Berger – Bighorns and Recreation

Annual Performance report for reporting period: 1/01/2023 to 12/31/2023

Public Land Recreation and Desert Bighorn Sheep

Blending Empiricism with Bio-Energetic Models to Predict Disturbance Costs during Late Gestation Critical Periods

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This report summarizes progress in the study and communication of results on how public land recreation is affecting desert bighorns sheep in Southeastern Utah. The sections below explain the bases for the study, approaches used, offer some preliminary findings, and communication and outreach efforts to stakeholders which includes state and federal agencies and the broader public.

Backdrop and Objectives.

'The Why' - In 2020 a formal study was initiated between the Bureau of Land Management and Colorado State University to understand how changing (increasing) levels of recreation affect bighorn sheep on public lands in SE Utah. Public lands are of unique value for both recreation and economy. In 2015, nearly 7.5 million visitors used Utah BLM lands; in 2022 that number increased nearly 50% to ~11+ million. Tourism-related use of public lands generated about $525 million to state revenue in 2015; in turn almost 5,000 jobs were supported (BLM-UT 2019).

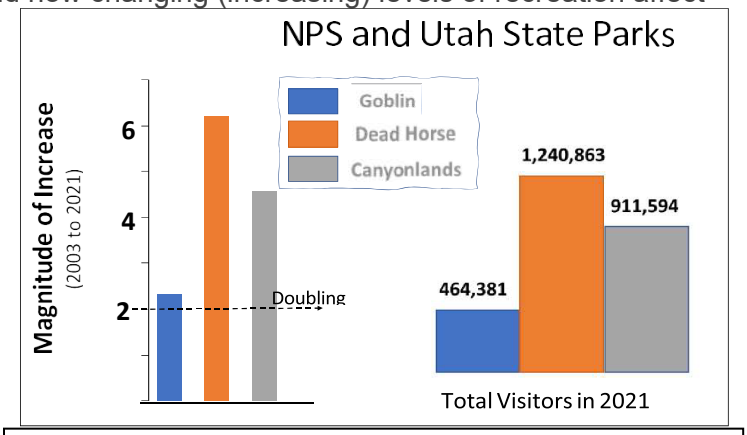

Fig. 1. Relationships among time (decade) and relative magnitude of increase in visitors (NPS, Utah State Park data) and total visitation in 2021.

Within this period, wildlife-associated recreation contributed just over $100 million and supported more than 15% of the aforementioned Utah jobs (Pew Trust 2018). Although tourism-based recreation contributes much to economies, and especially gateway communities, much remains unknown, about impacts of diverse and growing recreation on Utah BLM lands, especially on sensitive and iconic wildlife of cultural value such as Utah's only native persisting desert bighorn sheep (*Ovis canadensis nelson*) population and associated restored herds. Bighorns are the most featured animal in rock carvings which is demonstrative of a long-term recognizable bio-cultural icon (Berger 2023).

There has been a 6-fold increase in attendance to Dead Horse State Park, and about a quadrupling of attendees to Canyonlands National Park. Unknown has been the relative increase of visitors to adjacent BLM, and especially for areas with bighorn sheep.

‘The What’ – A variety of disturbances has been associated with interactions between people and bighorns. These vary from ‘no response’ to humans (which is rare) during feeding, to interruptions that include vigilance, walking away, flight, and total site abandonment. Responses obviously depend on type, intensity, and frequency of disturbance (Fig. 2), and the willingness of individuals or groups to tolerate or escape, especially when nutritional needs are high. The intensity of these responses vary but can be understood through experimental manipulations of sound and visual cues in the field (Fig. 3).

Fig. 2. Flight (top) and alarm (bottom); in most cases the interactants are not in the same frame because sheep flee.

Current efforts are aimed at understanding the extent to which inadvertent human-stressors are incurred by bighorns during their last trimester of gestation. Nutritional needs and fetal growth increase exponentially during late winter and early spring, and this is also when more than 100,000 recreationists visit south- eastern Utah. Understanding the degree to which these putative competing realms (1-pregnant female nutritional needs, and 2- recreational visits) intersect and impact desert bighorn sheep is the central focus of this continued research.

‘The How’ – To address questions about the nature of effects on female bighorns, my team and I have been focused on three broad study regions – each varying in the type and magnitude of recreation.

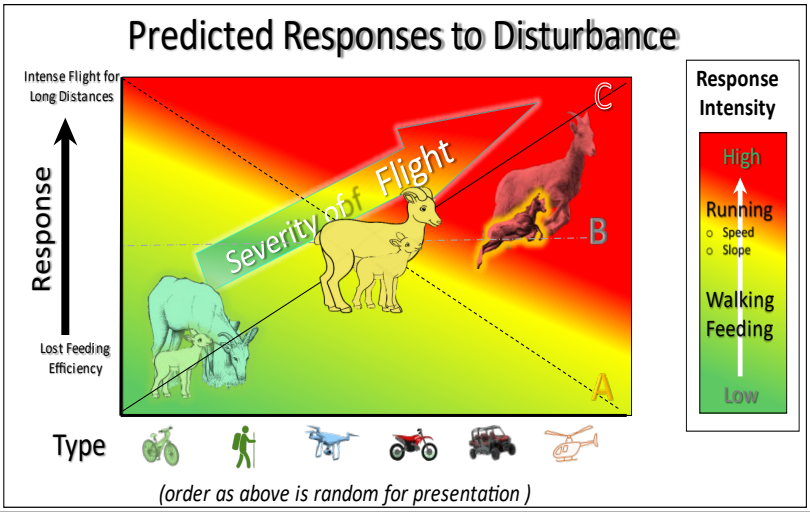

Fig. 3. Schematic of intensified (green to red) energetic- costly responses – with feeding being a net energy gain, and flight across steep terrain at high speeds being the most costly. Types of possible disturbance shown on X axis without an expectation of differential effects (e. g. null hypothesis).

The three study regions cover about 5,700 km^2 including two geographically (mostly) separated herds exclusively on BLM lands within the northern and southern parts of the San Rafael Swell. The 3rd study site is the Potash area which includes parts of Arches and Canyonlands National Parks and adjacent BLM lands. Visitation to these three sites has increased annually (Fig. 4) with spring the period of greatest visitation. For ease of presentation, types of recreation are classified as either motorized or non-motorized activities using spot checks across diurnal periods. For the purposes of this report, motorized vehicles are classified as to type and lumped (Fig. 4) and

include SUVs, side-by-sides, spiders, motorcycles, jeeps, trucks, and vans. Non-motorized refers to mountain bikes, hikers, and horse-back riders. Rarely is it possible to determine from a distance whether bicycles are eBikes or not, and they are lumped in with mountain biking; in most cases (<90% when in proximity it is obvious if a bicycle is electric or not). Among the variables contrasted among study areas to develop insights into sheep responses are the frequency, type, and magnitude of exposure to human presence coupled with types of recreational activity.

Project Objectives and Progress.

Preamble with Respect to Uncertainty. – Among the major aims of this research is to expand upon prior studies of disturbance in bighorn sheep. Whereas most recent studies use GPS data and the inferences drawn are based on resource selection functions, direct observations have lacked. Consider by way of example GPS data across a 30-day period. The average movement of a female sheep on a per day or per week will offer values with a mean, a variance, and a date-time stamp. Additional variables would also include weather, habitat, and distance to nearest road. A useful variable that also is frequently included an index of potential food is the Normalized Difference Vegetation Index (NDVI), which is essentially a measure of spectral conditions for which vegetation greenness is quantified and then used to map vegetation density.

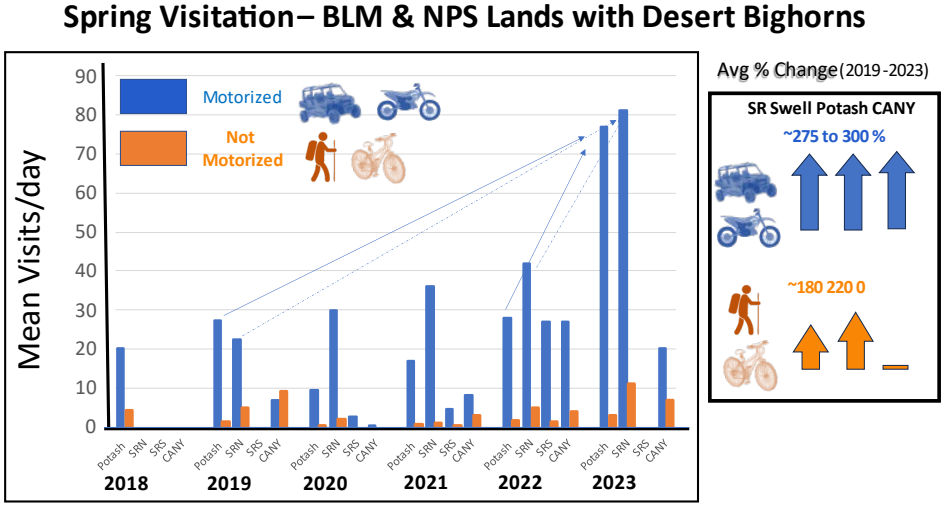

Fig. 4. Summary of visitation by category into four separated study areas (described more specifically in last year's proposal to CNHA s) as follows: Potash, SRN – San Rafael Swell North, SRS – S. R. Swell South, and CANY - Canyonlands.

Most analytical approaches of these sorts of data then model what is considered 'normal' in relation to movements that deviate from 'normal' using a probability distribution which is matched against a random one. If 90% of the points were clustered for instance but a few then were comprised of long-distance movements, it would not be possible to assess whether the long-distance movements were normal on a periodic basis, *or*, alternatively, if they were provoked by one or more disturbance events.

There are many other external and intrinsic factors that affect animal behavioral decisions such as flight or feeding and other reactions. Group size is one that has well known impacts on foraging decisions just as might road traffic, hikers, ravens, or aircraft. Insights on whether such factors may play a role, such as the illustrated long-distance flight after disturbance to two jeeps (Fig. 5). These could not have realistically deduced from GPS data alone in the absence of knowing a causal basis.

Real time movements of GPS points are reflected in an actual linear pathway (Fig. 5). While we don't know the relationship between linear (straight line movement) to reality which would include hills, cliffs, and other components of a navigable route, if the variation was 30% between real and the plotted linear, then the flight of this individual would be about 8.7 kms (~5.2 miles).

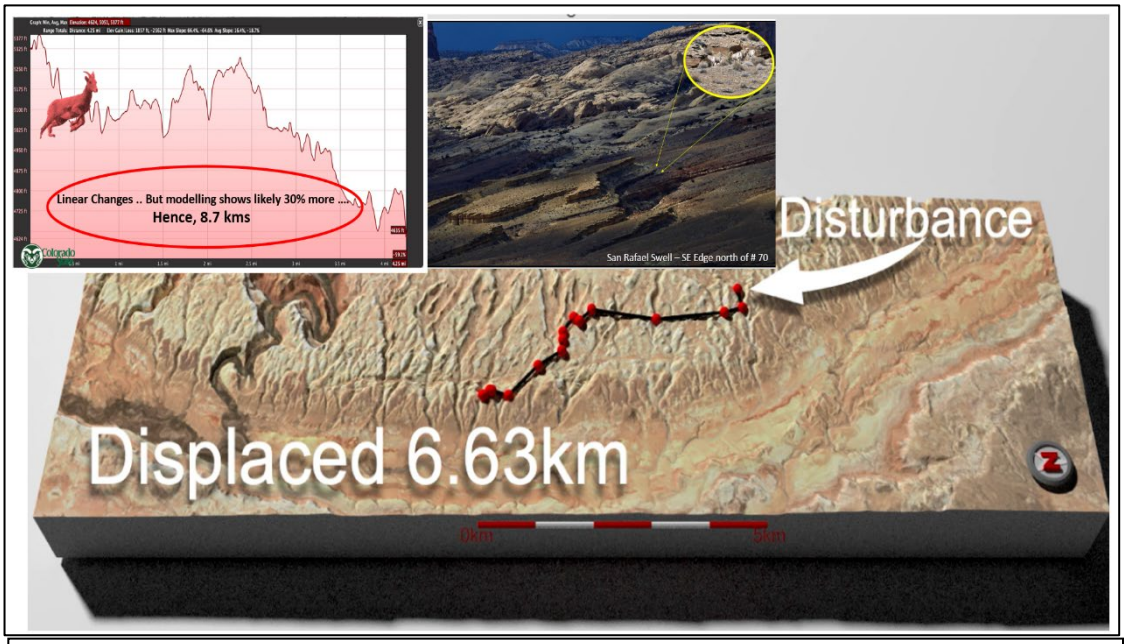

Fig. 5 . Real time movements of a bighorn female in late March 2022; traverse is across east face of the San Rafael Rift. Insets: Left - elevation gradients navigated across duration of flight. Simulation and projection by F. Hayes, - Colorado State University; Center – site topography where disturbance occurred.

Objectives and Explanations. – To increase insights that can be derived from studies of resource selection and movements, the current project is also reliant on direct observations. Some of these are ad lib observations of disturbance events (such as serious chasing by dogs of pregnant females with displacement more than three miles coupled with a failure to return to the traditional area (Figs. 6, 7). Other observations are created experimentally approaching bighorns on foot or on bicycles, or through exposure to auditory cues associated with humans and played through a speaker.

Hence, the primary objectives are:

1) To understand the extent to which bighorns are responsive to human activity,

2) to quantify the frequency, intensity, and duration of disturbances by type;

3) to apply measures of physiological costs (caloric expenditures through estimation of joules spent) of locomotion and gestation in wild bighorn (this objective is described in the Supplementary Material from last year's progress report).

Fig. 6. Dog chasing bighorns; *inset* – owner and dog. Displacement distance >3.85 miles (plotted in Fig. 7, Location is Northern San Rafael Swell).

An essential component of meeting these objectives is assessment of potential for habituation. Non-habituated individuals are more likely to flee and to expend more calories if disturbed, and this is especially costly to females in late gestation (the range of possible responses is depicted in Fig. 3 in relation to different types of recreation).

Fig. 7. Plot of distance traversed and elevational change as a response of dog (from above figure) chasing bighorns (Buckhorn Wash region of Northern San Rafel Swell.

<u>Data Collection</u> – We continue to gather information across all study areas by: 1) satellite downloads of locations of GPS collared females; 2) observations and experimental approaches to bighorns; and 3) ad hoc observations of bighorn responses to humans.

With respect to point 3, preliminary information is available on flight and its trajectories with group flights of considerable distances not being atypical. For instance, a post-disturbance flight in the Potash region covered 2.1 miles in eleven minutes, (Fig. 8 – image 'C'). data collection.

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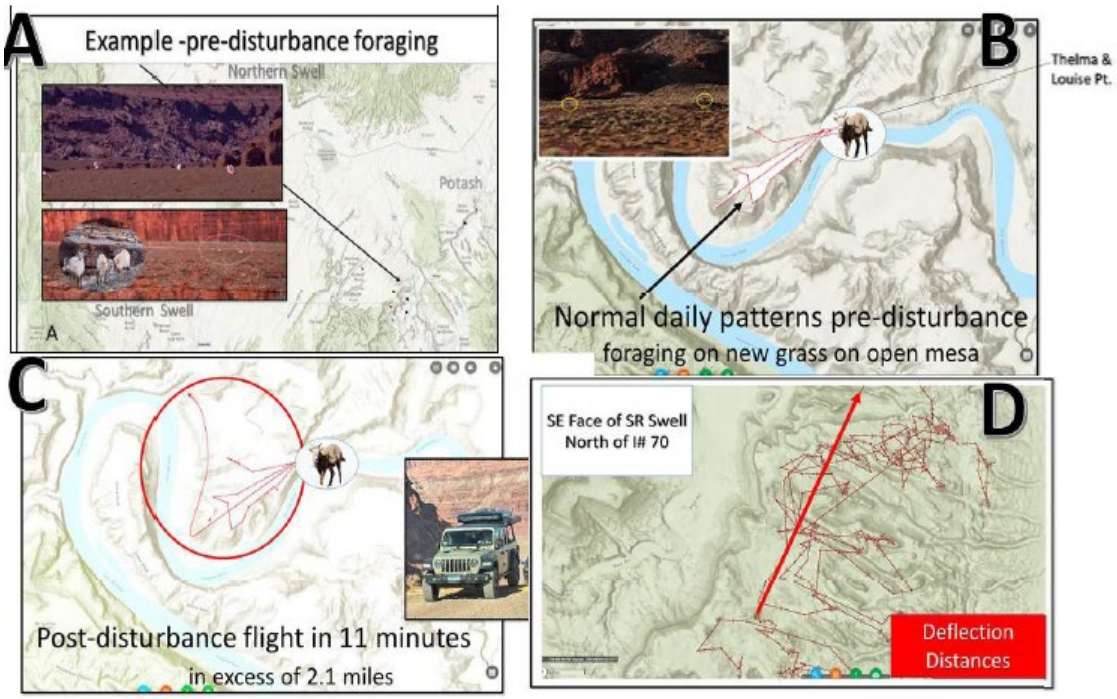

Fig. 8. Maps: A) – site-specific locale in Potash area with female sheep feeding away from escape terrain; B) – normal foraging patterns of non-disturbed sheep also illustrating feeding in flat terrain away from cliffs on BLM lands; stippled area is of minimum convex polygons of several prior days; C) whereas the long red line arching to northwest indicates flight path of same group from Panel B when disturbed by a pod of vehicles; and D) – normal daily movements of female sheep in thin red lines, and the thick line to the northeast shows the 4.6 mile flight trajectory in four hours. The circled sheep in A and B are visible if images are magnified to about 200%.

<u>Illustration of Light and Heavy Responses to Disturbance</u>. – Below are three photographic examples of light, medium, and serious responses to vehicles; the first (Fig. 9) is one in which two yearlings reflect curiosity as adult continue feeding. The second (Fig. 10), reflects stronger (but mixed) reactions along a road with high levels of sinuosity. Sound (decibel levels) are weaker and visual obstructions greater, which we are investigating to determine how these factors impact flight and foraging responses.

Fig. 9. A group of five bighorns; three adults foraging as bicyclists pass - White Rim Road in Canyonlands (2023).

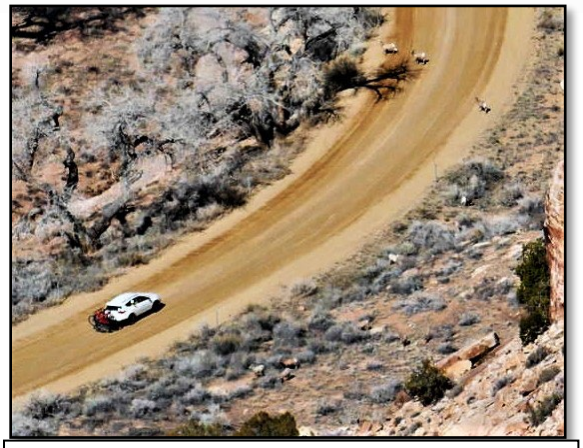

Fig. 10. Bighorn group with flight and vigilance in Buckhorn Draw – Northern San Rafael Swell (2023).

The final series (Figs. 11-13) illustrates evasive responses to a motorized group who then fled more than 600 meters when the animals could no longer be tracked.

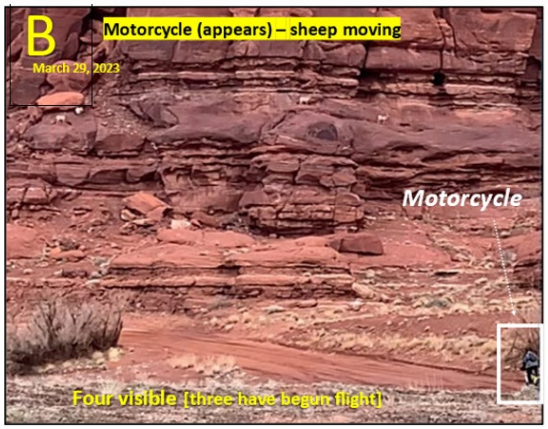

Fig. 11 A – Bighorns become vigilant to distant sound of motorcycles (not visible) about 400 m away; B – in flight as the motorcycle (far right bottom) appears. C – Motorcycle is obvious along with sheep. Potash Road (2023).

Fig. 12. – Four sheep (four) are running even though the motorcycle has departed. The sheep are above the yellow dots.

Fig. 13. – The post-flight response continued beyond 600 m (illustrated here by four sheep, above yellow dots) until disappearing.

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Auditory Experiments and Responses to Playback Experiments. – In addition to developing data sets based on experimental visual presentations and ad lib observations of responses of bighorns to disturbance, there is a growing interest in understanding how noise affects bighorns. Hence, we are exposing foraging female bighorns to the standardized pre-recorded sounds of motorcycles and human voices. We include those of ravens as a control since ravens are abundant and offer a non-threatening familiar sound. Although bighorns might react to a vehicle's speed and/or visual disturbance, our goal is exclusively to gather data on responses to noise; our playback experiments are conducted to the extent possible when bighorns do not see us. Our approach is appropriate because in many places bighorns are exposed to auditory disturbance but not the visual approaches of vehicles.

Measured responses include interruption of feeding, spacing between individuals, vigilance, group cohesion, clumping, and flight. Variables to be controlled by statistical models are distance to escape terrain, group size and composition, sex, distance between sheep and speaker (or vehicle), temperature, wind speed, and snow conditions. Notably, responses among the study areas will be contrasted to determine if exposure levels to recreationists vary; Potash having the most recreationists, San Rafael Swell-North as intermediate, and bighorns in the southwestern Swell least exposed (Fig 4).

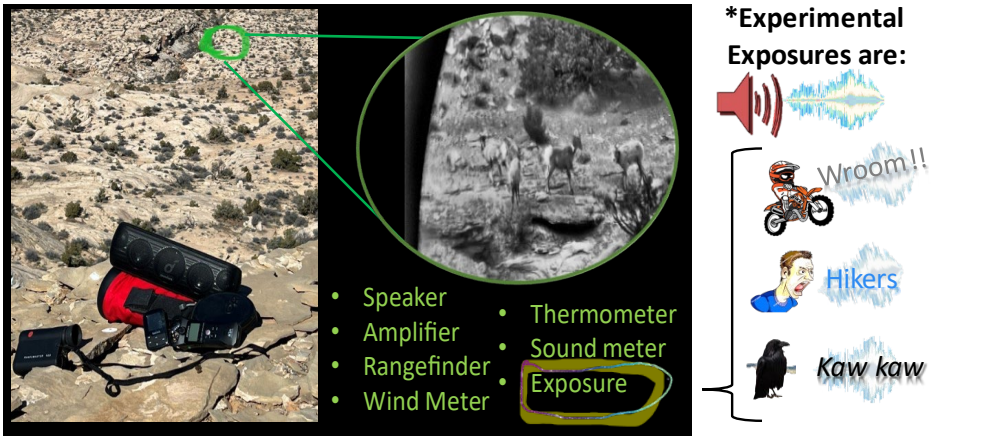


Fig. 14. – Overview of sound playback experiments. The image enlarged and circled in green are wild bighorns about 400 meters distant when exposed to sound playbacks. The types of auditory cues presented (motorcycle, raven, and human) are as indicated.

Playback experiments adopt the following protocols. The duration of broadcasted sounds is set at 20 second pulses separated by 10 second intervals and continued for three series (e. g. 60 seconds of exposure). Behavioral responses are quantified for 180 seconds, both before, during, and after exposure with traits as below (Table 1).

Table 1 – Description of response of bighorn sheep to experimental playbacks of sound exposure and in the absence of of experimental cues (e. g. control).

Trait	Description
Feeding	self-evident, but the animal may also be walking with head in lowered position
Vigilant	head focused ahead, ears erect and staring
Clumping	when group members form a tight herd (photo); clumping is an indication that the group experiences perceived danger
Walking	evident; & when head high (above shoulders) suggests lack of focus on food
Fleeing	Heightened response: our measures will include steepness of slope, distance fled until out of view, and speed (based on gait)

Each acoustic stimulus is stored as a separate (audio) file as: (i) humans talking, (ii) four-stroke motorcycle with fluctuating sounds to reflect acceleration and steady state, and (iii) a raven (as mentioned, a control for a familiar, non-threatening animal sound). As a template for contrasts with ravens is

the assessment of animal activity (e. g. feeding) when there is no exposure to any sounds. Decibel levels for all experiments are broadcast at 60–70 dB at 1 m from the speaker and levels identical for all experiments.

Preliminary (descriptive) analyses are based on 212 sound exposures to bighorns of which 60 were <225 m [Fig. 16*(A)*]. Because the sample sizes are limited, models have not yet been developed to parse out relative effects of different variables – in other words, only flight responses [Fig. 16 (*B*)] are displayed but show more than a three-fold probability of flight to motorcycle sounds than those of human hikers or raven calls when within 225 m. Nevertheless, covariates as noted in Fig. 15 including potential effects of wind, temperature, topography, and distance to speaker must be considered in future model development as sample sizes grow larger before stronger inferences are possible.

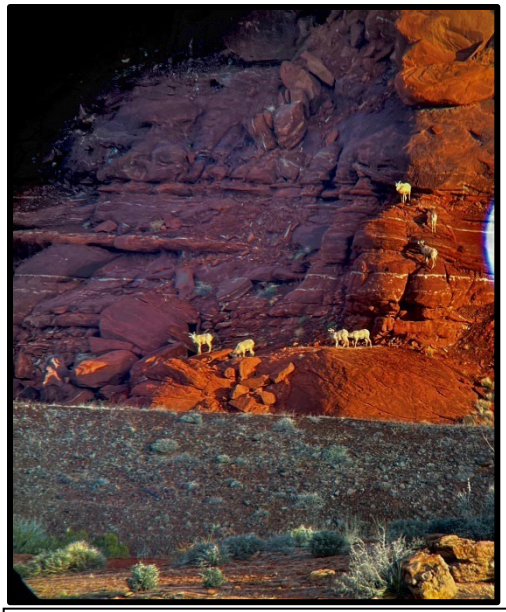


Fig. 15 – Example of sheep used as a control, with covariates of group size, distance to escape terrain (=0 m), and associated measures of green vegetation emergence (described and data in last year's progress report).

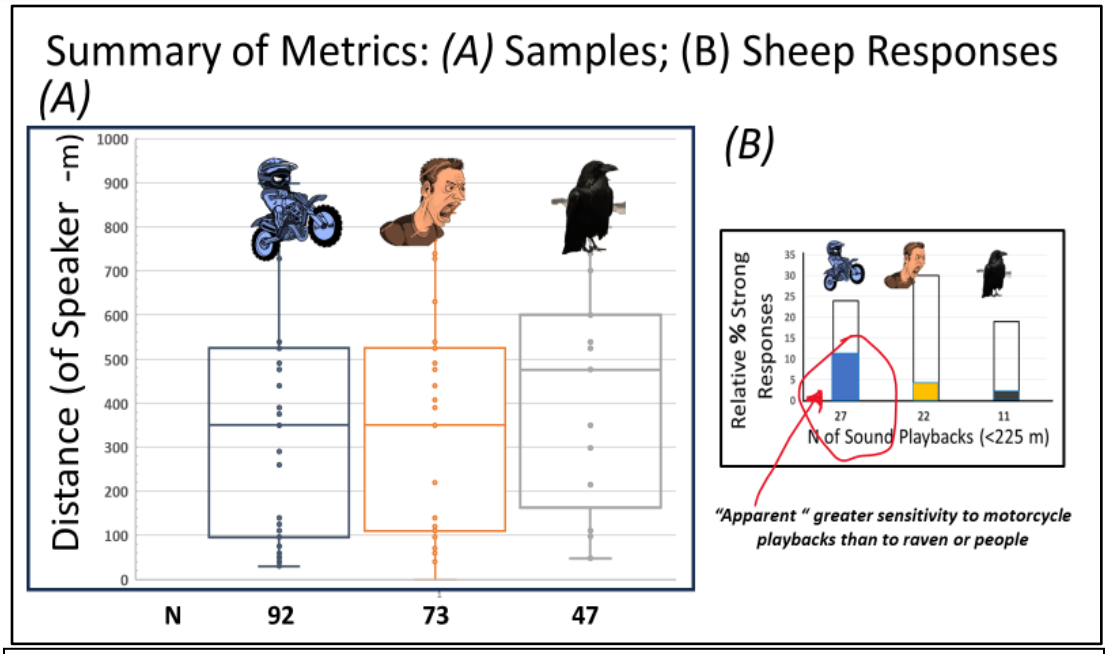


Fig. 16. – Descriptive statistics (A) of distance between sheep and speaker for sound experiments. (B) Colored bars are % occurrence of sheep flight responses relative to bar height; the blue suggests higher probability of fleeing from motorcycle sounds; Db level identical for all experiments. The height of histogram (bar) is the % of auditory playbacks within 225 m of the total sample (N) from (A). Strong sheep responses are operationally defined as those data bouts in which more than 50% of a group cease foraging for longer than 50% of a timed playback bout – responses could be clumping, walking, or vigilance, all of which precede serious flight.

Preliminary Findings (still in review)

- Energy expenditures are ~5-10X greater among non-habituated sheep in response to disturbance than those with greater familiarity to humans. Context, however, has a marked effect, even for semi-habituated animals, which can also respond strongly.
- Roads – both graveled and paved – tend to be avoided, and sheep respond more intensely when disturbed to roads of a sinuous nature.
- Motorcycles have a stronger effect due to sound than do hiking humans with loud voices, though these results are based on small samples sizes and incomplete development of statistical models.
- Low flying tourist-based helicopters regularly disturbed bighorns, causing serious long flight distances and habitat abandonment.

Outreach, Talks, and Other Communications and Cooperation

Talks, podcasts, interviews, and other forms of current outreach are highlighted in images below form 2022 and 2023. Of note, were four podcasts (one in 2022, three developed in 2023, but the last will be out in 2024). Seven lectures and public outreach events were delivered in 2023. I also wrote an OpEd/Commentary – published in the Salt Lake Tribune – was a call to heed bio-cultural respect by creation of a National Petroglyph with de facto recognition of desert bighorn or other animals of importance to Native Americans.

2021-2022

2023

Lectures (Desert Bighorns)

- National Public Lands Day (Sept – Grand Junction)
- Fort Lewis College (Sept Durango)
- Canyonlands Natural History Association (January – Moab)
- BLM-NPS – Annual Stakeholders Meeting (March – Moab)
- University of Utah (Feb – Salt Lake City)
- Science-Moab Week (Sept- Moab)
- Texas A & M University (Oct – College Station)

(c) Trails Inc.

Commentaries and Podcasts

https://www.mammalwatching.com/podcast/

https://soundcloud.com/user-495802209/human-noise-and-the-desert-bighorn

https://podcasts.apple.com/kh/podcast/conserving-species-in-extreme-environments-dr-joel-berger/id858218890?i=1000588772007

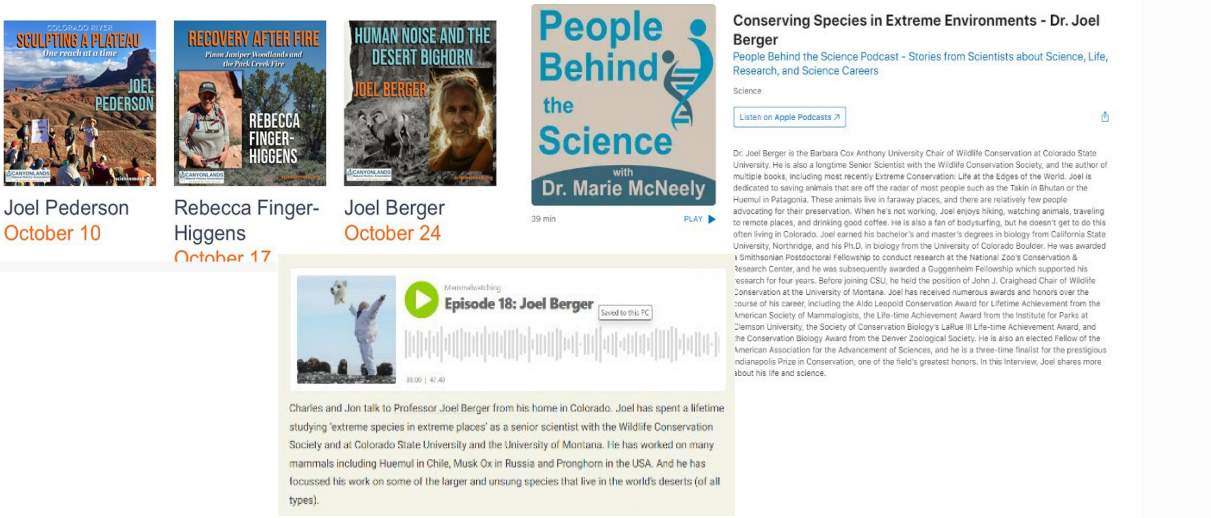

The Salt Lake Tribune MAY 30 2023

Joel Berger: What should our national petroglyph be?

It's time to elevate the telling of these remarkable symbols for future generations.

https://www.sltrib.com/opinion/commentary/2023/05/30/joel-berger-what-should-our/

Look for these podcasts in the coming weeks...



Cooperation with the State of Utah – I worked with Law Enforcement (Utah Department of Natural Resources) on wildlife harassment that involved dogs and helicopters chasing bighorns from critical habitats including along the Colorado River. Photo - work with a deputy examining maps of plots of harassment and disturbance.

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Investigative projects such as this would never succeed in the absence of not only interagency cooperation but the selfless actions of so many committed individuals and respective agencies. Wade Paskett, Dustin Mitchell, Daniel Olson, Aaron Bott, Guy Wallace of the Utah Department of Natural Resources have all made this project happen. But this project would not have even begun in the absence of BLM funding and the keen interests of so many within – including Yoni Argov, Rachelle Bruse, Carrie Darcey, David Pals, Nicollee Gaddis-Wyatt, Jonathan Blanc, and especially Jennifer Jones and Dana Truman. At USGS, a thank you to Erika Geiger for help at ScienceMoab week. But, without the multiple decades of interest and inspiration by the late Pamela Riddle, we'd know far less about desert bighorns. All of us would be short changed.

Others with pure altruistic intentions who have helped are Michael Krebs, Forest Hayes, Ken Wilson, Kristina Young, Carrie Schwartz (ScienceMoab), Doug Smith, and Kate Schoenecker. William Sloan continues to help all interested in bighorn sheep, for which I continue to learn more and more. For much of the field data collected herein I thank Kira Cassidy from Yellowstone, who commits time every spring. Science Moab helps spread the relevance of empiricism to management decisions. Both the Wildlife Conservation Society and Colorado State University enabled this project by offering financial support, as did the Bureau of Land Management. And, additional thanks to the generous support of the Canyonlands Natural History Association and efforts through Roxanne Bierman and Sam Wainer.