

2022-2023 Science Application Highlights



CPW RESEARCH SUPPORTS MANAGEMENT AND POLICIES

Colorado Parks and Wildlife (CPW) has an in-house science program that has served the agency for over seven decades. CPW research scientists investigate high-priority information needs, and develop and refine many of the tools and practices our agency uses to conserve and manage Colorado's fish, wildlife, and park resources for current and future generations. Below we highlight a few examples of CPW's science activities and their application to management during the past year.

Wildlife Health

Chronic Wasting Disease (CWD) – Current research is focused on broadening our understanding of shedding patterns and updating testing strategies for CWD surveillance.

- Patterns of CWD accumulation differ between elk and deer: We initiated a study to determine preferred tissues and tests for CWD sampling in elk. Results will be used to assess accuracy of prevalence estimates in elk using only one test and tissue type.
- CWD shedding: Timing and duration of CWD shedding may influence disease dynamics and parameters used for modeling management applications. We participated in a large collaborative study to assess timing and duration of CWD shedding in elk, mule deer, and white tailed deer held in captivity.

Plague – Plague research helped develop tools and techniques to improve its management on the landscape.

- Dose matters: Recent studies revealed that the original plague vaccine dose yields insufficient “herd immunity” in black-tailed prairie dogs to be protective for black-footed ferrets as a standalone tool.
- Vaccine modification improves response: A simple and economical modification to the vaccine preparation tripled immune responses in Gunnison's prairie dogs.
- A new insecticide duster, designed for use on ATV's makes plague management efforts more precise, efficient and cost effective.
- Systemic flea control products have potential as a new plague management tool. We are investigating the duration of efficacy and safety of these products for both target and non-target species.

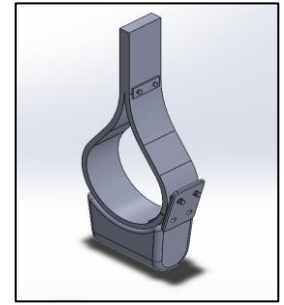


Respiratory Disease in Bighorn Sheep (BHS)

- New diagnostics improve understanding: We developed next generation sequencing capabilities to help assess the role of different respiratory pathogens in bighorn sheep population performance.
- Causative agent of BHS sinus tumors: Bighorn sheep sinus tumors are expansions of the upper respiratory sinus lining that contribute to chronic respiratory disease and poor herd performance in bighorn sheep. We are exploring a possible association between tumor development and presence of *Pasteurella multocida* in the upper respiratory sinuses. This could help to identify target populations for management interventions.

Tools and Techniques – Investigation of new drug combinations, diagnostic tests, and capture tools helps to improve safety of wildlife handling and increase understanding of wildlife diseases.

- **Metabolomics:** Understanding the nutritional status of wild ungulates provides valuable information on underlying population performance, habitat quality, and population resilience in the face of other environmental factors. We are conducting pilot work to measure substrates or products of metabolism in serum samples to assess the nutritional status of bighorn sheep.
- **Naturally degrading collar drop-offs:** A 3D printable collar drop-off using a biodegradable polyester, polycaprolactone (PCL), is under evaluation. This material has the ability to degrade via hydrolysis in a predictable manner and can be tailored to fail within a specific time frame depending on the thickness of the material. If successful, this could provide low-cost collar drop-off options for wildlife collaring projects.



Mammals Research

Elk Calf Recruitment – Ongoing research is addressing factors influencing declining elk calf recruitment by comparing adult female condition and calf survival from a relatively productive area in the northern part of the state to two lower productivity areas in the southern portion of the state. Data collection is scheduled to continue through 2025.

Recreation Impacts – Ongoing research is focused on elk behavioral and demographic responses to human recreational activity to develop and evaluate best management practices that accommodate recreational opportunities while protecting wildlife resources.

A Spatial Planning Tool for Energy Development on Mule Deer Winter Range – We applied previous research results addressing mule deer/energy development interactions to develop a spatial planning tool to inform future energy development on winter range. This tool will be applied to guide development planning in the Piceance Basin mule deer winter range and evaluated for application to other Pinyon-Juniper winter ranges.

Lynx/Snowshoe Hare Research – Research investigations addressing lynx/habitat/prey associations reported (1) stable lynx populations in Colorado, (2) lynx can tolerate moderate levels of winter recreation activity, and (3) hares and lynx were minimally influenced by the bark beetle outbreak; however, red squirrels, an important alternative food source for lynx, are negatively impacted by bark beetle outbreaks. Analyses of hare responses to varied forest management practices are ongoing.



Carnivore Management – We are continuing research in North Park to address wolf/prey relationships and have an ongoing project addressing cougar/mule deer interactions and evaluation of cougar/human incident levels relative to cougar density.

Bobcat Population Monitoring and Demographics – We initiated a pilot bobcat study in GMU 10 (Moffat County) and GMU 22 (Rio Blanco County). The goal is to capture bobcats and deploy GPS collars. Using game cameras, we will track the movements of collared bobcats to estimate abundance. This is the first step in a long-term study to develop monitoring approaches and better understand bobcat population dynamics in Colorado.

Effects of Wolf Exposure on Cattle Behavior, Stress, and Weight Gain – We are initiating a research project to quantify cattle time budgets, stress levels, and weight gain across different levels of wolf exposure in Colorado. This will provide the first empirical and mechanistic data about indirect effects of wolves on cattle in the state.

Mountain Lion Population Monitoring – Mountain lion density estimation methods developed by Mammals Research are being applied in the Northwest and Southwest Regions to evaluate assumptions about extrapolated density estimates for management planning.



Human Dimensions (HD)

Chronic Wasting Disease (CWD) – CPW’s Human Dimensions Specialist (HDS) led the development, implementation, and analysis of a CWD survey targeting landowners in northeastern Colorado. The survey sought to identify why landowners do (or do not) provide hunting access on their property, to determine how aware they are of CWD, and what concerns they have about the disease. Because this inquiry was part of a multi-pronged approach led by other CPW staff – additional efforts included focus groups and one-to-one interviews/videos with landowners – results will be used to improve communication efforts with landowners as well as CWD management in this part of the state. The survey results were synthesized as part of CPW’s technical report series

(<https://cpw.state.co.us/Documents/Research/SocialScience/Linking-Hunting-Access-and-CWD.pdf>). This survey was funded by a USDA Animal and Plant Inspection Service (APHIS) grant and was obtained by CPW staff members Matt Eckert (Terrestrial Section Statewide Programs Supervisor) and Mike Miller (State Wildlife Veterinarian).

Recently, CPW’s HDS partnered with a social scientist from the USGS and a graduate student from CSU to examine state wildlife agencies’ CWD response plans. Results from this effort will be used to identify similarities across agencies’ plans and to make recommendations about opportunities for HD or social science research to inform and evaluate them. Additionally, CPW’s HDS also co-chaired an organized special session at the 2023 Pathways: Human Dimensions of Wildlife Conference about CWD, specifically sharing insights about a collaborative project he is helping to lead with other state (Pennsylvania) and federal agency (USFWS, USGS) social scientists to develop a HD of CWD clearinghouse.

Latino(a) Angler Research – CPW’s HDS collaborated with Dr. Anna Lavoie (CSU faculty) and a graduate student (Arianna Basto-Eyzaguirre) to identify what drives Latino/a anglers to participate in fishing activities, what barriers get in their way to doing so, and how they negotiate these constraints to continue participating. This work, which served as Arianna’s Master’s thesis research, will be used by CPW staff to develop education and outreach opportunities that support Latino/a anglers.

Big Game Attitude Survey (BGAS) – CPW staff developed a survey instrument mailed to nearly 6,000 resident and nonresident hunters to understand their perspectives about CPW’s big game license distribution system and season structure. The BGAS was implemented at the same time CPW staff conducted focus groups with hunters. The findings from both efforts helped inform changes to CPW’s license distribution efforts. Specifically, findings from the BGAS were shared with the Colorado Parks and Wildlife Commission and were summarized in a peer-reviewed report published as part of CPW’s technical report series (<https://cpw.state.co.us/Documents/Research/SocialScience/CPW-Big-Game-License-Report.pdf>).

Wolf Reintroduction – The National Science Foundation awarded a grant to Colorado State University (CSU) and CPW to study the stakeholder engagement process for wolf reintroduction. As part of this research, CPW’s HDS served on a graduate committee for Mireille Gonzalez who received her Ph.D. in May 2023. One of Dr. Gonzalez’ dissertation chapters summarizes finds from this research and the team is currently drafting several peer-reviewed publications highlighting nuances in the stakeholder engagement process and perceived social outcomes from it.

Additionally, CPW's HDS and CSU colleagues started a new research project in 2023 to examine how various media sources discussed wolf reintroduction and corresponding processes during the same timeframe as the stakeholder engagement process as well as after the restoration and management plan was drafted/approved.

Eagle County Community Survey – To inform land use planning decisions in Eagle County, CPW collaborated with the Eagle County Community Wildlife Roundtable and CSU graduate students to survey county residents about their attitudes toward wildlife, outdoor recreation, and development. Residents were surveyed in 2021 and results were summarized as part of a peer-reviewed technical report (<https://cpw.state.co.us/Documents/Research/SocialScience/22-CPW-Tech-Report-60-Conservation-Intersection-Eagle-MRQ.pdf>) and shared with decision makers during the April 2023 Mayor and Managers meeting in Eagle County, Colorado. Results were also published in the Vail Daily, an outlet used by residents across the county to learn about the nexus between wildlife, recreation, and development.

Association of Fish and Wildlife Agencies & Western Association of Fish and Wildlife Agencies - As part of his role as Chair of both the WAFWA HD Committee and AFWA Social Science Subcommittee (SSS), CPW's HDS has continued to move the needle on the identification of barriers that wildlife organizations face when attempting to integrate social science into decision making processes. As part of the 2023 Pathways Conference, the HDS is chairing an organized special session about lessons learned when integrating social science into management, policy, and practice. He is also co-chairing another organized session where attendees learned about and apply an adaptive framework to more thoroughly integrate social science. The framework was published in a peer-reviewed paper (Niemiec et al., 2021) to which the HDS was a co-author.

Additionally, the AFWA SSS is in the process of summarizing results from a national survey of conservation social scientists in a peer-reviewed journal article, which CPW's HDS is leading (to be submitted in 2023). Lastly, the HDS collaborated with AFWA's Science and Research Committee to revamp and implement the national Science Needs and Priorities survey. Results from this effort will be presented during the 2023 AFWA annual meeting.

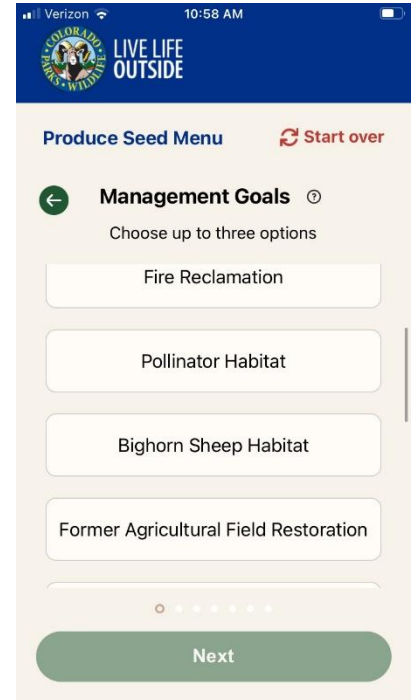
Statewide Comprehensive Outdoor Recreation Plan (SCORP) research – As part of the next SCORP update, CPW's HDS led the development and implementation of the 2023 Land Manager Survey. The goal of this survey is to identify challenges facing land managers in Colorado and to determine where opportunities exist to share expertise and innovative solutions. Capturing the perspectives of land managers and resource professionals will help increase understanding of the complex social-ecological system of land use and management throughout the state and inform future land management efforts.

Avian Research

Brewer's Sparrow Distribution and Taxonomy – Brewer's sparrow is a Tier 2 Species of Greatest Conservation Need in the State Wildlife Action Plan. Ongoing research has confirmed the species has a much broader breeding range in Colorado than previously known, including widespread presence in alpine habitats. The subspecies identity of alpine Brewer's sparrows is being determined using behavioral, song, morphological, and genetic data.

Bald Eagle Demography and Space Use – The bald eagle is a Tier 2 Species of Greatest Conservation Need in Colorado's State Wildlife Action Plan, and is a high-profile, charismatic species that often occurs in close proximity to human-dominated habitats. CPW is conducting ongoing research to determine demographics (breeding population size and trend, nesting effort, productivity) and space use (breeding and nonbreeding home range and movements, habitat use) in relation to land use and human disturbance, of bald eagles breeding along the northern Front Range in northcentral Colorado. Results of this project will be used to guide recommendations to minimize and mitigate impact to eagles in this rapidly developing landscape.

Seed Mix App for Habitat Projects – Land managers within and outside CPW put considerable effort into planning seed mixes for various habitat projects. The process can be time-consuming, as potential species must be evaluated with respect to their adaptation to the particular site, suitability for management goals, cost, and other factors. CPW research and field staff have been collaborating to produce a mobile application to help managers with this process. Drawing information from CPW habitat research, practitioner knowledge, scientific literature, and existing web sources, the mobile app produces a menu of plant species and varieties designed for a user’s particular site and management goals. The project was funded by a collaboration between Avian Research, the Habitat Partnership Program, and the Northwest region. A beta version of the app will be available in summer 2023.



Burrowing Owl Status Assessment – Burrowing owls are currently listed as a state threatened species in Colorado and are designated as a Tier 1 Species of Greatest Conservation Need in Colorado’s State Wildlife Action Plan. CPW, in collaboration with Colorado State University and the USGS Cooperative Research Unit, is conducting an updated assessment of burrowing owl occupancy, density, and productivity on black-tailed prairie dog colonies across eastern Colorado. This project is also testing field monitoring methods for this species (distance sampling, double observer surveys) and examining relationships between owl occupancy and abundance and characteristics of prairie dog colonies, to inform future monitoring efforts for burrowing owls in Colorado.

Estimates and Determinants of Breeding Duck Populations in North Park – North Park is a historically important area for breeding ducks in Colorado, and CPW, along with numerous partners, has invested substantial resources toward wetland habitat conservation to help support duck populations in this landscape. CPW is conducting ongoing, long-term research to estimate annual breeding populations, local production, survival and harvest rates, and harvest distribution of ducks captured in North Park during the breeding season, in relation to annual variation in habitat conditions across North Park. In addition, CPW is collaborating with Colorado State University to examine duck nest distribution and success in relation to habitat characteristics, and aquatic invertebrate abundance and diversity in relation to wetland habitat types. Results of this research will be used to evaluate wetland conservation efforts, and help target future conservation projects to address key factors that limit breeding duck populations in North Park.

Aquatic Research

Fish Disease – Whirling disease has become established in most major river drainages throughout the state, and is extremely difficult to eradicate. A previous study showed that it was possible to break the two-host life cycle of the parasite in a stream by making it fishless, although this had never been attempted in a lake. Biologists spent several summers removing fish from Lower Squaretop Lake on Guenella Pass. After determining that the lake was fishless, rainbow trout were held in cages in the lake for 30 days to allow exposure to the parasite, and then taken to a research lab in Fort Collins where they were held for about six months to allow development of the parasite for detection in the fish, if present. In 2022, all of the caged fish were whirling disease negative, suggesting the parasite was no longer in the lake. Lower Squaretop Lake will be stocked with greenback cutthroat trout within the next year. Biologists continue to use this method of making reclamation streams fishless and using caged fish to test for the absence of the parasite prior to restocking with conservation populations of cutthroat trout.

Native Suckers – Bluehead and Flannelmouth sucker populations, native to rivers and streams on the Western Slope below 8,000 ft, have declined across their range. Declines are attributed in part to the proliferation of non-native sucker species, which often replace or hybridize with native suckers. Native and non-native suckers migrate into tributaries to spawn, and we looked at differences in spawning behavior between the two groups in the Gunnison River. We found that in an intermittent tributary (one that flows during spring runoff only, when suckers spawn) larval suckers produced had a

significantly increasing probability of being genetically pure natives the farther from the stream's mouth they were collected. These findings suggest that native suckers need access to longer intermittent creeks to preserve a genetically pure, native component of the population.

Temperature tolerance – Streams used by Bluehead suckers *Catostomus discobolus* experience variable water temperatures of high and low extremes and extreme rates of change. Acute and chronic laboratory temperature tests are typically used to develop protective thermal criteria for native fish, but these methods do not allow for testing the lethality of temperature interactions with other stressors. For instance, fish density and temperature interactions are likely to occur during low flow periods with high densities of fish stranded in a stagnant pool; but standard thermal tests only include one fish. Thus, we investigated how the interaction of fish density and temperature influence the upper and lower temperatures Bluehead Sucker larvae can tolerate. The tolerant temperature range for the larvae at an acclimation temperature of 18°C was $7.2 \pm 1.6^\circ\text{C}$ to $32.1 \pm 2.4^\circ\text{C}$. However, when the density of fish was high ($n = 25$) the upper temperature limit significantly decreased by 5.9°C , indicating higher densities of fish negatively affect the tolerance of the fish to an increased temperature. These results indicate density and temperature interactions should be considered when developing protective temperature criteria instead of using single fish in laboratory tests.

Tiger Trout – Hybrid predators like tiger trout (cross between brook trout and brown trout) are sterile (cannot reproduce naturally) and often stocked to control undesirable or overabundant prey fish species that compete with other valuable sport fish such as rainbow trout and cutthroat trout. Over the lifespan of tiger trout, they also provide unique fishing opportunities and have the potential to grow to trophy sizes. New published research examining the growth of juvenile tiger trout stocked into a suite of subalpine lakes for biocontrol and to enhance recreational angling provides guidance to managers on best stocking practices. Informed stocking translates into the efficient use of tiger trout produced by CPW's hatchery system, a greater chance of meeting desired outcomes from the onset of stocking, and more rapid development of unique, quality fishing opportunities for anglers.



Aquatic Toxicology – Acid mine runoff can have lasting and devastating effects on aquatic invertebrates and fish populations. An intensive nine-year study to evaluate acid mine drainage cleanup the North Fork of Clear Creek was completed. The study results were published, describing the population-level effects on benthic macroinvertebrates before and after mine remediation (water diversion and treatment). The study found that very positive responses to these populations can be achieved by water treatment, but that lingering effects of pollutants persist downstream due to uncontained sources of metals, indicating that further remediation will be necessary to return the stream to pre-mining conditions.