STATE OF NEVADA

DEPARTMENT OF WILDLIFE

Game Division

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MEMORANDUM

April 3, 2019

To: Nevada Board of Wildlife Commissioners, County Advisory Boards to Manage Wildlife, and Interested Publics

From: Brian Wakeling, Administrator, Game Division

Title: **Presentation of Fiscal Year 2020 Draft Predation Management Plan (Final Draft) – For Possible Action**

Description: The Commission will review the final draft of the Fiscal Year 2020 Draft Predation Management Plan with the Department. The Commission may take action to modify or endorse the plan.

Presenter: Wildlife Staff Specialist Pat Jackson

<u>Summary</u>:

The Department has previously shared the Draft Fiscal Year 2020 Predation Management Plan with the Nevada Board of Wildlife Commissioners, County Advisory Boards, Predatory Animal and Rodent Committee, and Wildlife Damage Management Committee. Amendments have been adopted to address comments received throughout the review process. The Department presents this Final Draft Fiscal Year 2020 Predation Management Plan to the Commission for endorsement or amendment.

<u>Recommendation</u>:

The Department recommends that the Commission **VOTE TO ENDORSE THE FINAL FISCAL YEAR 2020 PREDATION MANAGEMENT PLAN AS PRESENTED.**

Final

Nevada Department of Wildlife
Predator Management Plan
Fiscal Year 2020

1 July 2019 to 30 June 2020

STATE OF NEVADA

Steve Sisolak, Governor

Nevada Department of Wildlife

Tony Wasley, Director

Jack Robb, Deputy Director
Liz O'Brien, Deputy Director
Brian F. Wakeling, Game Division Administrator

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Introduction

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, nonlethal 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. NDOW works with area biologists and monitors harvest data to ensure localized removal of predators does not result in negative biological consequences on a region or statewide level.

NDOW is a state agency that must balance the biological needs of wildlife, statutory mandates, and social desires of the public. In the 2015 legislative session, Assembly Bill 78 was adopted which in part amended NRS 502.253 (4) (b) to read: [The Department] "Shall not adopt any program for the management and control of predatory wildlife developed pursuant to this section that provides for the expenditure of less than 80 percent of the amount of money collected pursuant to subsection 1 in the most recent fiscal year for which the Department has complete information for the purposes of lethal management and control of predatory wildlife." NDOW intends to comply with statute and apply the tools of scientific predation management in biologically sound, socially responsible means.

Budget Summary

Fiscal year 2018 predator fee revenues totaled $677,186. The Department expects to need to allocate about $541,749 on lethal removal to meet the requirements set forth by Assembly Bill 78. Proposed predator projects for fiscal year 2020 include $699,000 for lethal work, these funds include fiscal year 2018 revenues and previous fiscal years surpluses.

Map Note

Maps for each project may be found in the last page of this document.

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TYPES OF PROJECTS

Below are the three categories of projects in the predator management plan. Some projects have aspects of multiple types within a single activity or action. The project types are listed throughout this document.

1. **Implementation**: The primary objective is to implement management of predators through lethal or non-lethal means. NDOW will collaborate with USDA Wildlife Services and private contractors to conduct lethal and non-lethal management of predators. Identifying and monitoring a response variable is not a primary objective for implementation.
2. **Experimental Management**: The primary objectives are management of predators through lethal or non-lethal means and to learn the effects of a novel management technique. NDOW will collaborate with USDA Wildlife Services, private contractors, and other wildlife professionals to conduct lethal or non-lethal management of predators and will put forethought into project design. Response variables will be identified and data will be collected to determine project effectiveness. Expected outcomes will include project effectiveness, agency reports, and possible peer-reviewed publications.
3. **Experimentation**: The primary objective is for increasing knowledge of predators in Nevada. NDOW may collaborate with other wildlife professionals to study and learn about predators of Nevada. Expected outcomes will include agency reports, peer-reviewed publications, and information on how to better manage Nevada's predators.

LEVELS OF MONITORING

Below are the three levels of monitoring outlined in the predator management plan. The level of monitoring for each project is identified within the project description.

1. **Standard Monitoring**: The primary objective of standard monitoring is to use existing survey protocols to evaluate the response of game species or sensitive wildlife to lethal or non-lethal management of predators. NDOW conducts annual and biannual surveys to evaluate trend and composition of game species or sensitive wildlife and to inform the season and quota-setting process. Composition surveys will yield response variables such as recruitment of juveniles into the adult population and will be compared to published benchmarks of productivity in the management area of interest, to neighboring areas not receiving predator management, or in the same area before treatment began. Standard monitoring represents no change to existing monitoring efforts. Expected outcomes include an indication of project effectiveness and agency reports.
2. **Intermediate Monitoring**: The primary objective of intermediate monitoring is to apply a specific monitoring plan designed to evaluate the response of game species or sensitive wildlife to lethal or non-lethal management of predators. NDOW may collaborate with other wildlife professionals to identify reference and treatment areas or evaluate productivity of game species or sensitive wildlife before, during, and after implementation to determine effectiveness of predator management. Composition surveys may be modified to thoroughly evaluate productivity in the reference and treatment areas and to better accommodate annual variation in survey conditions. Expected outcomes will include an indication of project effectiveness, agency reports, and possible peer-reviewed publications.
3. **Rigorous Monitoring**: The primary objective of rigorous monitoring is to evaluate several response variables known to affect productivity of game species or sensitive wildlife and to determine the relative influence of those variables when measuring the response to lethal or non-lethal management of predators. NDOW may collaborate with other wildlife professionals to identify the requirements of rigorous monitoring and to further evaluate factors influencing productivity of game species or sensitive wildlife such as survival of juveniles, body condition of adults, or habitat productivity. Rigorous monitoring efforts will help to disentangle biotic and abiotic conditions that may influence productivity of game species or sensitive wildlife from the effects of lethal or non-lethal management of predators. Expected outcomes will include agency reports, peer-reviewed publications, and information on how to better manage Nevada's wildlife.

FY 2020 PROJECTS RECOMMENDED FOR CONTINUATION

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

Justification	This project proposes to lethally remove common ravens from known Greater Sage-grouse habitat, common raven predation on Greater Sage-grouse nests and broods can limit population growth. Common ravens will be removed around known Greater Sage-grouse leks because most nest sites are located within 4 km of a lek. Common ravens will be removed in areas of known greater abundance to benefit sensitive populations of Greater Sage-grouse.
Project Manager	Pat Jackson, Nevada Department of Wildlife
Project Type	Implementation
Monitoring Level	Standard to intermediate
Potentially Affected Species	Common raven, Greater Sage-grouse
Span More Than One Fiscal Year	Yes
Project Area	Elko, Eureka, Humboldt, Lander, Lincoln, Lyon, Washoe, and White Pine counties.
Limiting Factor Statement	Though predation is a naturally occurring phenomenon for Greater Sage-grouse, their populations can be suppressed by abiotic factors such as dry climate and loss of quality habitat. Increases in predator numbers can also cause decreases in Greater Sage-grouse populations; common raven abundance has increased throughout their native ranges, with increases as much as 1,500% in some areas (Boarman 1993, Coates et al. 2007, 2014, Sauer et al. 2011, O'Neil et al. 2018). Under these circumstances, common raven predation can have a negative influence of Greater Sage-grouse nesting success, recruitment, and population trend (Coates and Delehanty 2010).
Response Variable	Common raven point counts may be conducted before, during, and after removal to detect changes in common raven densities.

Project Goals	1. Reduce common raven populations in high abundance areas that overlap sensitive Greater Sage-grouse populations identified by NDOW and USDA Wildlife Services wildlife biologists. 2. Increase populations of Greater Sage-grouse in specific areas where deemed feasible.
Habitat Conditions	Areas of common raven removal will be within or in close proximity to Greater Sage-grouse leks, nesting habitat, and brood-rearing habitat. Persistent drought throughout Nevada has reduced herbaceous cover, along with nesting and brood rearing habitat; these effects are exacerbated by wildfire and the invasion of cheatgrass. Transmission lines, substations, and nearby agriculture production often attract common ravens which may threaten nearby Greater Sage-grouse populations.
Comments from FY 2018 Predator Report	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.
Methods	*Lethal Removal* Chicken eggs treated with corvicide (DRC-1339) will be deployed to remove common ravens (Coates et al. 2007). To reduce non-target species exposure, no eggs will be left in the environment for over 168 hours. No leftover eggs will be used on subsequent treatments. All remaining eggs and any dead common ravens found will be collected and disposed of properly as per DRC-1339 protocol. DRC-1339 is effective only on corvids and most mammals and other birds are not susceptible to the specific effects from this agent. *Monitoring* Point counts for common ravens will be conducted from March through July of each year, which corresponds with Greater Sage-grouse nesting and brood-rearing season. Surveys will be similar to Ralph et al. (1995): lasting 10 minutes; conducted between sunrise and 1400 hrs; conducted under favorable weather conditions; and stratified randomly across study areas (Luginbuhl et al. 2001, Coates et al. 2014).
Anticipated Result	The removal of common ravens is intended to result in long-term protection for Greater Sage-grouse populations through increases in nest success, brood survival, and recruitment. This project will continue until evidence demonstrating Greater sage-grouse nest success and recruitment are not limiting population growth due to common raven predation or common raven populations are in decline from non-lethal measures. The Department anticipates a change in the USFWS raven depredation permit in the upcoming years.

Staff Comment	Project 21 will become progressively more precise with deliverables from Project 41. It is the Department's desire to ultimately use Project 21 to create temporary voids of ravens for Greater sage-grouse during sensitive times and to reverse the common raven population growth curve.
Project Direction	Fund Project 21. Evaluate efficacy of Project 21 annually.

Budget

$3 Predator Fee	Pittman-Robertson	Total
$175,000	N/A	$175,000

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

Justification	Common ravens are a leading nest and brood predator for Greater Sage-grouse and reducing common raven abundance can influence Greater Sage-grouse nest success and brood survival (Coates and Delehanty 2010). This project will lethally remove common ravens in habitats surrounding known Greater Sage-grouse leks and nesting habitats to enhance nesting success and brood survival.
Project Manager	Pat Jackson, Nevada Department of Wildlife
Project Type	Implementation and Experimental Management
Monitoring Level	Intermediate
Potentially Affected Species	Common raven, Greater Sage-grouse
Span More Than One Fiscal Year	Yes, depending on outcomes associated with Greater Sage-grouse response. The scope and location of this project may be modified in future years.
Project Area	Unit 02
Limiting Factor Statement	Though predation is a naturally occurring phenomenon for Greater Sage-grouse, their populations can be suppressed by abiotic factors such as dry climate and loss of quality habitat. Increases in predator numbers can also cause decreases in Greater Sage-grouse populations; common raven abundance has increased throughout their native ranges, with increases as much as 1,500% in some areas (Boarman 1993, Coates et al. 2007, 2014, Sauer et al. 2011, O'Neil et al. 2018). Under these circumstances, common raven predation can have a negative influence of Greater Sage-grouse nesting success, recruitment, and population trend (Coates and Delehanty 2010).
Response Variable	The response variables will be nest success and brood survival of Greater Sage-grouse within treated areas before and after treatment. This monitoring will not be paid for with $3 predator fees.
Project Goal	1. Increase populations of Greater Sage-grouse through improved nest success and brood survival in treated areas. 2. Determine common raven removal effort needed to reduce raven densities to a level they are not detrimental to Greater Sage-grouse nest success.

Habitat Conditions	Areas of common raven removal will be within or in close proximity to Greater Sage-grouse leks, nesting habitat, and brood-rearing habitat. Persistent drought throughout Nevada has reduced herbaceous cover, along with nesting and brood rearing habitat; these effects are exacerbated by wildfire and the invasion of cheatgrass. Transmission lines, substations, and nearby agriculture production often attract common ravens which may threaten nearby Greater Sage-grouse populations.
Comments from FY 2018 Predator Report	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.
Methods	*Lethal Removal* Chicken eggs treated with avicide (DRC-1339) will be deployed to remove common ravens (Coates et al. 2007). To reduce non-target species exposure, no eggs will be left in the environment for over 168 hours. No leftover eggs will be used on subsequent treatments. All remaining eggs and any dead common ravens found will be collected and disposed of properly as per avicide protocol. DRC-1339 is effective only on corvids and most mammals and other birds are not susceptible to the specific effects from this agent.
Anticipated Result	The removal of common ravens is intended to result in long-term protection for Greater Sage-grouse populations through increases in nest success, brood survival, and recruitment.
Staff Comment	Project inception focused on lethal raven removal and its effects on Greater sage-grouse nesting success. Due to unforeseen large-scale fires, the analysis for this project has been confounded.
Project Direction	Fund project 21-02 through FY 2020.

Budget

$3 Predator Fee	**Pittman-Robertson**	**Total**
$25,000	N/A	$25,000

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

Justification	California bighorn sheep populations have been reintroduced in northwestern Nevada; mountain lion predation can be a significant source of mortality that may threaten this population's viability. Area 01 is in close proximity to the Sheldon National Wildlife Refuge, California, and Oregon; all three may act as a source for mountain lions. Mountain lions will be removed proactively by USDA Wildlife Services and private contractors until the local bighorn sheep population reaches the population objective.
Project Manager	Chris Hampson, Nevada Department of Wildlife
Project Type	Implementation
Monitoring Level	Standard to intermediate
Potentially Affected Species	California bighorn sheep, mountain lion, mule deer
Span More Than One Fiscal Year	Yes
Project Area	Units 011 and 013
Limiting Factor Statement	Mountain lions are known predators of bighorn sheep (Rominger et al. 2004). Though predation is a naturally occurring phenomenon for bighorn sheep and other big game, their populations can be lowed or suppressed by abiotic factors such as dry climate and loss of quality habitat. Mitigating abiotic factors by removing predators is imperative for some bighorn sheep populations to stabilize (Rominger 2007).
Response Variable	The response variable will be the number of radio marked bighorn sheep killed by mountain lions.
Project Goal	Remove mountain lions to proactively protect reintroduced California bighorn sheep.
Habitat Conditions	Persistent drought combined with fires and human disturbances throughout Nevada have reduced herbaceous cover, lambing, and browsing habitat. These effects may also be suppressing bighorn populations below carrying capacity or preventing them from reaching self-sustaining levels. Currently, several collaborations between the Bureau of Land Management and NDOW to remove pinyon-juniper are scheduled. These removals are intended to improve bighorn

	sheep habitat, improve access to water sources, and to remove habitat that is ideal for mountain lions to focus on bighorn sheep.
Comments from FY 2018 Predator Report	NDOW supports continuing Project 22-01 until the local bighorn sheep populations reach viability as defined in the annual Predator Plan.
Methods	NDOW biologists, USDA Wildlife Services, and private contractors will collaborate to identify current and future California bighorn sheep locations and determine the best methods to reduce California bighorn sheep mortality. Traps, snares, baits, call boxes, and hounds will be used to proactively capture mountain lions as they immigrate into the defined sensitive areas.
Population Estimate	The population estimate for California Bighorn sheep is 35-40 individuals for area 011 and 45 individuals in area 013
Anticipated Result	Decrease or prevent predation from mountain lions for all age classes of reintroduced California bighorn sheep, resulting in an established, viable population.
Staff Comment	Proactive mountain lion removal to assist struggling bighorn sheep populations is well documented within the scientific literature.
Project Direction	Fund project 22-01. Monitor population. Cease proactive removal efforts after the local bighorn sheep population reaches 60 in each area (011 and 013; table 1).

Table 1. Population numbers to be used to redirect focus of project.

Action	Bighorn Sheep Population
Monitor bighorn population, conduct removal on case by case basis	> 80
Remove mountain lions that consume bighorn sheep*	60 - 80
Remove all mountain lions in area	< 60

*Indicates need for monitoring local mountain lion population.

Budget

$3 Predator Fee	Pittman-Robertson	Total
$90,000	N/A	$90,000

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

Justification	Rocky Mountain bighorn sheep populations have been established in portions of Nevada, but mountain lion predation can be a significant source for mortality that may threaten the population's viability. One collared bighorn sheep has been killed by mountain lions in the past year. The area biologists believe that mountain lion predation is not currently limiting the small bighorn sheep population, but even a small amount of predation has the potential to affect its viability.
Project Manager	Kari Huebner and Tyler Nall, Nevada Department of Wildlife
Project Type	Implementation
Monitoring Level	Standard to intermediate
Potentially Affected Species	Rocky Mountain bighorn sheep, mountain lion
Span More Than One Fiscal Year	Yes
Project Area	Unit 074
Limiting Factor Statement	Mountain lions are known predators of bighorn sheep (Rominger et al. 2004). Though predation is a naturally occurring phenomenon for bighorn sheep and other big game, their populations can be lowed or suppressed by abiotic factors such as dry climate and loss of quality habitat. Mitigating abiotic factors by removing predators is imperative for some bighorn sheep populations to stabilize (Rominger 2007).
Response Variable	The response variable will be the number of radio marked bighorn sheep killed by mountain lions.
Project Goal	Bighorn sheep populations will be monitored on a continual basis and predator control will be implemented as deemed necessary at the discretion of the Area Biologist.
Habitat Conditions	Persistent drought combined with fires and human disturbances throughout Nevada have reduced herbaceous cover, lambing, and browsing habitat. These effects may also be suppressing bighorn populations below carrying capacity or preventing them from reaching self-sustaining levels.

Comments from FY 2018 Predator Report	NDOW supports continuing Project 22-074 until the local bighorn sheep reaches population viability as defined in the annual Predator Plan.
Methods	NDOW biologists will identify current and future Rocky Mountain bighorn sheep locations and determine the best methods to monitor this population. Additional GPS collars will be purchased and deployed to monitor the bighorn sheep population. If mountain lion predation is identified as an issue, then traps, snares, baits, call boxes, and hounds will be used to lethally remove mountain lions from the area.
Population Estimate	The population estimate for Rocky Mountain Bighorn sheep is approximately 25-30 individuals in area 074.
Anticipated Results	1. Monitor the population of Rocky Mountain bighorn sheep. 2. If mountain lion predation is identified as an issue, conduct lethal removal.
Staff Comment	Proactive mountain lion removal to assist struggling bighorn sheep populations is well documented within the scientific literature. This project has evolved from a proactive lethal removal project to a monitoring project.
Project Direction	Fund project 22-074. Monitor population. Begin mountain lion removal efforts if mountain lion predation is detected (table 2). Evaluate efficacy of project 22-074 annually. The Department will allocate project 22-074 funds to project 37 if they are not spent by 1 March 2020.

Table 2. Population numbers to be used to redirect focus of project.

Action	Bighorn Sheep Population
Monitor bighorn population, conduct removal on case by case basis	> 15
Remove mountain lions that consume bighorn sheep*	10 - 15
Remove all mountain lions in area	< 10

*Indicates need for monitoring local mountain lion population.

Budget

$3 Predator Fee	Pittman-Robertson	Total
$20,000	N/A	$20,000

Project 37: Big Game Protection-Mountain Lions

Justification	Predation issues frequently arise in a very short timeframe. These issues often occur within a fiscal year. By the time a project can be drafted, approved, and implemented, it may be too late to prevent or mitigate the predation issue. Removing mountain lions that prey on sensitive game populations quickly is a required tool to manage big game populations statewide.
Project Manager	Pat Jackson, Nevada Department of Wildlife
Project Type	Implementation
Monitoring Level	Standard
Potentially Affected Species	Mountain lion, mule deer, bighorn sheep, antelope
Span More Than One Fiscal Year	Yes
Project Area	Statewide
Limiting Factor Statement	Mountain lions are known predators of bighorn sheep and other big game species (Rominger et al. 2004). Though predation is a naturally occurring phenomenon for bighorn sheep and other big game, their populations can be lowered or suppressed by abiotic factors such as dry climate and loss of quality habitat. Mitigating abiotic factors by removing predators is imperative for some bighorn sheep populations to stabilize (Rominger 2007).
Response Variable	Response variables may include reduction of prey taken by mountain lions, removal of a mountain lion that was documented consuming the concerned big game species, or a reduction in mountain lion sign. Because of the quick nature of the project, there may be times when no response variable will be measured.
Project Goal	Remove specific, problematic mountain lions to benefit game species.
Habitat Conditions	Persistent drought combined with fires and human disturbances throughout Nevada have reduced herbaceous cover, lambing, and browsing habitat. These effects may have reduced mule deer and other big game populations below carrying capacity. These effects may also be suppressing mule deer or big game populations below carrying capacity (Ballard et al. 2001).
Comments from FY 2018 Predator Report	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.
Methods	NDOW will specify locations of mountain lions that may be influencing local declines of sensitive game populations. Locations will be determined with GPS

	collar points, trail cameras, and discovered mountain lion kill sites. Removal efforts will be implemented when indices levels are reached, these include low annual adult survival rates, poor fall young:female ratios, spring young:female ratios, and low adult female annual survival rates (table 3). Depending on the indices identified, standard to intermediate levels of monitoring will be implemented to determine the need for or effect of predator removal. These additional monitoring efforts may be conducted by NDOW employees, USDA Wildlife Services, or private contractors. Staff and biologists will identify species of interest, species to be removed, measures and metrics, and metric thresholds. This information will be recorded on the Local Predator Removal Progress Form (see appendix), and included in the annual predator report.
Anticipated Results	1. Lethal removal of individual, problematic mountain lions will provide a precise tool, protecting reintroduced and sensitive big game populations. 2. Implementation will occur in association with game populations that are sensitive (e.g., small in size, limited in distribution, in decline) and may benefit from rapid intervention from specific predation scenarios.
Staff Comment	Proactive mountain lion removal to assist struggling bighorn sheep populations is well documented within the scientific literature.
Project Direction	Fund Project 37.

Table 3. Indices used to initiate predator removal.

Species	Annual Adult Survival Rates	Fall Young: Female Ratios	Spring Young: Female Ratios	Adult Female Annual Survival Rates
California Bighorn Sheep	< 90%	< 40:100	--	--
Rocky Mountain Bighorn Sheep	< 90%	< 40:100	--	--
Desert Bighorn Sheep	< 90%	< 30:100	--	--
Mule Deer	--	--	< 35:100	< 80%
Pronghorn	< 90%	< 40:100	--	--

Budget

$3 Predator Fee	Pittman-Robertson	Total
$75,000	N/A	$75,000

Project 38: Big Game Protection-Coyotes

Justification	Predation issues frequently arise in a very short timeframe. These occurrences often occur within a fiscal year, therefore by the time a project can be drafted, approved, and implemented, to prevent or mitigate the predation issue, it may be too late. Removing problematic coyotes quickly is a required tool to manage big game populations statewide.
Project Manager	Pat Jackson, Nevada Department of Wildlife
Project Type	Implementation
Monitoring Level	Standard
Potentially Affected Species	Coyote, mule deer, antelope, Greater Sage-grouse
Span More Than One Fiscal Year	Yes
Project Area	Statewide
Limiting Factor Statement	Though predation is a naturally occurring phenomenon for mule deer and other big game, their populations can be lowered or suppressed by abiotic factors such as dry climate and loss of quality habitat Predation from coyotes may further suppress these populations (Ballard et al. 2001).
Response Variable	Response variables may include reduction of prey taken by coyotes, removal of a coyote that was documented consuming the concerned big game species, or a reduction in coyote sign. Because of the quick nature of the project, there may be times when no response variable will be measured.
Project Goal	Conduct focused coyote removal to protect game species.
Habitat Conditions	Persistent drought combined with fires and human disturbances throughout Nevada have reduced herbaceous cover, lambing, and browsing habitat. These effects may have reduced mule deer and other big game populations below carrying capacity. These effects may also be suppressing mule deer or big game populations below carrying capacity (Ballard et al. 2001).
Comments from FY 2018 Predator Report	NDOW supports continuing Project 38 pending available funding.
Methods	USDA Wildlife Services and private contractors, working under direction of NDOW, will use foothold traps, snares, fixed-wing aircraft and helicopters for

	aerial gunning, calling and gunning from the ground to remove coyotes in sensitive areas during certain times of the year. Work will be implemented when indices levels are reached, these include low annual adult survival rates, poor fall young:female ratios, poor spring young:female ratios, and low adult female annual survival rates (table 3). Depending on the indices identified, standard to intermediate levels of monitoring will be implemented to determine the need for or effect of predator removal. These additional monitoring efforts may be conducted by NDOW employees, USDA Wildlife Services, or private contractors.
Anticipated Results	1. Removal of coyotes in winter range and fawning and lambing areas in certain situations will provide a valuable tool for managers. 2. Implementation will occur during times and locations where sensitive game species are adversely affected (e.g., local decline, reduced recruitment) based on the best available biological information.
Staff Comment	Proactive coyote removal to assist struggling pronghorn populations is well documented within the scientific literature.
Project Direction	Fund Project 38.

Table 3. Indices used to initiate predator removal.

Species	**Annual Adult Survival Rates**	**Fall Young: Female Ratios**	**Spring Young: Female Ratios**	**Adult Female Annual Survival Rates**
California Bighorn Sheep	< 90%	< 40:100	--	--
Rocky Mountain Bighorn Sheep	< 90%	< 40:100	--	--
Desert Bighorn Sheep	< 90%	< 30:100	--	--
Mule Deer	--	--	< 35:100	< 80%
Pronghorn	< 90%	< 40:100	--	--

Budget

$3 Predator Fee	**Pittman-Robertson**	**Total**
$75,000	N/A	$75,000

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

Justification	Continuing predator removal will complement previous coyote removal, feral horse removal, and habitat restoration to benefit mule deer populations.
Project Manager	Clint Garrett, Nevada Department of Wildlife
Project Type	Implementation
Monitoring Level	Standard to intermediate
Potentially Affected Species	Coyote, Greater Sage-grouse, mule deer
Span More Than One Fiscal Year	Yes
Project Area	Units 141-144
Limiting Factor Statement	Though predation is a naturally occurring phenomenon for mule deer and other big game, their populations can be reduced or suppressed by abiotic factors such as dry climate and loss of quality habitat, these populations can be suppressed by predation from coyotes (Ballard et al. 2001).
Response Variable	The response variable will be the fawn to doe ratios in the Diamond Mountains. This ratio will be observed throughout the life of the project. The project will be altered or discontinued after three consecutive years of observed spring fawn:adult ratios averaging 50:100 or higher. Historical adult:fawn ratios have declined since 1976 (figure 1).
Project Goal	To increase mule deer and Greater Sage-grouse populations by removing coyotes and mountain lions.
Habitat Conditions	Persistent drought combined with fires and human disturbances throughout Nevada have reduced herbaceous cover, fawning, and browsing habitat. These effects may have reduced mule deer below carrying capacity. These effects may also be suppressing mule deer below carrying capacity (Ballard et al. 2001).
Comments from FY 2018 Predator Report	NDOW supports continuing Project 40 until mule deer populations reach levels defined in the annual Predator Plan.
Methods	USDA Wildlife Services and private contractors working under direction of NDOW and Eureka County, will use foothold traps, snares, fixed-wing aircraft and helicopters for aerial gunning, and calling and gunning from the ground to remove coyotes in sensitive areas during certain times of the year.
Anticipated Result	Coyote removal will complement feral horse removal already conducted by the BLM, habitat improvement conducted by Eureka County, private coyote

	removal funded by Eureka County, and Wildlife Service coyote removal funded through Wildlife Heritage funds in 2011 and 2012.
Staff Comment	The Department supports multi-faceted management projects such as Project 40.
Project Direction	Fund Project 40. Evaluate efficacy of Project 40 annually.

Budget

$3 Predator Fee	**Pittman-Robertson**	**Total**
$100,000	N/A	$100,000

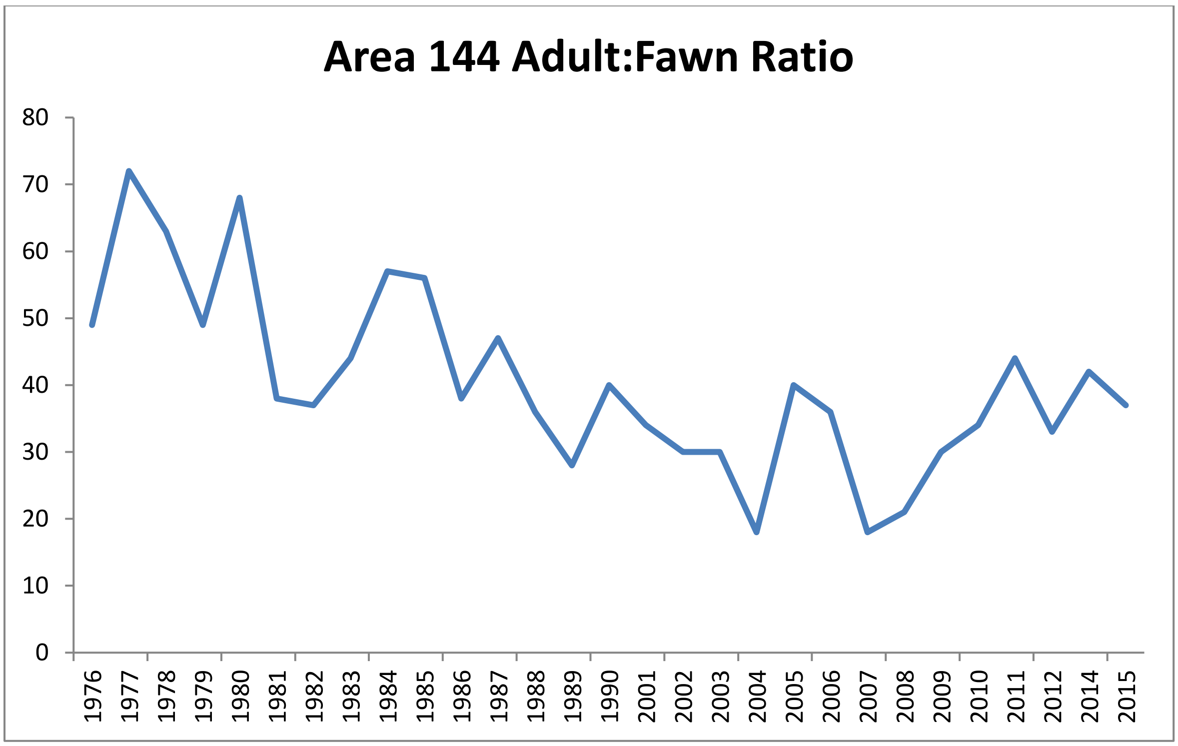

Figure 1. Adult to fawn ratios gathered on spring helicopter surveys for area 144 since 1976.

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

Justification	Common ravens are the primary predator of Greater Sage-grouse nests and chicks (Coates and Delehanty 2010). Their populations have increased dramatically in Nevada, primarily due to human subsidies (Boarman 1993, Sauer et al. 2011). Understanding common raven density, distribution, and subsidy use will allow for intelligent management decisions to be made to reduce or alter common raven densities in Nevada. These efforts are intended to benefit Greater Sage-grouse, though desert tortoise may also benefit from this project.
Project Manager	Pat Jackson, Nevada Department of Wildlife
Project Type	Experimentation
Monitoring Level	Rigorous
Potentially Affected Species	Greater Sage-grouse, common raven, desert tortoise
Span More Than One Fiscal Year	Yes
Project Area	Statewide
Limiting Factor Statement	Though predation is a naturally occurring phenomenon for Greater Sage-grouse, their populations can be suppressed by abiotic factors such as dry climate and loss of quality habitat. Increases in predator numbers can also cause decreases in Greater Sage-grouse populations; common raven abundance has increased throughout their native ranges, with increases as much as 1,500% in some areas (Boarman 1993, Coates et al. 2007, Sauer et al. 2011). Under these circumstances, common raven predation can have a negative influence of Greater Sage-grouse nesting success, recruitment, and population trend (Coates and Delehanty 2010). Common raven predation has also been documented to negatively impact desert tortoise populations (Boarman 1993, Kristan and Boarman 2003)
Response Variable	No response variable will be collected, this is an experimentation project.
Project Goals	1. Increase understanding of common raven density, distribution, and subsidy use to maximize common raven management effectiveness. 2. Develop a protocol to estimate common raven populations in Greater Sage-grouse habitat, and monitor these populations. 3. Increase the understanding of how human subsidies affect common raven movements and space use, particularly near Greater Sage-grouse leks and nesting areas. 4. Develop a resource selection function model to identify landscape features that influence common raven abundance and that may be used in conjunction with Greater Sage-grouse priority habitat maps to locate sites where lethal

	treatments of common ravens may be applied with the greatest efficacy and efficiency.
Habitat Conditions	Persistent drought throughout Nevada has reduced herbaceous cover, along with nesting and brood rearing habitat; these impacts are exacerbated through wildfire and the invasion of cheatgrass. Transmission lines, substations, and nearby agriculture production also threaten Greater Sage-grouse habitat.
Comments from FY 2018 Predator Report	NDOW supports continuing Project 41.
Methods	*Population monitoring and space use* Point counts for common ravens will be conducted from March through July of each year, which corresponds with Greater Sage-grouse nesting and brood-rearing season. Surveys will be similar to Ralph et al. (1995): lasting 10 minutes; conducted between sunrise and 1400; conducted under favorable weather conditions; and stratified randomly across study areas (Luginbuhl et al. 2001, Coates et al. 2014). ARGOS backpack transmitters will be deployed to monitor common raven space use and space use. *Development of Resource Selection Function (RSF)* An RSF will be developed using data on landscape features collected in habitats with varying observed abundance indices for common ravens. The abundance indices collected will include common raven point count and Greater Sage-grouse point counts. The landscape features that will be entered into the model will include 1 meter resolution digital elevation models and fire regime. The RSF for common ravens will be overlaid on polygons that feature Greater Sage-grouse priority habitats. Identifying habitats likely to support high numbers of common ravens where Greater Sage-grouse conservation is of highest priority will provide future locations where common raven removal may be warranted, land use activities may be modified, or more intensive Greater Sage-grouse monitoring may be focused. *Utility line surveys* Various utility lines will be identified in and near Greater Sage-grouse habitat from February until June of each year, which corresponds with common raven nesting and brood rearing. Surveys will be conducted from OHV vehicles, variables including utility pole type, cross arm type, utility pole height, insulator position, perch deterrent effectiveness, and proximity to Greater Sage-grouse habitat will be recorded.

Anticipated Results	1. Develop a protocol to estimate common raven populations in Greater Sage-grouse habitat, and monitor these populations. 2. Increase the understanding of common raven density and distribution in the state of Nevada, and how human subsidies increase common raven density and distribution. 3. Determine what common raven removal location will provide the greatest benefit to Greater Sage-grouse. Determine what time of the year is the optimal time to conduct common raven removal to optimize benefit to Greater Sage-grouse.
Staff Comment	Project 41 has resulted in the largest GPS location dataset for common ravens in history. It has also resulted in several peer-reviewed publications including: 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. Coates et al. (*Submitted to Condor: Ornithological Applications*) Estimating Common Raven densities in a semi-arid ecosystem: implications for conservation of sage-grouse and other sensitive prey species. 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. 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. 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.

	Coates et al. *In review.* Annual Data Series Reports. Example: Greater Sage-Grouse (Centrocercus urophasianus) Monitoring at the McGinness study area, California, 2012–18. Data Series XXXX. U.S. Geological Survey, U.S. Department of the Interior. This project will develop a statewide population estimate for ravens, common raven growth rate, a common raven density map, detailed analysis of common raven movement and space use, and information necessary to increase the USFWS depredation permit.
Project Direction	Fund Project 41. Evaluate efficacy of Project 41 annually.

Budget

$3 Predator Fee	**Pittman-Robertson**	**Total**
$87,500	$262,500	$300,000

Project 42: Assessing Mountain Lion Harvest in Nevada

Justification	Nevada Department of Wildlife has a yearlong mountain lion hunting season limited by harvest quotas, although mountain lion are also lethally removal for livestock depredation and to limit predation on specific wildlife populations. Statewide annual adult female harvest is ≤35%, which indicates that statewide harvests are unlikely to be reducing statewide mountain lion population abundance (Anderson and Lindzey 2005). Nevertheless, regional area harvests may be greater and can be more difficult to assess the effects due to small sample sizes. Conversely, current NDOW mountain lion removal projects may not be sufficiently intensive to reduce local mountain lion populations to attain reduced predation on prey populations. Improved understanding of mountain lion population dynamics in Nevada would allow for better informed management.
Project Manager	Pat Jackson, Nevada Department of Wildlife
Project Type	Experimentation
Monitoring Level	Rigorous
Potentially Affected Species	Mountain lion, mule deer, bighorn sheep, elk
Span More Than One Fiscal Year	Yes
Project Area	Statewide
Limiting Factor Statement	Habitat and prey availability likely limit mountain lion populations in the state of Nevada.
Response Variable	No response variable will be collected, this is an experimentation project.
Project Goals	1. Develop a population model that incorporates NDOW mountain lion harvest data to predict the number of mountain lions that must be removed to reach desired goals in mountain lion removal projects. 2. Identify limitations and gaps in the existing demographic data for mountain lions that precludes a more complete understanding of mountain lion population dynamics and limits NDOW's management ability with the greatest efficacy and efficiency.
Habitat Conditions	This work would not be conducted in the field, but would rely on statewide harvest data collected over time to include periods of normal and less-than-normal precipitation. Due to the span of the state data collection, habitat during the period of inference would also span a wide variety of conditions and vegetative communities.

Comments from FY 2018 Predator Report	None
Methods	A private contractor will use existing mountain lion harvest data collected by NDOW biologists to develop a harvest model. The modeling approach will involve Integrated Population Modeling (IPM) which brings together different sources of data to model wildlife population dynamics (Abadi et al. 2010, Fieberg et al. 2010). With IPM, generally a joint analysis is conducted in which population abundance is estimated from survey or other count data, and demographic parameters are estimated from data from marked individuals (Chandler and Clark 2014). Age-at-harvest data can be used in combination with other data, such as telemetry, mark-recapture, food availability, and home range size to allow for improved modeling of abundance and population dynamics relative to using harvest data alone (Fieberg et al. 2010). Depending on available data, the contractor will build a count-based or structured demographic model (Morris and Doak 2002) for mountain lions in Nevada. The model (s) will provide estimates of population growth, age and sex structure, and population abundance relative to different levels of harvest.
Anticipated Results	1. Estimate statewide population dynamics, age structure, and sex structure of mountain lions in the state of Nevada with existing NDOW data. 2. Recommend additional data that could be collected to improve the model and reduce uncertainty in model results in the future.
Staff Comment	Building an Integrated Population Model for mountain lions will allow the Department to manage mountain lions on a finer scale.
Project Direction	Fund Project 42 through FY 2020.

$3 Predator Fee	**Pittman-Robertson**	**Total**
$2,500	$7,500	$10,000

Project 43: Mesopredator removal to protect waterfowl, turkeys, and pheasants on Wildlife Management Areas

Justification	Mesopredators including coyotes, striped skunks, and raccoons often consume waterfowl, pheasant, and turkey eggs. Consuming these eggs may limit fowl species population growth, and could be causing a declines on Overton and Mason Valley Wildlife Management Areas.
Project Manager	Isaac Metcalf and Bennie Vann, Nevada Department of Wildlife
Project Type	Implementation
Monitoring Level	Standard
Potentially Affected Species	Assorted waterfowl, turkey, pheasant, coyote, striped skunk, raccoon
Span More Than One Fiscal Year	Yes
Project Area	Overton and Mason Valley Wildlife Management Areas
Limiting Factor Statement	Though predation is a naturally occurring phenomenon for waterfowl, turkeys, and pheasants, their populations can be lowed or suppressed by abiotic factors such as dry climate and loss of quality habitat.
Response Variable	The response variable for waterfowl, turkeys, and pheasants will be the number of females with clutches, and the number of young per clutch.
Project Goals	To increase clutch size and survival of waterfowl, turkeys, and pheasants on Overton and Mason Valley WMAs.
Habitat Conditions	Persistent drought throughout Nevada has reduced herbaceous cover, nesting, and browsing habitat.
Comments from FY 2018 Predator Report	NDOW recommends continuing project 43 pending funding availability.
Methods	USDA Wildlife Services and private contractors working under direction of NDOW, will use foothold traps, snares, calling and gunning from the ground to

	remove coyotes, striped skunks, and raccoons during waterfowl, turkey, and pheasant nesting seasons.
Anticipated Results	1. Increase the number of female turkeys, waterfowl, and pheasants that successful raise clutches. 2. Increase the number female turkeys, waterfowl, and pheasants that have clutches. This project will be cancelled or altered once there are two consecutive three year averages where: The average hen turkey successfully raises 3 polts. Area biologists believe waterfowl no longer need predator removal. Area biologists believe pheasants no longer need predator removal.
Staff Comment	Area managers have noticed a substantial increase in waterfowl nest success and an increase in clutch size since the inception of project 43.
Project Direction	Fund Project 43 through FY 2020.

Budget

$3 Predator Fee	Pittman-Robertson	Total
$50,000	N/A	$50,000

Project 44: Lethal Removal and Monitoring of Mountain Lions in Area 24

Justification	The local desert bighorn sheep population has been underperforming in the Delamar Mountains since the initial reintroduction in 1996 (M. Cox, *personal communication*). Mountain lions may be a contributing factor to this underperformance.
Project Manager	Pat Jackson, Nevada Department of Wildlife
Project Type	Experimental Management
Monitoring Level	Intermediate
Potentially Affected Species	Mountain lion, bighorn sheep,
Span More Than One Fiscal Year	Yes
Project Area	Area 24, potentially extending into Area 22
Limiting Factor Statement	Mountain lions are known predators of bighorn sheep and other big game species (Rominger et al. 2004). Though predation is a naturally occurring phenomenon for bighorn sheep and other big game, their populations can be lowered or suppressed by abiotic factors such as dry climate and loss of quality habitat. Mitigating abiotic factors by removing predators is imperative for some bighorn sheep populations to stabilize (Rominger 2007).
Response Variable	Response variables may include reduction of prey taken by mountain lions, removal of a mountain lion that was documented consuming the concerned big game species, or a reduction in mountain lion sign. Because of the quick nature of the project, there may be times when no response variable will be measured.
Project Goals	1. Remove specific, problematic mountain lions to benefit desert bighorn sheep 2. Deploy and maintain up to 12 GPS collars on mountain lions in proximity area to increase understanding of mountain lion diet, space use, and movement.
Habitat Conditions	Persistent drought combined with fires and human disturbances throughout Nevada have reduced herbaceous cover, lambing, and browsing habitat. These effects may have reduced bighorn sheep and other big game populations below carrying capacity. These effects may also be suppressing mule deer or big game populations below carrying capacity (Ballard et al. 2001).
Comments from FY 2018 Predator Report	N/A

Methods	Mountain lions in the area of concern will be lethally removed (see map) until three consecutive years of adult annual survival for bighorn sheep exceed an average of 90% and fall female to young ratios exceed 30:100. Mountain lions in the proximity area (see map) will be captured with the use of hounds and/or foot snares. Captured mountain lions will be chemically immobilized and marked with a GPS collar. Marked mountain lions that enter the area of concern and consume bighorn sheep will be lethally removed.
Anticipated Results	1. Remove any offending mountain lion known to be consuming bighorn sheep. 2. Increase understanding of mountain lion movements, space use, and diet within the proximity area. 3. Increase local bighorn sheep adult annual survival rates and fall young:female ratios.
Staff Comment	Determining mountain lion prey selection prior to lethal removal allows the Department to make more informed decisions on which mountain lion to remove. The Delamar based lions are consuming a substantial number of feral horses. The Department will increase our understanding of the effect mountain lions can have on feral horse populations.
Project Direction	Fund Project 44

$3 Predator Fee	**Pittman-Robertson**	**Total**
$ 75,000	N/A	$ 75,000

Project 45: Passive Survey Estimate of Black Bears in Nevada

Justification	Black bears are expanding numerically and geographically, and in so doing they are recolonizing historic ranges in Nevada. It is imperative the Department be able to estimate Nevada's black bear population and monitor growth and change. Being able to do so passively will ensure the Department can reach these objectives safely and cost efficiently.
Project Manager	Pat Jackson, Nevada Department of Wildlife
Project Type	Experimentation
Monitoring Level	Rigorous
Potentially Affected Species	Black bear
Span More Than One Fiscal Year	Yes
Project Area	Units 014, 015, 021, 192, 194, 195, 196, 201, 202, 203, 204, 291
Limiting Factor Statement	Black bears have recently expanded their distribution in western Nevada to include historical bear habitat in desert mountain ranges east of the Sierra Nevada and Carson Front (Beckmann and Berger 2003, Lackey et al. 2013). Nevada black bears are an extension of a California based metapopulation (Malaney et al. 2017), monitoring this rewilding is important for proper management.
Response Variable	No response variable will be collected, this is an experimentation project.
Project Goals	1. Passively estimate the abundance of black bears in Nevada. 2. Predict the density and occupancy of black bears in Nevada. 3. Provide guidance to the Department on which passive methods should be continued for future use.
Habitat Conditions	The study area consists of mountain ranges and associated basins that are characterized by steep topography with high granite peaks and deep canyons. Mountain ranges are separated by desert basins that range from 15–64 km across (Grayson 1993). These basins are often large expanses of unsuitable habitat (e.g., large areas of sagebrush) that bears and mountain lions do not use as primary habitat.

Comments from FY 2018 Predator Report	N/A
Methods	In a collaboration with Michigan State University and University of Montana, hair snare stations and trail cameras will be deployed on a grid to determine black bear density. Existing black bear GPS data will be incorporated into models. These data will ultimately result in a population estimate. Please see the appendix for project proposal.
Anticipated Results	1. A statewide black bear population estimate. 2. An estimate of black bear occupancy, density, and abundance based on hair snares and trail cameras. 3. Guidance to the Department on which methods will be best suited for sustained population estimation.
Staff Comment	Project 45 will allow the Department to make more informed decisions on statewide black bear management, including the black bear hunt seasons and harvest limits.
Project Direction	Fund Project 45 through FY 2022.

Budget

$3 Predator Fee	**Pittman-Robertson**	**Total**
$40,000	$120,000	$160,000

Overall FY 2020 Budget

Project	Predator Fee	PR Funds	Total
Department of Agriculture Administrative Support Transfer[a]	$14,000	N/A	$14,000
Project 21: Greater Sage-Grouse Protection (Common Raven Removal)	$175,000	N/A	$175,000
Project 21-02: Common Raven Removal to Enhance Greater Sage-Grouse Nest Success	$25,000	N/A	$25,000
Project 22-01: Mountain Lion Removal to Protect California Bighorn Sheep	$90,000	N/A	$90,000
Project 22-074: Monitor Rocky Mountain Bighorn Sheep for Mountain Lion Predation	$20,000	N/A	$20,000
Project 37: Big Game Protection-Mountain Lions	$75,000	N/A	$75,000
Project 38: Big Game Protection-Coyotes	$75,000	N/A	$75,000
Project 40: Coyote and Mountain Lion Removal to Complement Multi-faceted Management in Eureka County	$100,000	N/A	$100,000
Project 41: Increasing Understanding of Common Raven Densities and Space Use in Nevada	$87,500	$262,500	$300,000
Project 42: Assessing Mountain Lion Harvest in Nevada	$2,500	$7,500	$10,000
Project 43: Mesopredator Removal to Protect Waterfowl, Turkeys, and Pheasants on Wildlife Management Areas	$50,000	N/A	$50,000
Project 44: Lethal Removal and Monitoring of Mountain Lions in Area 24	$75,000	N/A	$75,000
Project 45: Passive Survey Estimate of Black Bears in Nevada	$40,000	$120,000	$160,000
Total[b]	**$829,000**	**$390,000**	**$1,169,000**

[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 Wildlife Services (e.g., mountain lion removal to benefit wildlife).

[b] The projects that contain lethal removal as a primary aspect, making them ineligible for Federal Aid funding.

Expected Revenues and Beginning Balance of Predator Fee

	FY 2017 Actual	FY 2018 Actual	FY 2019 Estimated	FY 2020 Projected
Beginning balance	$778,844	$592,122	$412,582	$398,268
Revenues	$653,835	$677,186	$677,186	$677,186
Plan Budget	$839,500	$961,500	$691,500	$754,000
Expenditures	$840,557	$856,726	$691,500	$754,000
Ending balance	$592,122	$412,582	$398,268	$321,454

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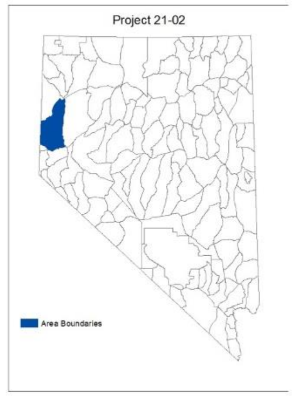
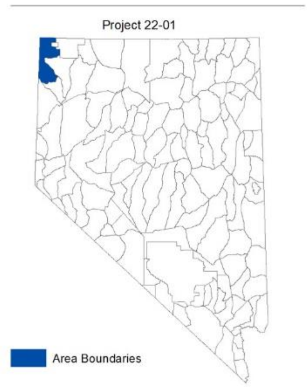
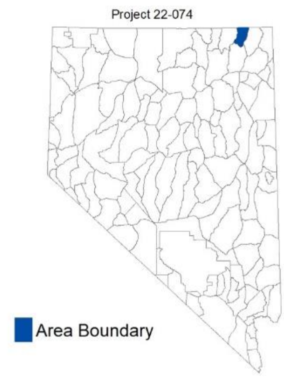
Appendix

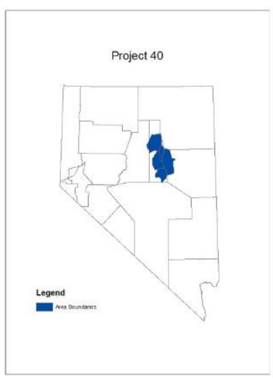
http://www.ndow.org/Nevada_Wildlife/Conservation/Nevada_Predator_Management/

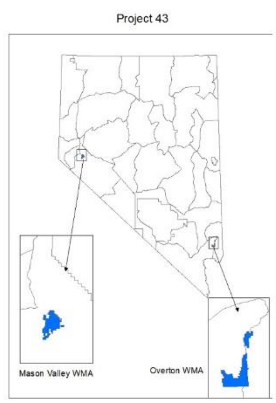

Project 21
Counties for Raven Removal

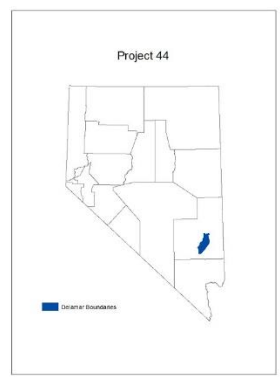

Project 21-02
Area Boundaries


Project 22-01
Area Boundaries


Project 22-074
Area Boundary


Project 40
Legend
Area Boundaries


Project 43
Mason Valley WMA
Overton WMA


Project 44
Delamar Boundaries

Predator Management Plan
Fiscal Year 2020 Appendix

Annual Predator Management Project Reporting From

Please fill out this form to the best of your ability. If you have questions please contact Predator Management Staff Specialist Pat Jackson at Pjackson@ndow.org or 775-688-1676. If necessary please use additional pages in your responses.

1. Fiscal Year Reporting:
2. Date Report Submitted:
3. Name of Contractor (include name of submitter if different):
4. Address of Contractor:
5. Phone Number of Contractor:
6. Email of Contractor:
7. Contract Number:
8. Dates of Contract:
9. Dates Worked:
10. Assessment of Habitat Conditions of Project Area (if applicable):
11. Briefly describe work conducted:
12. List number and species of predators removed.
13. Provide an overall assessment of project. In your opinion should the project continue?

State: Nevada
Organization: Nevada Department of Wildlife
Grant Opportunity: Black Bear Surveying
Contact: Pat Jackson – pjackson@ndow.org

TITLE: Using non-invasive techniques to estimate the abundance and occurrence of black bears (*Ursus americanus*) in Nevada

DETAILED STUDY DESIGN

Nevada's black bears occupy parts of the Sierra Nevada, Sweetwater, Pine Nut, Wassuk, and White mountain ranges on the western edge of the state near Lake Tahoe (Beckmann 2002). More specifically, black bears select conifer forests within these mountain ranges, while the sage-brush valley bottoms are readily traversable but not highly suited to the establishment of home ranges (Beckmann and Lackey 2004). In addition to these more rural areas, black bears will also use urban environments in western Nevada (Beckmann 2002). Black bears in these urban areas tend to be larger in body size, occur at higher densities, and generally have smaller home ranges than more rural black bears. These differences are attributable to the relative abundance of anthropogenic food sources near towns and cities (Beckmann 2002).

We have centered our sampling efforts on the current range of black bears. NDOW maintains a shapefile depicting this extent (http://gis.ndow.nv.gov/ndowdata/). Sampling schemes are typically devised with a resolution determined by some proportion to the overall home range size of the target species. Within this context, there are a variety of sampling schemes that could be implemented including array sampling, stratified random sampling, clustered sampling, or temporal sequence sampling (Sun et al. 2014). Here we have implemented a consistent grid sampling approach (i.e., regular sampling) throughout the current range of black bears. We selected this approach given that; *i*) NDOW's scope of work is to develop *"(1) a statewide population estimate on black bear with statistical confidence intervals, (2) an estimate on how densities vary throughout inhabited portions of Nevada, and (3) an optimal sampling framework that may be used to develop population estimates*," 2) the most recent sampling for black bear home range size and distribution in Nevada occurred in 2002, and 3) this effort identified highly variable home range sizes. For instance, the home range size for black bears inhabiting more rural areas was estimated to be 172.8 - 519.6 km^2 for female and male bears respectively (Beckmann 2002). The home range sizes were smaller and much more consistent in the urban areas. These ranged from 52.9 - 55.2 km^2 (Beckmann 2002).

As NDOW is interested in the application of passive survey techniques for population and distribution estimation of black bears, sampling across the range of the species distribution in the state is necessary. Thus, a grid sampling approach provides the most reliable means to precisely measure the abundance and distribution of black bears in the state. This approach is consistent with a growing appreciation among researchers and wildlife managers that unbiased sampling designs are more appropriate measures for depicting animal occurrence (Tobler and Powell 2013; Swanson et al. 2015). With a grid sampling scheme selected, the next decision was the resolution that most appropriate to assess the research objectives.

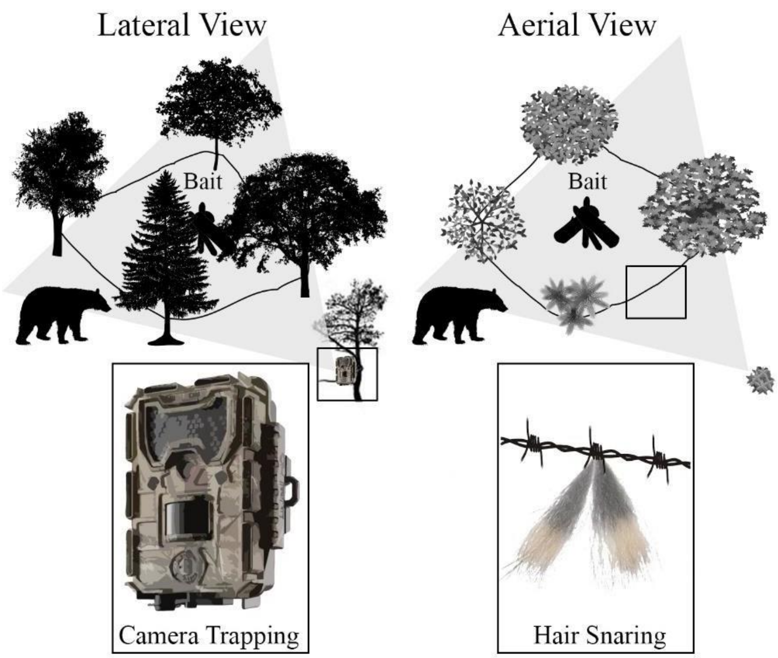
The spacing of sampling efforts is fundamental to the quantification of accurate population and distribution estimates (Sun et al. 2014). If traps are too far apart, animals of interest may only be detected at a single trap and the resultant models will not converge. If the traps do not span an adequate amount of the state space, then all animals across that range will not have a non-zero probability of detection, and density will be under estimated (Sollmann et al. 2012). Further, trap placement that is too close together can be cost-prohibitive when implemented across a species population range. There were several factors that we considered herein;

1) Resolutions for hair snaring and camera trapping of black bears in the published literature vary from 2.6 km^2 to 157.1 km^2 (see Kelly and Holub 2008; Gardner et al. 2010; Wilton et al. 2014).

2) Resolution should be, at a minimum, the size of one animal's home range (Tobler and Powell 2013) and a resolution of two traps per home range is advised (Dillon and Kelly 2007).

3) Given this evidence and the fact that home ranges for black bears in Nevada vary from 52.9 and 519.6 km^2 (Beckmann 2002), we selected a resolution of 49 km^2 or 1- 10 traps per Nevada black bear home range. The other advantage of this resolution is that it was effectively applied in another published study for black bear density (Stetz et al. 2013).

Data Collection System Our data collection system includes; 1) DNA mark-recapture estimation using SCR techniques from hair snaring of black bears and 2) density estimation and probability of occurrence mapping from concurrent camera trapping (Fig. 1). At each site we have deployed barbed wire hair snares and Bushnell Trophy Cam HD Aggressor – No Glow, Model 119776C camera-traps (Lepard et al. in review; Fig. 1). These passive, non-invasive technologies enable us to pursue our research objectives in this study.



Evaluating Objective 1 - Abundance Estimation via SCR and Hair Snaring We are in the process of collecting black bear hair samples using barbed wire snares (Woods et al. 1999; Wilton et al. 2014, 2016).

These snares consist of 16-gauge barbed wire oriented 50 cm above ground and wrapped around nearby trees forming a perimeter around the site (Fig. 1; Stetz et al. 2013). In the center of each site we are depositing an attractant including raspberry oil (Mother Murphy's Laboratories, Inc., Greensboro, NC), fish oil, anise oil (Minnesota Snareline Products, Pennock, MN), and Ultimate Bear Lure (Wildlife Research Center, Ramsey, MN; see Wilton et al. 2014). Hair snares are being checked weekly. This time period coincides with the summer season when bears are losing hair on their coats. During each visit, we check the length of the barbed wire for hair and package each individual hair sample into coin envelopes using gloved hands. The samples are then be air dried and prepared for processing.

Via genetic sequencing analysis, each bear in our study will be marked and potentially recaptured at later time periods. We will then implement SCR techniques to develop the population estimate (Efford and Fewster 2013; Royle et al. 2014). The SCR model uses the spatial correlation of recaptures of bears over a sampling grid to estimate the location of individual centers of activity of both marked and unmarked animal subjects. This approach models the spatial correlation in animal detections as a natural process (Royle et al. 2014). Within this modeling framework, the capture histories (i.e., number of times each bear was detected) are assumed to derive from a Poisson distribution;

$$y_{ijk} \sim Poisson(\lambda_{ij})$$

where y_{ijk} is the number of detections for animal *i*, at trap *j* in occasion *k* while λ_{ij} is the probability of detecting animal *i* at location *j*. The spatial pattern of detections from an individual animal is used to estimate the parameters of the chosen detection model, including the unobserved location of the animal's activity center and the scale parameter (Royle et al. 2014P. 128). The detection model quantifies an intuitive concept; that an individual is more likely to be detected at traps closer to the center of that individual's core activity. This part of the model takes the form;

$$\lambda_{ij} = \lambda_0 e^{\frac{\|\boldsymbol{x}_j - \boldsymbol{s}_i\|^2}{2\sigma^2}}$$

where λ_{ij} is the probability animal *i* is detected at trap *j*, λ_0 is the probability an animal is detected at a trap given that it occupied that area, σ is the scale parameter (i.e., how detection probability decreases with distance), x_j is the location of trap *j*, $\boldsymbol{s}_i$ is the unobserved location of the activity center of animal *i*, and $\|\boldsymbol{x}_j - \boldsymbol{s}_i\|$ is the Euclidean distance between trap *j* and unobserved activity center location *i*. The output of this technique will be an estimate, with associated confidence intervals, of the number of black bears in Nevada. Furthermore, this estimate divided by the effort across the sampling area will provide an estimate of the density (#Bears / km^2; Fig. 2).

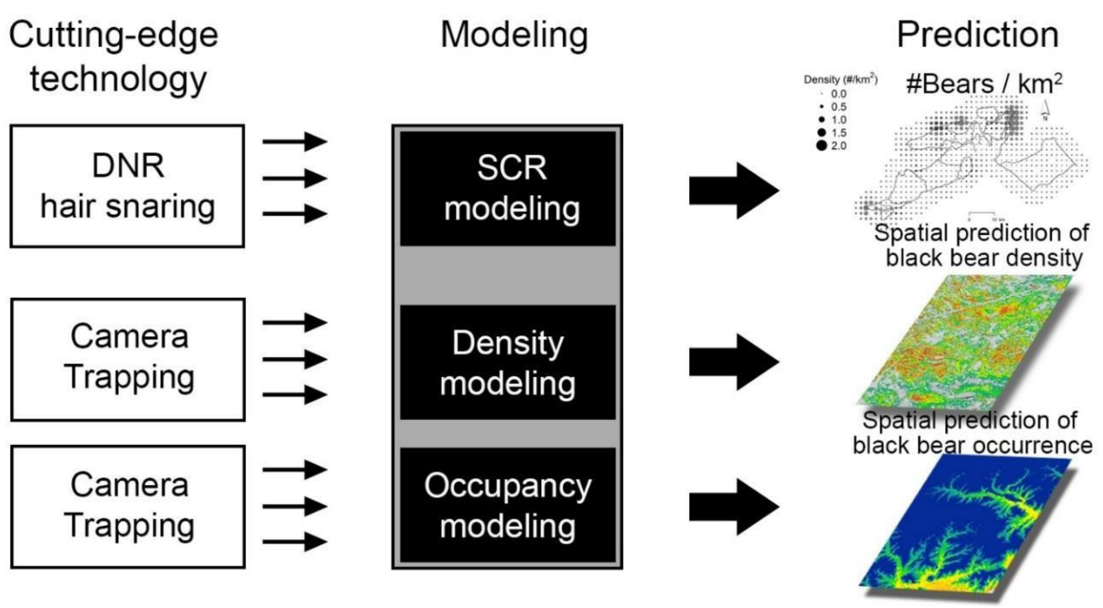


Fig. 2. The passive non-invasive technology and the modeling techniques that will be used to predict black bear abundance, density, and occurrence in the state of Nevada.

While SCR modeling is a robust technique for developing a population estimate of the number of bears with an associated confidence interval, mapping the spatial variation in density is most suited to occupancy mapping where habitat and multi-species effects can be readily incorporated (Kelly and Holub 2008; Royle et al. 2009; Tobler and Powell 2013; Swanson et al. 2015). The spatial variation in black bear density and occurrence is particularly useful information for understanding how increasing black bear abundance may lead to conflict with human communities (Lackey et al. 2004). Given NDOW's stated desire to identify "*an optimal sampling framework that may be used to develop population estimates*" we have elected to also consider the role that camera trapping may play in examining spatial variable in black bear density/occurrence and how these variation may correlate with human activity in Nevada. Camera trapping is a flexible tool which can produce maps depicting spatial variation in black bear density and occurrence (Kays and Slauson 2008; Kelly and Holub 2008; Gardner et al. 2010). These predictive maps can be developed by season and can be compared with known patterns of human activity to identify where conflict hotspots may occur even before conflict incidences are reported. Thus, camera trapping provides a useful framework for the optimization of future research efforts and the prioritization of potential mitigation work conducted by NDOW.

Evaluating Objective 2 - Density Estimation and Probability of Occurrence Mapping from Camera Trapping While mark-recapture studies are a traditional means to derive abundance estimates of wildlife, emerging techniques, such as camera trapping, demonstrate that density estimates can be calculated from unmarked individuals (Chandler et al. 2013; Denes et al.

2015; Chauvenet et al. 2017). Thus, in addition to the hair snaring, we are also mapping black bear density (Royle et al. 2009) and the probability of black bear occurrence (Kelly and Holub 2008) from camera trap data. At each site we have deployed a Bushnell Trophy Cam camera trap. As with the barbed wire, we have positioned each camera 50 cm above the ground. However, in this case, the camera is affixed to a tree outside of the hair snare site (Fig. 1). The camera traps are positioned in a northerly direction directed across the viewshed of the hair snare (Fig. 1). The northerly direction is a proven technique to decrease false triggers caused by sunrise and sunset (Kays and Slauson 2008; Newey et al. 2015). We have programmed these camera traps to take three images per trigger via these settings (LED control = high, time interval = 10 seconds, sensor level = auto, and night vision shutter = high; Lepard et al. in review). Furthermore, we have set a time interval between triggers of 5 minutes. Our previous research has shown that this time interval does not compromise detections of conspicuous species, such as black bears, but can drastically extend battery life and memory (Lepard et al. in review). We chose these settings (LED, sensor, and shutter) following a series of pilot deployments that suggested these settings simultaneously maximized the sensitivity of camera-trap detection and the clarity of wildlife photographed.

The camera trapping effort will be able to provide robust density estimates and predict the probability of black bear occurrence across seasons. This is important, given that black bear conflict with humans has been shown to exhibit seasonal variability (Baruch-Mordo et al. 2014; Obbard et al. 2014). All data will be processed (i.e., animals on the images identified) by undergraduate student employees in the PI's laboratory at Michigan State University.

Density Estimation - Encounter histories from camera traps will be analyzed using a spatial capture modeling for unmarked populations (Royle et al. 2014 p. 473). Note: we will also consider time-to-event (TTE) approaches to estimate abundance via the interpretation of unmarked animal trapping rates (see Moeller 2017). From trapping rate and encounter data (i.e, interpretation of camera trap photographs) black bears will not be individually identifiable, as they are in our hair snare encounter models. The hair snare encounter data consist of counts (y_{ijk}) of detection for specific animals (i) at a particular trap (j) on a given occasion (k). The camera encounter histories will simply be the total number of detections (n_{jk}) at a particular trap (j) on a given occasion (k). The observed encounter histories from the camera (n_{jk}) can be thought of as the sum of unobserved individual encounter histories ($\acute{y}_{ijk}$) over all detected animals, such that $n_{jk} = \sum_i \acute{y}_{ijk}$. The number of detections (n_{jk}) are then assumed to be Poisson distributed with probability Λ_j such that

$$n_{jk} \sim Poisson(\Lambda_j)$$

where ,

$$\Lambda_j = \lambda_0 \sum_i e^{\left(\frac{\|\boldsymbol{x}_j - \boldsymbol{s}_i\|^2}{2\sigma^2}\right)}$$

λ_0 is the rate at which an animal is detected at a trap given the animal encountered the trap,
$\boldsymbol{x}_j$ is the location of trap *j*,
$\boldsymbol{s}_i$ is the unobserved location of the center of activity for animal *i*,
σ is the scale parameter, relating how detection probability decreases with distance and
$\|\boldsymbol{x}_j - \boldsymbol{s}_i\|$ is the Euclidean distance between trap *j* and unobserved activity center location *i*.

Additionally, the same assumptions of the marked model are made in the unmarked model with respect to the chosen distance function and spatial distribution (see equations from previous section). Given that camera detections will be unable to distinguish between male and female bears, this model will require the additional assumption that male and female bears have equal baseline encounter rates (λ_0) and equivalent scale parameters (σ). The density estimates from the camera data will undoubtedly be less precise given the reduced amount of information (Royle et al. 2014 p. 486). Though the hair snare data and camera data will not be independent, we feel there is value in comparing these two estimates of black bear density to determine the best technique for NDOW to use to map black bear density in future.

Occupancy Estimation - To estimate detection and occupancy (hereafter synonymous with *p* and *ψ*, respectively), we will use a hierarchical Bayesian framework to fit occupancy models to detection/non-detection histories of black bears. Here, *p* refers to the probability of detecting black bears at a site during a single survey replicate (i.e., one week), given that it is occupied by that species (Mackenzie et al. 2002), and *ψ* refers to the probability that the site was used by the species during the study (Kendall and White 2009). We will bin black bear detections into one-week survey replicates using the camtrapR package (Niedballa et al. 2016). We will select one-week intervals to reflect common practice among mammalian camera-trap studies (e.g., Kilshaw et al. 2015; Moll et al. 2016) and to help ensure our models meet the closure assumption of single-season occupancy models (Kendall and White 2009).

We will include a random intercept by site to account for potential spatial autocorrelation among model residuals (Rhodes et al. 2009; Moll et al. 2016). This model will take the form:

$$\text{logit}(\psi_i) = \alpha_r + \alpha_1 {*}\text{habitat}_i \ldots + \alpha_2 {*}\text{habitat}_n,$$

where ψ_i is the occupancy probability at the *i*th camera-trap site, the intercept *α* is a normally distributed random variable whose mean and variance are hyperparameters, and a series of habitat covariates that describe each of the *i*th sites. Habitat covariates will be developed as part of a Geographic Information System (GIS) that we will develop to describe the study area. This GIS database will be built using data housed in the NDOW and Nevada state geospatial libraries.

Finally, we will develop a predictive black bear occupancy map for each season by multiplying the vector of coefficients from the occupancy model (detailed above), composed of the posterior mean of the random intercept (*μ*) and model-averaged posterior means of habitat coefficients, with values of rasters for each habitat covariate across the full extent of the black bear range in Nevada. To develop these predictions, we will use the inverse logit function (i.e., exp(**α**)/(exp(**α**) +1)) to back-transform the response variable such that it was scaled from 0 to 1 (i.e., estimated probability of occupancy, ψ) on our predictive maps.

Model Prediction, Evaluation, and Assessment In all cases, models will be implemented using appropriate software (STAN, BUGS, glmmADMB, see, e.g., Fournier et al. 2012; Skaug et al. 2015; Hooten and Hobbs 2015), or depending on the computational complexity (e.g., if spatio-temporal residual dependence structures are necessary to meet model assumptions) we will write our own software. We will conduct extensive exploratory data analysis (EDA) using R (R Core Team 2016) and thoroughly assess key model assumptions (test for multicollinearity among the predictor variables excluding those with high correlations or use a variable selection model, e.g., Bayesian lasso), assess the appropriateness of the posited error sub-models, and diagnose and treat issues e.g., via spatio-temporal random effects, departures from independent and identically distributed residuals.

The analytical frameworks will include an integrated approach for assessing model performance and comparing different models using replicated datasets. A replicated dataset refers to the dataset that the model would have predicted using the value of the model parameters estimated from the observations. Here, each replicated data point can be regarded as the “model-predicted” value for the corresponding observation. The posterior distribution for the replicated observation is precisely the posterior predictive distribution (e.g., Gelman et al. 2013; see also Banerjee et al. 2014, for spatial models specifically) but evaluated at the observed space-time coordinates. Given field observations, we will confirm if a posited model sufficiently explains data variability (i.e., whether the model is consistent with the data). This is called model adequacy and is assessed by how well the replicated data emulates the observed data. More precisely, we will use some omnibus test measure and compute a Bayesian p-value (see e.g., Gelman et al. 2013).

We will also implement statistical sensitivity analysis for the models. This is relevant because we must acknowledge the possibility of more than one reasonable model to provide an adequate fit to the dataset under investigation. In some cases, we anticipate enhancing and extending a model to address specific aspects of the data, e.g., spatial and/or temporal autocorrelation of depredation. There, we want to assess how much the posterior inferences change when other probability models are used in place of the present model. Finally, model selection techniques will be used to assess the impact of predictor variable and model choice among a set of competing models (e.g., Hooten and Hobbs 2015).

All data, code, results, and predictions will be provided to NDOW. The objective is to use the information derived from this study to optimize future efforts to map the population density and occurrence of Nevada black bears using non-invasive techniques that are robust.

PROJECT INVESTIGATORS

Dr. Montgomery (PI) is a professor of carnivore ecology in the Department of Fisheries and Wildlife at Michigan State University (MSU) the first Land Grant University (see attached Biographical Sketch below for more information). At MSU, he is the Director of the Research on the Ecology of Carnivores and their Prey (RECaP) Laboratory. The research conducted in the RECaP Laboratory is both spatially and taxonomically diverse. However, it consistently involves the application and development of techniques to map the abundance, distribution, and occurrence of large carnivores.

Dr. Millspaugh (PI) is the Boone and Crockett Professor of Wildlife Conservation at the University of Montana (see attached Biographical Sketch below for more information). His research addresses animal space use, habitat interactions, and population dynamics. Dr. Millspaugh has worked throughout the Midwest and Western states on a diversity of species and systems with a common theme of collaborative research that is applied and intended to address relevant questions to wildlife managers.

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