulting in a total of 50 birds tracked during the season. At the end of the season, 15 ravens were still alive with active transmitters (4 juveniles and 11 adults). One raven slipped its transmitter, 5 devices stopped transmitting, 28 ravens died (24 juveniles and 4 adults) and 1 raven had an unknown fate. We could not find any remains near the transmitter of the last raven but it's possible it was scavenged. Two recovered transmitters were covered in a pink residue; it's unclear whether the substance was related to the cause of death.

Raven Nest Monitoring

We actively monitored 63 nests to capture juveniles as they fledged. While monitoring, we confirmed 20 mortalities of unmarked fledglings, generally found under or near the nests. We saw 3 of these fledglings electrocuted on utility lines as they fell from the nest. Of the 24 radio-tagged juvenile mortalities, 8 appeared depredated or scavenged and 13 carcasses were intact. Five intact carcasses were on train tracks near their nest.

Point Count Surveys

NDOW technicians conducted 978 raven and raptor point count surveys. These data will be part of the USGS' statewide population estimate.

Transmission Line Surveys

NDOW technicians collected data on 390 miles of transmission lines and located a total of 25 nests.

USGS Report

MODELING COMMON RAVEN OCCURRENCE ACROSS SAGEBRUSH ECOSYSTEMS IN THE GREAT BASIN, USA

Background

- Raven populations across the Great Basin have been increasing during the last several decades, However, methodology and resolution of data are inadequate for estimating abundance, density, and true occurrence of ravens.
- Spatially explicit information on raven density and occurrence is also needed at regional and local levels in order to guide management, especially where high raven prevalence overlaps sage-grouse breeding habitats.

Methods

- We used hierarchical occupancy models to estimate and predict probability of raven occurrence across the Great Basin, using data from >15,000 point count survey.
- We related raven occurrence to a large suite of natural and landscape predictors, which were then used to predict spatial variation in raven occurrence across regions where surveys did not occur.
- We generated model predictions of areas where raven occupancy was likely driven by anthropogenic as opposed to natural factors; these products were overlapped with sage-grouse concentration areas to identify areas where spatial prioritization can either target habitat improvements or reduction of subsidies on the landscape.

Results

- Results indicated high raven occurrence (>0.8) across much of the study area
- Many of the drivers of raven occurrence were anthropogenic (road density, landfills, transmission lines, agriculture).

Synthesis

- Findings will be used to help provide science-driven solutions for management of ravens and sensitive prey species across the semi-arid ecosystems of the Great Basin
- Specifically, spatial products from this project help to identify regions where ravens likely have strong top-down impacts on breeding sage-grouse and also provide guidance on what category of management action will likely be most effective in these areas.

Products

O'Neil et al. (2018) Broad-scale occurrence of a subsidized avian predator: reducing impacts of ravens on sage-grouse and other sensitive prey. *Journal of Applied Ecology*: https://doi.org/10.1111/1365-2664.13249

O'Neil et al. (2018) Data from broad-scale occurrence of a subsidized avian predator: reducing impacts of ravens on sage-grouse and other sensitive prey. U.S. Geological Survey data release: https://doi.org/10.5066/p93oniqt

O'Neil et al. (2018; *presentation*) Broad-scale occurrence of a subsidized avian predator: implications for reducing impacts of ravens on sage-grouse. Western Association of Fish and Wildlife Agencies Sage and Columbian Sharp-Tailed Grouse Workshop, June 18–21, 2018, Billings, MT, USA.

ESTIMATING COMMON RAVEN DENSITIES IN A SEMI-ARID ECOSYSTEM: IMPLICATIONS FOR CONSERVATION OF SAGE-GROUSE AND OTHER SENSITIVE PREY SPECIES

Background

- Raven populations across the Great Basin have been increasing during the last several decades. Methodology and resolution of data are inadequate for estimating abundance, density, and true occurrence of ravens.
- Effects of ravens on sage-grouse reproductive success are largely unknown at broad spatial scales.
- A method for rapid assessment of raven densities is needed to guide and evaluate the effectiveness of raven management actions.

Methods

- We used distance sampling to estimate site-level densities of ravens across 41 field sites in the Great Basin region, 2007 – 2016.
- We related raven density to sage-grouse nest survival at the site level to evaluate possible effects of elevated raven density on reproduction.
- We explored the validity of using an index for rapid evaluation of raven density (# of ravens / # of surveys).

Results

- Raven densities commonly exceeded ~ 0.4 ravens km^{-2} across the Great Basin. Several sites had raven densities > 0.6 ravens km^{-2}, and raven density appeared to be increasing at some sites.
- At the site level, there was evidence of a raven density effect on sage-grouse nest survival, where greater raven densities (e.g. > 0.48) corresponded with below-average nest survival.
- Comparisons of model-based raven density estimates to the index of raven density indicated a strong relationship between estimated raven density and # of ravens/survey.

Synthesis

- Findings will be used to help provide science-driven solutions for management of ravens and sensitive prey species across the semi-arid ecosystems of the Great Basin.
- Negative effects of raven density on sage-grouse nest survival are likely at raven densities > 0.5.
- In the absence of large sample sizes, an index can be rapidly applied with reasonable accuracy to evaluate the effects of management actions.

Products

O'Neil et al. (2018; *presentation*) Spatially explicit modeling of common raven density and occurrence in sagebrush ecosystems. The Wildlife Society-Western Section Annual Meeting, Feb. 5–9, 2018, Santa Rosa, CA, USA.

RELATING RAVEN DENSITY TO SAGE-GROUSE NEST SUCCESS AT THE NEST LEVEL IN CALIFORNIA AND NEVADA

Background

- Effects of ravens on sage-grouse reproductive success are largely unknown at broad spatial scales.
- Raven density likely varies within sites depending on local environmental drivers
- Raven effects on sage-grouse nests success are likely to be more precise when accounting for local variation.

Methods

- We applied distance sampling procedures (Project # 2) combined with spatial kriging models to estimate local raven density at distances < 3.5 km of individual sage-grouse nests (n = 984) during years 2009–2017.
- Using a Bayesian frailty model for sage-grouse nest survival, we included the local estimator for raven density as a covariate while also including relevant landscape predictors (% sagebrush, elevation, etc.).

Results

- While greater elevations and sagebrush cover had positive influences on sage-grouse nest survival, local raven density had a strong negative effect (effect on hazard: $\beta = 0.151$, $p(\beta > 0) = 0.999$).

Synthesis

- Negative effects of raven density on sage-grouse nest survival are likely at raven densities > 0.5; probability of nest success is greatest at low raven density.
- Local variation in raven density is likely driven by site-specific environmental drivers, with consequences for sage-grouse nesting in the same areas.

Products

O'Neil et al. (2018; *presentation*) Reduced nest success in greater sage-grouse associated with common raven density in Nevada & California, USA. International Grouse Symposium, Sep. 24–28, Logan, UT, USA.

O'Neil et al. (*In prep*) Spatially-explicit estimation of Common Raven density within Great Basin sagebrush ecosystems.

RAVEN AND SAGE-GROUSE INTERACTIONS AND BEHAVIORAL ECOLOGY

Background

- Behavioral ecology is important in understanding the impacts that breeding & territorial ravens might have on sage-grouse, as well as how predator control techniques such as egg oiling might affect ravens.

Methods

- Raven eggs were oiled on Alcatraz Island, CA and the nest was video-recorded.
- A raven nest was also video-recorded without egg oiling at Virginia Mountains (VM), NV.
- Raven and sage-grouse behaviors were observed and harassment behavior was documented at ~ 200 lek counts in NV and CA.

Results

- Ravens exhibited cannibalism in two circumstances. It was suspected that raven parents consumed their own eggs after egg oiling occurred. Secondly, ravens attacked and killed conspecific chicks in Virginia Mountains.
- Observations of sage-grouse flushing and ceasing to display were documented when ravens were present.
- Chi-squared tests indicated that ravens were more likely to flush or cease displaying when ravens were present as opposed to absent.

Synthesis

- Egg oiling may alter raven behavior in unanticipated ways.
- It is suspected that competing or transient ravens were responsible for killing the chicks of resident ravens at VM.
- Sage-grouse reproductive activity may be impacted by avian predators indirectly (e.g. altering behavior at leks) as well as directly (e.g. nest depredation).

Products

Atkinson et al. (*Submitted to Journal of Ornithology*). Conspecific egg and nestling consumption in Northern Raven (*Corvus corax*).

Atkinson et al. (*In prep*) Novel reactions to Common Ravens from lekking Greater Sage-Grouse.

Department Comments on Project

NDOW supports continuing Project 41.

$3 Planned Expenditures	P-R Planned Expenditures	Wildlife Services Expenditures	NDOW Lethal Expenditures	NDOW Non-Lethal Expenditures	NDOW Salary, Travel, and Office	Total
$100,000	$300,000	$0	$0	$351,417	$12,816	**$364,233**

Project 42: Assessing Mountain Lion Harvest in Nevada

No work was performed on Project 42 during FY 2018.

$3 Planned Expenditures	P-R Planned Expenditures	Wildlife Services Expenditures	NDOW Lethal Expenditures	NDOW Non-Lethal Expenditures	NDOW Salary, Travel, and Office	Total
$0	$0	$0	$0	$0	$0	**$0**

Project 43: Mesopredator Removal to Protect Waterfowl, Turkeys, and Pheasants on Wildlife Management Areas

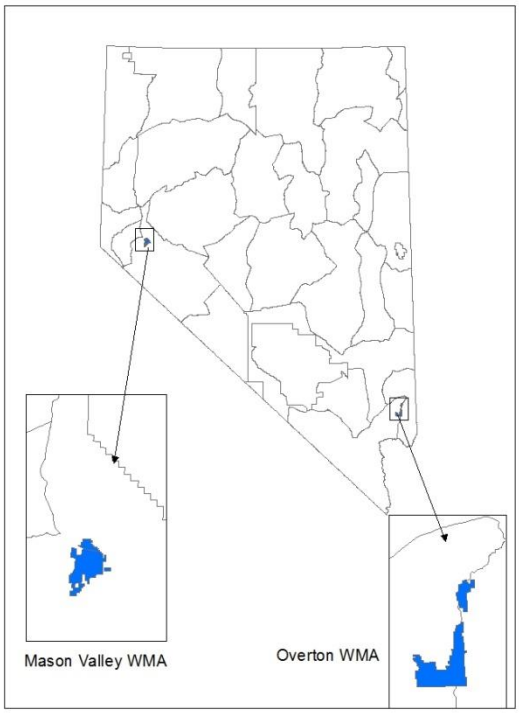
USDA WS conducted mesopredator removal for the benefit of primarily waterfowl and turkeys in Mason Valley and Overton Wildlife Management Areas in FY 2018.

Species	Mason Valley	Overton
Badger	0	1
Coyote	23	19
Feral Cat	0	2
Mink	1	0
Kit Fox	0	1
Raccoon	4	5
Spotted Stunk	0	1

Department Comments on Project
NDOW recommends continuing project 43 pending funding availability.

$3 Planned Expenditures	P-R Planned Expenditures	Wildlife Services Expenditures	NDOW Lethal Expenditures	NDOW Non-Lethal Expenditures	NDOW Salary, Travel, and Office	Total
$50,000	$N/A	$28,447	$0	$0	$12,816	**$41,263**

Wildlife Management Areas for Lethal Predator Control



Overall Budget and Expenditures for FY 2018

Project	$3 Planned Expenditures	P-R Planned Expenditures	Wildlife Services Expenditures	NDOW Lethal Expenditures	NDOW Non-Lethal Expenditures	NDOW Salary, Travel, and Office[b]	Total
Department of Ag Transfer[a]	$14,000	N/A	$14,000	$0	$0	$0	**$14,000**
Project 21	$100,000	N/A	$39,151	$0	$5,848	$12,816	**$57,815**
Project 21-02	$25,000	N/A	$16,695	$0	$0	$12,816	**$29,511**
Project 22-01	$90,000	N/A	$95,341	$27,800	$0	$12,816	**$135,957**
Project 22-074	$90,000	N/A	$0	$0	$4,900	$12,816	**$17,716**
Project 32	$40,000	$120,000	$0	$0	$80,274	$12,816	**$93,090**
Project 37	$175,000	N/A	$40,932	$134,285	$21,627	$12,816	**$209,660**
Project 38	$175,000	N/A	$133,720	$0	$0	$12,816	**$146,536**
Project 40	$100,000	N/A	$110,960	$0	$20,343	$12,816	**$144,119**
Project 41	$100,000	$300,000	$0	$0	$351,417	$12,816	**$364,233**
Project 42	$2,500	$7,500	$0	$0	$0	$0	**$0**
Project 43	$50,000	N/A	$28,447	$0	$0	$12,816	**$41,263**
Total[c]	**$961,500**	**$427,500**	**$479,246**	**$162,085**	**$484,409**	**$128,160**	**$1,253,900**

[a]This transfer of $3 predator fees for administrative support to the Department of Agriculture partially funds state personnel that conduct work for the benefit of wildlife at the direction of USDA WS (e.g., mountain lion removal to benefit wildlife).
[b]Incorporates both $3 and P-R expenditures
[c]Nevada Department of Wildlife spent $641,331 on lethal predator removal during FY 2018. This accounted for 108% of FY 2016 revenues.

Expected Revenues and Beginning Balance of $3 Predator Fee

	FY 2016 Actual (revised)	FY 2017 Actual (revised)	FY 2018 Actual (revised)	FY 2019 Projected
Beginning balance	$732,094	$778,844	$592,122	$412,582
Revenues	$595,107	$653,835	$677,186	$677,186
Plan Budget	$556,000	$839,500	$961,500	$691,500
Expenditures	$548,357	$840,557	$856,726	$691,500
Ending balance	$778,844	$592,122	$412,582	$398,268

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Appendix

http://www.ndow.org/Nevada_Wildlife/Conservation/Nevada_Predator_Management/