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Wildlife Research Reports
MAMMALS – JULY 2021

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WILDLIFE RESEARCH REPORTS

JULY 2020–JUNE 2021

MAMMALS RESEARCH PROGRAM

COLORADO PARKS AND WILDLIFE
Research Center, 317 W. Prospect, Fort Collins, CO 80526

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EXECUTIVE SUMMARY

This Wildlife Research Report represents summaries (≤5 pages each with tables and figures) of wildlife research projects conducted by the Mammals Research Section of Colorado Parks and Wildlife (CPW) during 2020 and 2021. These research efforts represent long-term projects (4–10 years) in various stages of completion addressing applied questions to benefit the management and conservation of various mammal species in Colorado. In addition to the research summaries presented in this document, more technical and detailed versions of most projects (Annual Federal Aid Reports) and related scientific publications that have thus far been completed can be accessed on the CPW website at http://cpw.state.co.us/learn/Pages/ResearchMammalsPubs.aspx or from the project principal investigators listed at the beginning of each summary.

Current research projects address various aspects of wildlife management and ecology to enhance understanding and management of wildlife responses to habitat alterations, human-wildlife interactions, and investigating improved approaches for wildlife management. The Nongame Mammal Conservation Section addresses ongoing monitoring of lynx in the San Juan mountain range and preliminary results addressing influences of forest management practices on snowshoe hare density in Colorado. The Ungulate Conservation Section includes 6 projects addressing mule deer/energy development interactions to inform future development planning, related research addressing vegetation and mule deer responses to 3 mechanical treatment methods, evaluation of moose demographic parameters that will inform future moose management in Colorado, an evaluation of factors influencing elk calf recruitment, and 2 recent studies addressing elk response to human recreation. The Support Services Section describes the CPW library services to provide internal access of CPW publications and online support for wildlife and fisheries management related publications.

In addition to the ongoing project summaries described above, Appendix A includes 12 publication abstracts (<2 page summaries) under 5 subject headings completed by CPW research staff since July 2020. These scientific publications provide results from recently completed CPW research projects and other collaborations with universities and wildlife management agencies. Topics addressed include nongame species ecology and conservation (lynx associations with beetle killed forests, and a collaborative modelling effort to address lynx distribution in the southern extent of their range), carnivore ecology and management (mountain lion population response to hunter harvest), ungulate ecology and management (mule deer response to energy development activity, applying memory covariates to enhance assessment of mule deer habitat use patterns, developing an approach to estimate timing of moose calf births, addressing the influence of willow nutrition and morphology on moose calving rates, and investigation of potential disease spread from migratory elk to livestock), university collaborations addressing wildlife genetics and disease research (evaluation of how human altered landscapes influence viral transmission in cougars, characteristics of anelloviruses in domestic and various wild cat species, and reconstructing statewide viral phylogenies from commonly collected mountain lion tooth samples), and a *Journal of Wildlife Management* editorial representing an evaluation of the journal from senior and mid-career scientists to provide suggestions for future improvement.

We have benefitted from numerous collaborations that support these projects and the opportunity to work with and train wildlife technicians and graduate students that will likely continue their careers in wildlife management and ecology in the future. Research collaborators include the CPW Wildlife Commission, statewide CPW personnel, Federal Aid in Wildlife Restoration, Colorado State University, Montana State University, University of Wyoming, U.S. Bureau of Land Management, U.S. Forest Service, CPW big game auction-raffle grants, Species Conservation Trust Fund, Great Outdoors Colorado, CPW Habitat Partnership Program, Safari Club International, Boone and Crocket Club, Colorado Mule Deer Association, The Mule Deer Foundation, Muley Fanatic Foundation, EnCana Corp., ExxonMobil/XTO Energy, Marathon Oil, Shell Exploration and Production, WPX Energy, and numerous private land owners providing access to support field research projects.

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Colorado Parks and Wildlife

WILDLIFE RESEARCH PROJECT SUMMARY

Canada lynx monitoring in Colorado

Period Covered: July 1, 2019 – June 30, 2020

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In an effort to restore a viable population of Canada lynx (*Lynx canadensis*) to the southern portion of their former range, 218 individuals were reintroduced into Colorado from 1999–2006. In 2010, the Colorado Division of Wildlife (now Colorado Parks and Wildlife [CPW]) determined that the reintroduction effort met all benchmarks of success, and that the population of Canada lynx in the state was apparently viable and self-sustaining. To track the persistence of this new population and thus determine the long-term success of the reintroduction, a minimally-invasive, statewide monitoring program is required. During 2014−2020 CPW initiated a portion of the statewide monitoring scheme described in Ivan (2013) by completing surveys in a random sample of monitoring units (n = 50) from the San Juan Mountains in southwest Colorado (n = 179 total units; Figure 1).

During 2019−2020 personnel from CPW and USFS completed the sixth year of monitoring work on this same sample. Specifically, 14 units were sampled via snow tracking surveys conducted between December 1 and March 31. On each of 1–3 independent occasions, survey crews searched roadways (paved roads and logging roads) and trails for lynx tracks. Crews searched the maximum linear distance of roads possible within each survey unit given safety and logistical constraints. Each survey covered a minimum of 10 linear kilometers (6.2 miles) distributed across at least 2 quadrants of the unit. The remaining 36 units could not be surveyed via snow tracking. Instead, survey crews deployed 4 passive infrared motion cameras in each of these units during fall 2019. Cameras were baited with visual attractants and scent lure to enhance detection of lynx living in the area. Cameras were retrieved during summer or fall 2020 and all photos were archived and viewed by at least 2 observers to determine species present in each. Camera data were then binned such that each of 10 15-day periods from December 1 through April 30 was considered an 'occasion,' and any photo of a lynx obtained during a 15-day period was considered a 'detection' during that occasion.

Surveyors covered 650 km during snow tracking surveys and detected lynx at 6 units (Table 1). These results are among the lowest recorded for the project, but mirror those recorded during the past 3 years (Table 1). Surveyors collected more than 3 times the photos during 2019–2020 than have been collected in any other year. This can be mostly attributed to the use of new, more sensitive cameras along with new, high capacity memory cards. However, for the third year in a row we collected <50% of the number of lynx photos taken during the initial years of the monitoring effort (Table 2). In fact, the 36 lynx photos collected during the 2019−20 season was the fewest recorded since the inception of the project. We initially considered at least 3 possible explanations for the lack of photos collected in recent years. First, we hypothesized that abnormal snow patterns (lack of snow in 2017–18, record snow in

2018–19) could have impacted detection probability. Second, lack of detections could have been due to the new lure (Caven's Violator 7; Minnesota Trapline Products, https://www.minntrapprod.com/Bobcat-and-Lynx/products/829/) we used in 2017–18, 2018–19, and 2019−20 after the lure we used previously (Pikauba; Luerres Forget's Lures, http://www.leurresforget.com/product.php?id_product=15) became unavailable. Finally, it could be that lynx have disappeared from a number of camera units. Unfortunately, the changes in snow and lure were confounded for a few years, thus making it difficult to determine which factor resulted in fewer detections. However, 2019−20 was a normal snow year, yet the number of lynx photos was still low. This indicates that abnormal snow was not the cause of the pattern we observed. Also, the number of snow tracking units with lynx has remained fairly steady throughout the project; we can think of no reason why snow track units would remain occupied while lynx blinked out of camera units, unless just by chance. Thus, we suggest that the new lure is less effective than the original. Fortunately the original formulation is again available and will be deployed for the 2020−21 survey. We plan to utilize this lure for the remainder of the survey efforts, provided it remains available. We obtained lynx detections for only the second time at a camera unit near Wolf Creek Pass. Lynx were again detected at Lizard Head Pass after no detections last year, and in all four snow tracking units along the Hwy 550 corridor after two of the four went without detections in 2018−19. However, we failed to detect lynx in at the Table Mountain Unit northwest of Creede, at Lemon Reservoir, at Little Squaw Creek west of Creede, and at Trujillo Meadows near the New Mexico border, where they had been detected the previous two seasons (Figure 1).

We used the R (R Development Core Team 2018) package 'RMark' (Laake 2018) to fit multiple-season (i.e., "dynamic") occupancy models (MacKenzie et al. 2006) to our survey data using program MARK (White and Burnham 1999). Thus, we estimated the derived probability of a unit being occupied (i.e., used) by lynx over the course of the winter (ψ), along with the probability of detecting a lynx (p) given that the unit was occupied, the probability a unit that was unused in one year was used the next (i.e., "local colonization", γ), and the probability a used unit became unused from one year to the next (i.e., "local extinction", ε). Based on previous work, we treated 'survey method' as a group variable so that we could allow p to vary by method. Additionally, we allowed p for 2017–18, 2018–19, and 2019–20 to differ from other years due to the new lure, and we included a breeding season effect for detection at cameras (lynx tend to move more in late winter when they begin to breed, and thus should encounter cameras more often). Also based on previous work, we specified initial ψ in the time series to be a function of the proportion of the unit that was covered by spruce/fir forest. We then allowed annual estimates of ε to be constant or a function of average years since bark beetle infestation, proportion of the unit impacted by bark beetles, proportion of the unit that was burned during Summer 2013, and the number of photos of other species that could potentially impact presence of lynx (e.g., snowshoe hares as a food source; coyotes, bobcats, foxes, and cougars as potential competitors). We allowed annual estimates of γ to be constant or a function of snowshoe hares. We limited our model set by first setting a general structure for ψ while assessing fit of various combinations of variables expected to affect p. We then fixed the best-fitting structure for p, and assessed combinations of the covariates expected to influence ε or γ, allowing up to 2 of these covariates at a time, in addition to the covariates on detection. We made inference from the best-fitting model as selected via Akaikie's Information Criterion (AIC), adjusted for small sample size (Burnham and Anderson 2002).

As has been the case since the inception of our monitoring program, the proportion of the sample unit covered by spruce-fir forest was positively associated with the initial occupancy estimate in the time series. Local colonization probability was estimated to be low ($\gamma = 0.03$, SE = 0.01) and constant; local extinction was also low, but in some years twice that of colonization ($\varepsilon = 0.03$ to 0.06, SE = 0.03 to 0.05). Furthermore, in all of the top models, ε was negatively (but weakly) associated with the number of coyote photos collected on the year indicating that the probability of extinction of a unit in any given year goes up as the index of coyote abundance goes down (Appendix 1). Local extinction was also significantly, positively associated with the number of fox photos in the top model, suggesting that extinction is more likely in units in which we detected fox more often. Other models for ε that performed better than a constant structure included a negative relationship with number of snowshoe hare photos (less likely to go extinct as hare index increases), a positive relationship with the number of bobcat photos (more likely to go extinct as bobcat index increases), and a positive association with proportion of a unit impacted by beetles. However, the hare, bobcat, and beetle models were not as well supported as those including coyotes and foxes. The five occupancy growth rates (λ) estimated between surveys were all near 1.0, indicating a stable distribution with little to no growth (Figure 2). Similar to previous years, detection probability was relatively high for snow tracking surveys (p = 0.59, SE=0.05), and relatively low for camera surveys (p = 0.23, SE = 0.04) during December–February and April, although detection at cameras increased to 0.34 (SE = 0.07) during breeding season (March) as expected. We found a significant, negative effect on p during winters when Violator 7 was used as lure (p = 0.08, SE = 0.02 for December–February and April; p = 0.13, SE = 0.05 for breeding season). We estimated that 29% of the sample units in the San Juan's were occupied by lynx (95% confidence interval: 15–43%) during 2019–20 (Figure 2). The spatial distribution of lynx in the San Juans remained largely unchanged (Figure 1).

Table 1. Summary statistics from snow tracking effort.

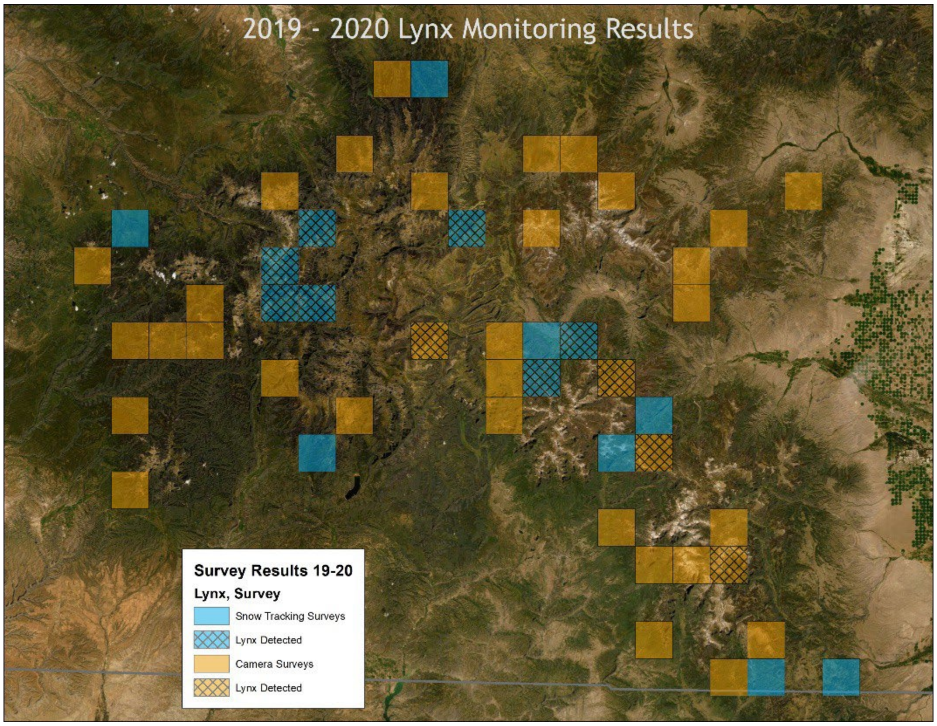
Season	#Units Surveyed	#Units with Lynx	#Lynx Tracks	#Genetic Samples[a]	Km Surveyed (Total)	Mean Km Surveyed per Visit	#CPW Personnel	#USFS Personnel
2014-2015	24	8	13	10[b]	1,088	20.1	30	13
2015-2016	17	7	14	9[c]	987	21.9	23	6
2016-2017	16	8	13	7[d]	703	18.0	20	8
2017-2018	14	7	9	3[e]	578	19.3	14	5
2018-2019	14	6	7	2[e]	510	19.6	16	5
2019-2020	15	6	10	2[b]	650	19.7	15	3

[a] Number of genetic samples (scat or hair) collected via backtracking putative lynx tracks
[b]DNA analysis confirms that all samples collected from putative lynx tracks were lynx
[c]DNA analysis confirms that 6 of 9 samples were lynx (1 coyote, 1 either mule deer or human, 1undetermined)
[d]DNA analyses confirmed that 5 of 7 samples were lynx (1 coyote, 1 snowshoe hare)
[e]DNA analysis confirms 1 sample was lynx; remaining samples were not analyzed

Table 2. Summary statistics from camera effort.

Season	#Units Surveyed	#Units With Lynx	#Photos (Total)	#Photos (Lynx)	#Cameras With Lynx	#CPW Personnel	#USFS Personnel
2014-2015	32	8	134,694	301	14	46	12
2015-2016	31	7	101,534	455	10	33	9
2016-2017	33	6	168,705	251	10	29	9
2017-2018	35	5	173,279	90	8	35	8
2018-2019	36	6	204,243	59	9	31	7
2019-2020	36	4	701,724	36	4	29	6

a)



b)

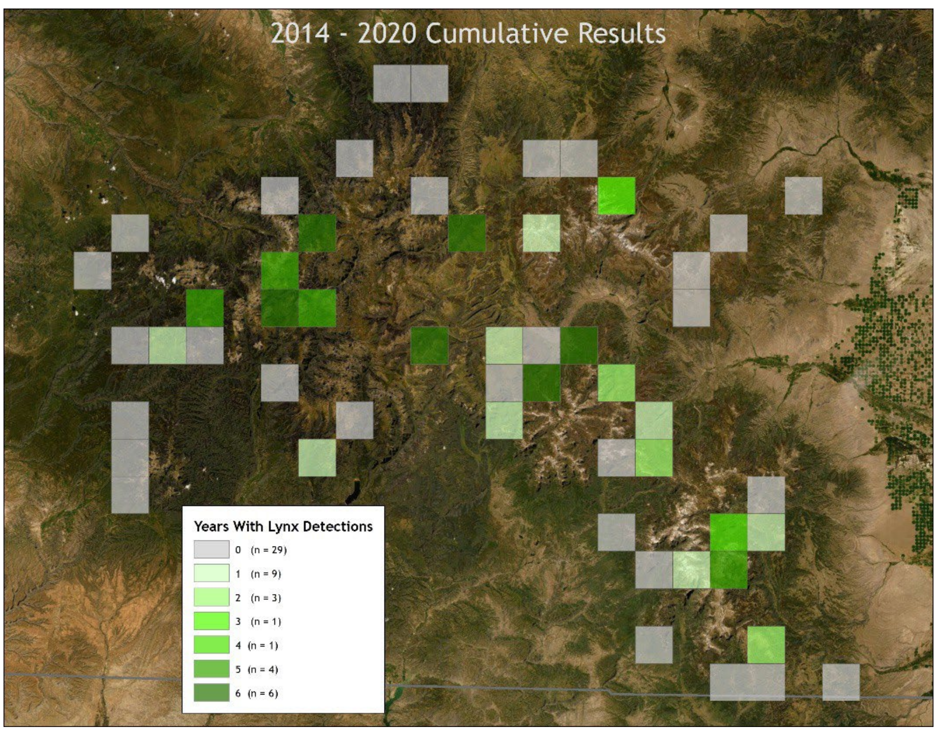


Figure 1. Lynx monitoring results for a) the current sampling season (2019–2020) and b) the cumulative monitoring effort (2014–2020), San Juan Mountains, southwest Colorado. Colored units (n = 50) depicted here are those selected at random from the population of units (n = 179) encompassing lynx habitat in the San Juan Mountains. Lynx were detected in 11 units in 2019−2020 and 23 units cumulatively since monitoring began in 2014−2015.

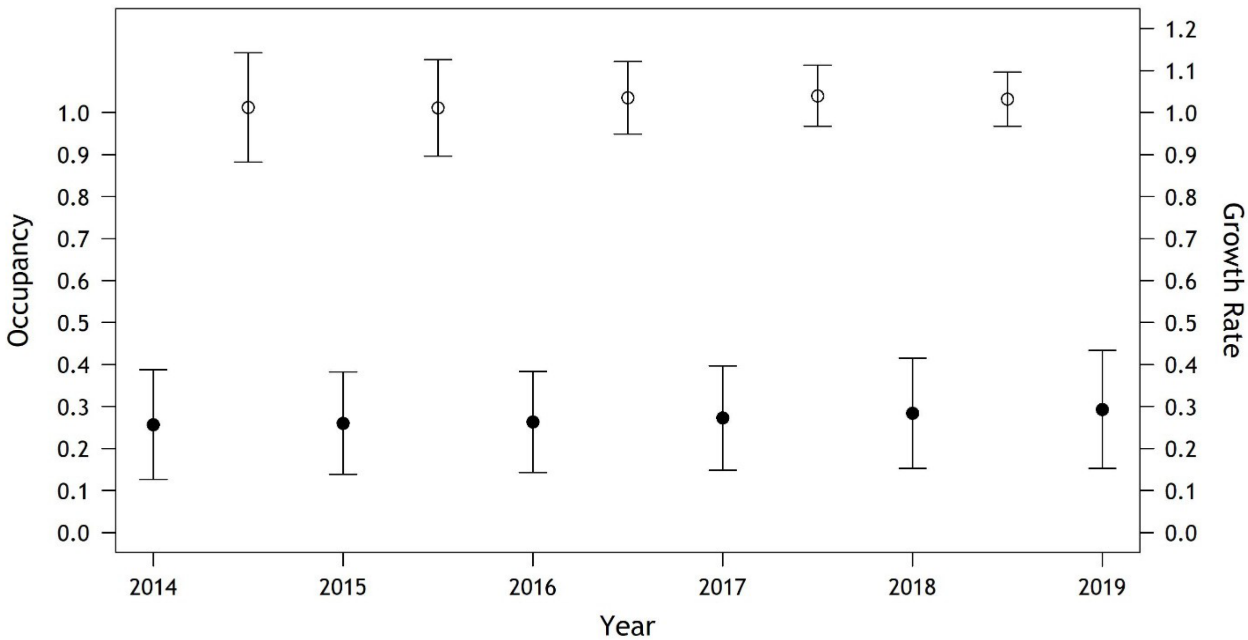


Figure 2. Occupancy estimates (Ψ, filled circles, left axis) and annual growth rate (λ) in occupancy between surveys (open circles, right axis) for Canada lynx in the San Juan Mountains, southwest Colorado. 'Year' indicates when the efforts were initiated (e.g., winter 2014−15, winter 2019−20). Growth rates less than 1.0 indicate a decline in occupancy; those >1.0 indicate an increase.

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Appendix 1. Model selection results for lynx monitoring data collected in the San Juan Mountains, Colorado, 2014–2020. Rankings are based on Akaike's Information Criterion adjusted for small sample size (AIC_c). Eight variables were considered as covariates to inform estimation of local extinction (ε); one was considered for local colonization (γ). The complete model set (n = 46) included all combinations of two of these covariates, in addition to modeling detection (*p*) as a function of survey method, breeding season, and alternate lure used during the 2017–18, 2018–19, and 2019–2020 seasons. Only the best 10 models are shown.

Model	AIC_c	ΔAIC_c	AIC_c Wts	No. Par.
ψ (Prop Spruce/Fir) ε (Coyote + Fox) γ (.) *p* (Best)	574.54	0.00	0.19	10
ψ (Prop Spruce/Fir) ε (Coyote) γ (.) *p* (Best)	576.43	1.89	0.08	9
ψ (Prop Spruce/Fir) ε (Coyote + PropBeetle) γ (.) *p* (Best)	576.50	1.96	0.07	10
ψ (Prop Spruce/Fir) ε (Coyote + Hare) γ (.) *p* (Best)	576.61	2.07	0.07	10
ψ (Prop Spruce/Fir) ε (Bobcat + Coyote) γ (.) *p* (Best)	577.17	2.63	0.05	10
ψ (Prop Spruce/Fir) ε (.) γ (.) *p* (Best)	578.01	3.47	0.03	8
ψ (Prop Spruce/Fir) ε (Coyote + PropBurn) γ (.) *p* (Best)	578.12	3.58	0.03	10
ψ (Prop Spruce/Fir) ε (BKAvg + Coyote) γ (.) *p* (Best)	578.21	3.67	0.03	10
ψ (Prop Spruce/Fir) ε (Cougar + Coyote) γ (.) *p* (Best)	578.30	3.76	0.03	10
ψ (Prop Spruce/Fir) ε (Bobcat) γ (.) *p* (Best)	578.50	3.96	0.03	9

[a]Best-fitting structure for detection probability included effects for survey method, breeding season, and an effect for the 2017–18, 2018–19, and 2019–20 survey seasons when Violator 7 was used for lure rather than Pikauba.