“WHAT MOVES US? ADVANCES IN THE STUDY OF ANIMAL MOVEMENTS”

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BOOK OF ABSTRACTS

ABSTRACTS, PLENARY SPEAKERS

DONNELLY, J. PATRICK. U.S. Fish and Wildlife Serivce

CHALLENGES OF WETLAND AND MIGRATORY BIRD CONSERVATION IN THE NEW ERA OF WATER SCARCITY

Changing climate is rapidly accelerating shifts in ecological norms and feedback loops driven by land use and natural resource policies. Migratory waterbirds (i.e., shorebirds, wading birds, and waterfowl) are particularly vulnerable to these changes because of life-history strategies supported by diffuse wetland networks that can expose populations to multiple independent risks across their range. Recent studies of waterbird flyways have shown surface water declines of nearly 50% since 2005 in wetland landscapes that are key to supporting continental migration. While some waterbirds have changed their migration chronology and range extent to align with shifting climate and land-use patterns, increasing environmental pressures are likely to outstrip the adaptive plasticity of many species. Our ability to sustain animal movement must now more than ever rely on adaptive strategies capable of efficiently monitoring and identifying emerging bottlenecks across habitat networks. To examine the climate-driven impacts of increasing water scarcity and migration, this talk will utilize wetland ecosystems and waterbird movements in western North America to discuss resource challenges facing wildlife managers in Idaho and throughout the flyway. Recent work from the presenter will highlight the disproportionate impacts on wetland function and the feedback loops in water use that magnify the inequity of wildlife winners and losers.

KAUFFMAN, MATTHEW. The University of Wyoming

ECOLOGY AND CONSERVATION OF MIGRATORY UNGULATES IN THE CHANGING AMERICAN WEST

The American West harbors vast landscapes still capable of supporting long-distance ungulate migrations. Herds of big game move across rugged landscapes up to 150 miles to access important seasonal habitats. Such movements present a conservation challenge because they require animals to cross multiple-use lands, some of which are rapidly changing. Recent research on ungulate migrations has enhanced our understanding of the benefits of migration and the threats they currently face. Detailed movement analyses indicate that migrating mule deer track ephemeral pulses of forage, a phenomenon referred to as "surfing the green wave". New work is also emerging that quantifies the foraging and potential fitness benefit of surfing and of seasonal migration more generally for temperate ungulates. I will describe how new research and new conservation tools our bringing people, agencies, and NGOs together to make such journeys easier for migrating ungulates.

LUCIA, MATT. Sagebrush Steppe Land Trust

PRIVATE LAND – THE KEY TO LANDSCAPE CONNECTIVITY

Managing wildlife on a landscape-scale is not a new concept for managers but is often difficult to achieve in practice. For example, neighboring landowners (e.g., state, federal, tribal, nonprofit, and private landowners) within the same landscape may have competing management goals or may have different mandates and implementation strategies within jurisdictional boundaries. Further adding to this management dilemma is the impact of human development on the landscape. Fragmentation and infrastructure create barriers to landscape connectivity and complicate landscape-level habitat management. Since 2017, Idaho has consistently ranked among the 3 fastest growing states in the nation, making wildlife management at a landscape-scale increasingly more challenging. However, collaborative conservation partnerships throughout the state are providing more private landowners with more conservation options for their lands. This presentation will explore some of the successes and challenges of protecting private property from development through perpetual conservation easement agreements.

MERKLE, JEROD. The University of Wyoming

THE LATEST AND GREATEST IN MOVEMENT ECOLOGY: IS FANCIER AND MORE COMPLEX METHODS BETTER?

With improvements in GPS technology, battery life, and computer processing speeds, the field of movement ecology has flourished. Much of the recent research has focused on the big data and analytical aspects of animal movement. For instance, right now, thousands of big game animals across the West are wearing GPS collars collecting locations every hour or so. These collars are resulting in datasets with tens of millions of rows per study, triggering issues in data management and analysis that few biologists have ever faced. Nonetheless, these big datasets have provided novel discoveries in movement ecology while providing much improved information to guide conservation action. In this talk, I will first review some of the latest developments in movement ecology with a specific focus on intrinsic influences on space use such as memory and sociality. Second, I will discuss how these developments in our understanding of animal movement might influence how we manage and conserve wildlife. Finally, I will talk about how these big GPS collar datasets can be used to inform conservation action. My contention, however, is that the latest data and analytical aspects of animal movement are not the answer to improved conservation. Instead, we must simplify our methodological approaches so we can focus on the space and habitat that wildlife need for survival. Once that information is clear and understandable across stakeholders, we can collectively work to conserve habitat for wildlife.

ABSTRACTS, ORAL PRESENTATIONS

ABERG, MADELINE* and J. Carlisle. Boise State University, Boise, Idaho, 83725. Intermountain Bird Observatory, Boise, Idaho, 83725

HUMAN DIMENSIONS OF WILDLIFE CONSERVATION ON PUBLIC LANDS

Public lands provide important habitat for wildlife conservation as well as opportunities for outdoor recreation. Outdoor recreation is an important goal of public lands and has many benefits for participants, including an increased awareness and concern for environmental issues. However, recreation activities can have negative impacts on wildlife, and the magnitude of impact may be related to the intensity of recreational use. We used a social-ecological approach to study the impacts of outdoor recreation on wildlife in the sagebrush-steppe ecosystem. We monitored the patterns of outdoor recreation and the abundance of multiple wildlife species at the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA) near Boise, Idaho. We created a recreation intensity variable using our observations of recreation, then used the variable as a predictor in our models of ecological outcomes. Recreation intensity varied across the NCA with a higher concentration of use in the northern portions of the site, which are closest to Boise. There was also temporal variation in recreation intensity with the highest amount of use in the spring and a decrease in the hottest summer months. Recreation intensity had an impact on the abundance of the wildlife species, but the impact differed by species. The abundance of avian and mammalian scavengers had a positive relationship with recreation intensity, while the abundance of breeding ground-nesting birds had a negative relationship. Including recreation intensity as a spatially and temporally informed variable helped us to better assess these relationships. Together, these results provide information to help balance the conservation and recreation goals of public lands.

BASSING, SARAH B., Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho 83844, David E. Ausband, U.S. Geological Survey, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho 83844, Matt Mumma, Idaho Department of Fish and Game, Boise, Idaho 83712, Matt Falcy, U.S. Geological Survey, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho 83844

SPATIAL PATTERNS OF PREDATOR INTERACTIONS IN NORTHERN IDAHO: PRELIMINARY FINDINGS

Understanding the multiple drivers that influence population dynamics is necessary for making informed wildlife management decisions. To this end, the Idaho Department of Fish and Game (IDFG) launched a broad-scale multi-year study in northern Idaho, designed to understand species interactions and community dynamics in a multi-predator, multi-prey system. Beginning summer 2020, IDFG deployed 750 camera traps across game management units (GMU) 1, 6, and 10A to investigate species interactions, including those among black bears (*Ursus americanus*), bobcats (*Lynx rufus*), coyotes (*Canis latrans*), mountain lions (*Puma concolor*), and wolves (*C. lupus*). We are in the initial stages of exploring these data to answer questions regarding the spatial, temporal, and relative abundance relationships among these predator species. In a preliminary analysis, we fit multi-species occupancy models to detection data from July – September 2020 and 2021 to explore the spatial patterns of predator detection and co-occurrence.

We found coyotes were the most frequently detected species whereas mountain lions and wolves were detected least frequently. Species-specific site-use varied by GMU and was influenced by habitat features and, in some cases, wolf activity. These factors also influenced whether black bears, bobcats, and coyotes were likely to use areas where other carnivores were present. These preliminary results pave the way for asking more in-depth questions about how interspecific interactions influence northern Idaho's predator community, as well as investigating how predator harvest, human activity, and prey affect these interactions.

BECK, JASON. Idaho Department of Fish and Game, Pocatello, ID 83204

CONSERVATION GRAZING ON THE BLACKFOOT RIVER WILDLIFE MANAGEMENT AREA

A conservation grazing plan for the Blackfoot River WMA was developed and first implemented in 2019. The plan was designed to work across boundaries with adjacent landowners to align grazing practices with fish and wildlife needs without compromising the economic viability of ranching partners. Implementation has not been without challenges, but a collaborative approach found solutions and developed improvements in tools and techniques. A couple examples include using drones alongside traditional herding to refine cattle movements and focus grazing on objective areas and discovering grazing methods that help native riparian vegetation expand. Many habitat improvements came quickly, and we are looking forward to long-term results.

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WHAT DO PAST WEATHER PATTERNS INFER ABOUT SEASONALLY MIGRATORY LARGE UNGULATE POPULATION VULNERABILTY IN SOUTHERN IDAHO?

Several large ungulates in Idaho depend on multiple habitat regions throughout the year to complete their life history. This requires individuals to use seasonal movements to avoid and to capture meteorological and phenological nutrition benefits for parts of the year. One paradigm posits that the annual fecundity can be estimated by the balance between nutrition gained with summer ranges versus the cost of avoiding deep snows with the individual's winter range. In this framework, severe winter range conditions can influence the abilities of the individual to gain subsequent nutrition during the following summer for the purposes of production. *Vice versa*, poor nutritional gains in the summer can result in an individual's condition as insufficient for it to meet the metabolic needs lowering survivorship and condition, thus further impacting the productivity of the subsequent summer. In this talk we will compare the seasonal movement patterns, through identifying individuals herd member's winter and summer ranges, of winter herds for mule deer, pronghorn antelope, and elk in southern Idaho. Summer ranges will be assessed through time measuring the annual time integrated Normalized Difference of Vegetation (Tin-NDVI) as a proxy for forage condition for 2001- 2019. Winter ranges will be assessed by using Snow Model (Liston et al. 2021) estimations of snow depth and duration. The variability of these conditions, forage availability and winter severity, will be assessed on an annual basis. We will also assess these conditions across seasons to access the variability of cross seasonal variation of conditions, i.e. severe winters followed by poor nutrition summers, as well as poor forage summers followed by severe winters. We will present these results and interpret

the relative vulnerability of winter herds considering changing snow and forage phenological patterns witnessed in southern Idaho across the recent decades.

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WHITE-NOSE SYNDROME PRELIMINARY ACOUSTIC BASELINE RESEARCH IN THE UPPER SNAKE RIVER PLAIN

North American insectivorous bats provide vital ecosystem functions and services. However, drastic declines in North American bat populations put these services at risk. The spread of white-nose syndrome has raised concerns for susceptible bat species in the west, including the little brown bat (*M. lucifugus*) and the western small-footed myotis (*M. ciliolabrum*). However, research into seasonal western bat population patterns and cave use of *M. lucifugus* and *M. ciliolabrum* is still lacking. Given this, the objective of my research was to establish a baseline of bat activity patterns using acoustic monitoring techniques in riparian and cave roost habitats throughout the Snake River Plain. I set a total of 17 acoustic detectors to document the activity levels from June to October in 2022. I collected 175,992 call files of bats (known maternities = 22,112, known hibernacula = 125,078, riparian campsites = 6,238, South Fork Snake River = 10,609, South Fork Snake River cliffs = 11,955). Preliminary data shows that both focus species were detected acoustically at all sites. Bat activity peaked from July to September. Activity at cave sites were highest at Apartment 1 and Fool's Wading Pool. Sites located at river and cliff sites along the South Fork of the Snake River differed significantly in activity levels ($\chi 2 = 437$, df =1, n = 418, p = 2.2e-16) with Swan Valley cliffs having the highest activity. These data provide an essential seasonal baseline of bat activity in the Snake River Plain prior to the arrival of white-nose syndrome.

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DEVELOPING RIGOROUS APPROACHES TO ESTIMATING HABITAT USE OF BLACK-TAILED JACKRABBITS IN THE SAGEBRUSH STEPPE

Conditions in the deserts and elsewhere are becoming more extreme in the Anthropocene. Human-caused climate change has led to several changes in weather patterns including increased temperatures, decreased rainfall, and increased fire frequency. These pressures have contributed to increased extinctions and declines of species across multiple taxa. One possible way species may be adapting is by shifting their habitat use. I will use black-tailed jackrabbits (*Lepus californicus*) living in the sagebrush steppe ecosystem as a model species to assess how medium-sized mammals are using vegetation that provide different levels of protection. Jackrabbits are key prey in semi-arid trophic webs, but little is known about their distribution, abundance, or their responses to rapid and ongoing landscape changes or the recently detected Rabbit Hemorrhagic Disease. For my Masters, I aim to (1) assess how spotlight methods compare to emerging unmanned aerial systems to estimate abundance of jackrabbits. I also aim to (2) assess how habitat jackrabbits are using different habitats in the Morley Nelson Birds of Prey National

Conservation Area. In this presentation I will outline field protocols for both field methods and factors that may be influencing detection and abundance of jackrabbits. Finally, I will discuss our preliminary findings from this year's pilot season and our goals for next year.

CLARK, BRENT* and J. Belthoff. Raptor Research Center and Department of Biological Sciences, Boise State University, Boise, Idaho 83725

RECENT ANNUAL PRODUCTIVITY IN BURROWING OWLS IS ALARMINGLY LOW.

Through annual mark-recapture and other approaches, we collected information about occupancy, distribution, ecology, and reproductive success of western burrowing owls (*Athene cunicularia hypugaea)* in the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA). Western burrowing owls are small, ground-dwelling owls that occupy open, well-drained grasslands, steppes, deserts, prairies, and agricultural lands. They are federally endangered in Canada, threatened in Mexico, and a species of conservation concern in many portions of their U.S. range, including in Idaho and in the NCA. We report (1) results of two recent (2017 and 2021) standardized NCA-wide surveys for burrowing owls finding burrowing owls are widespread in the NCA, but (2) other data spanning 28 years (1994 – 2022) showing an alarming pattern of very low productivity in the last 6 years, including in 2022 which was the lowest of all years between 1994 and 2022. Although point-count results indicate that burrowing owls are widespread, and there was no apparent reduction in number or spatial distribution between 2017 and 2021, continued low productivity combined with any future decreases in abundance would be even more concerning. Causes of low productivity and other possible threats to burrowing owls are discussed.

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LOOKING BACK AT HISTORICAL VEGETATION CHANGES TO ENSURE A RESILIENT FUTURE FOR OUR WILDLIFE

We are losing species faster than ever before. Habitat loss continues to be one of the main drivers of species losses and declines. However, knowledge of how animals respond to habitat change remains uncertain, as animals often lag decades in their responses to change. I aimed to evaluate how three decades of historical changes in habitat have influenced Piute ground squirrels, a key prey species in the Sagebrush Steppe rangelands of western US. During 2021 and 2022, we conducted repeated count surveys of ground squirrels at 48 sites within the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA). We used satellite-derived imagery of vegetation cover estimates from 1985 to 2020 to quantify current cover and metrics of historical change for four dominant vegetation types: sagebrush (dominant), other shrubs, annual herbaceous (predominantly invasive species) and perennial herbaceous (predominantly native species) understory. Using N-mixture models that also accounted for imperfect detection, we estimated how squirrel abundance changed among sites that had a variety of current and historic vegetation metrics. Preliminary results suggest that higher amounts of current understory (regardless of type) were associated with higher abundances of Piute ground squirrels. However, historical changes in shrubs also mattered. Ground squirrel abundance was lower at sites that had experienced historical

losses in non-sagebrush shrubs. Ground squirrels were more abundant at sites with stable, unaltered sagebrush. Overall, these preliminary results suggest that historical changes in shrub cover continue to impact the prey populations of today (i.e. there was a lag in squirrels' response to shrub change). However, ground squirrels appear to respond faster to low cover of understory vegetation. Combined with the wide scale declines in prey populations at the NCA, I suggest that conservation managers should prioritize protection and restoration of understory vegetation, while also avoiding further declines in shrub cover.

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MOURNING DOVE MANAGEMENT IN IDAHO: LESSONS FROM THE STATEWIDE BANDING PROGRAM

The mourning dove is the most abundant game bird in Idaho and North America. It provides extensive hunting opportunities across the state. As a migratory game bird, hunting seasons are set within frameworks established by the U.S. Fish and Wildlife Service, after they consult with all state fish and wildlife agencies. Idaho participates in this process as a member of the Pacific Flyway Council. To inform these regulatory decisions, wildlife management agencies have implemented banding programs to estimate harvest, survival, and population size. In Idaho, intensive efforts to band mourning doves occurred from 1964–1974 and from 2003–Present. Over 13,000 doves have been banded across the state during the current operational banding program that informs the national mourning dove harvest strategy; band returns have been reported from across the United States and Mexico. We summarized results of this banding effort to estimate harvest and survival rates of mourning doves banded in Idaho, population estimates for the Western Management Unit, and report distribution and timing of harvest as estimated by band returns. conclusions from the spatial/migration data provided by band returns. Our results suggest most mourning dove harvest and survival rates are low. Furthermore, most band recoveries in Idaho originated from birds produced or banded in Idaho. Mourning dove banding represents the important role of citizen science in migratory game bird harvest management.

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GENETIC MONITORING OF THE NORTHERN IDAHO GROUND SQUIRREL FOR RECOVERY PLANNING

Northern Idaho ground squirrels (*Urocitellus brunneus*, hereafter NIDGS) are endemic to Idaho and federally listed as a threatened species. They persist within only a fraction of their former range due to habitat and population connectivity loss, mostly as a result of forest encroachment likely due to fire suppression. Since 2002, we have collected genetic samples from this species and evaluated genetic diversity and gene flow using mitochondrial DNA sequencing and nuclear DNA microsatellites. More recently, we identified 3,575 single nucleotide polymorphism loci (SNP) and evaluated connectivity and adaptive diversity for 15 populations and 80 individuals. However, our SNP analyses were limited to samples with large amounts of high-quality DNA,

and thus represent an incomplete sampling of individuals and populations. To address this limitation, we developed a set of 307 SNP loci for a Genotyping-in-Thousands by sequencing (GT-seq) panel that is currently being applied to approximately 1,200 archived and newly collected genetic samples from 29 populations. This dataset will be used to evaluate genetic diversity at neutral and adaptive loci, evaluate genetic structure and connectivity, estimate Ne, and identify conservation units based on neutral and adaptive loci. This information will provide insights into the extent to which NIDGS populations have had or continue to have genetic connectivity across the landscape, which populations are most important for species persistence, which populations show adaptive genetic differentiation, and which habitat features are appropriate targets for management action. Results will be used to inform recovery actions and provide critical information for future recovery planning.

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THE NORTHERN ROCKY MOUNTAIN BIODIVERSITY CHALLENGE: UNITING PEOPLE ACROSS AN ECOREGION

The City Nature Challenge (CNC) started in 2016 as a competition between San Francisco Bay Area and Los Angeles County to find and document urban biodiversity. In a mere eight years, it has become the largest annual bioblitz, with 455 sites around the world participating in 2022. While the name has remained the same, both urban and rural boundaries are now common. In 2021, Idaho first got on the map with CNCs in the Boise area, and in Bonner County. From that core, a regional mini competition was created called the Northern Rocky Mountain Challenge (NRMC). In 2022, a total of 16 jurisdictions in Idaho (3), Washington (1), Montana (2), British Columbia (8) and Alberta (2) participated. The winner of the competition is the site that gets the most people per capita to make at least one observation. The CNC is always held in the spring. The cooler temperatures limit the number and kind of species able to be observed. As a result, the CNC was used as a springboard to create summer and fall Northern Rocky Mountain Biodiversity Challenges (NRMBCs). The NRMBC involves all 106 jurisdictions that comprise the Yellowstone to Yukon ecoregion, 33 of which are counties within Idaho. Organizing county-level NRMBCs would be a great vehicle for ICTWS members, especially students, to help lay people understand the importance of biodiversity at the landscape level, and the need to mitigate habitat fragmentation. It could also be used to foster collaboration among, and some friendly competition between, various stakeholders.

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BEHAVIORAL AND NEST SUCCESS RESPONSES BY GREATER SAGE-GROUSE TO CONSTRUCTION OF A HIGH-VOLTAGE ELECTRICAL TRANSMISSION LINE

Impacts of linear anthropogenic structures, such as electrical transmission lines, on wildlife species are of important interest to wildlife and land managers. Research into these effects is often hampered by such features already existing, thus precluding the ability for before-during-after types of experimental designs. We took advantage of a natural experiment whereby a

230kV transmission line (Gateway West) was built and operational through a greater sage-grouse (*Centrocercus urophasianus*) population that we had GPS-tagged and nest monitored before, during, and after construction of the transmission line. We used Hidden Markov Models to estimate the impact of the transmission line on latent behavioral movement states of sage-grouse hens during the reproductive season as well as a generalized linear model to evaluate the impact of the transmission line on sage-grouse nest success. We identified three distinct behavioral movement states and found that movement behavior was unaffected by construction of the transmission line. Nest success was also unrelated to proximity to the transmission line, but only before and during construction. After construction nest success was strongly related to proximity, with 0% nest success within 500 m of the line, with the negative impact decreasing until there was 100% nest success > 2 km from the line. Together, these results match those of other sage-steppe and prairie tetraonid birds (grouse spp.) in central and western U.S., with mixed behavioral impacts of transmission lines on behavior and negative distance-based impacts of transmission lines on reproductive success.

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MICROHABITAT AND MICROCLIMATE INFLUENCE SEASONAL TERRITORY OCCUPANCY OF COLLARED PIKAS

Collared pikas (*Ochotona collaris*) are cold adapted alpine lagomorphs of western Canada and Alaska that are vulnerable to direct and indirect effects of climate change. However, we do not yet know to what extent they can adapt to these changes. Pikas are highly philopatric, and high rates of turnover and low rates of colonization of individual territories may be an early sign of population declines. The goal of this research was to determine whether territory-specific microclimate and microhabitat characteristics influence occupancy of individual collared pika territories across years. We quantified both summer and winter thermal stresses, which have not often been tested in conjunction but are known drivers of pika extinctions. We trapped 175 pikas, fitted colored ear-tags, recorded territory characteristics, and placed temperature loggers within pika dens across 3 study areas with contrasting climate gradients in southcentral and interior Alaska during 2017-2022. We examined changes in pika den occupancy by estimating annual colonization and extinction rates with a Bayesian dynamic occupancy model with forage availability, rock size, and multiple den temperature metrics as the explanatory variables. Across all pika dens within our study areas over 5 years, the average colonization rate (0.47) was higher than the average extinction rate (0.38), and our top models indicated that chronic rather than acute temperature metrics best predicted pika occupancy rates. These results demonstrate that specific microclimate requirements within pika dens, during both summer and winter, can influence territory occupancy. This information can advance understanding about the mechanistic links between climate and population persistence for collared pikas under the rapidly changing arctic climate.

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EFFECTS OF LEAD POLLUTION AND STREAM FLOW ON HOODED MERGANSER AND WOOD DUCK REPRODUCTION IN NORTHERN IDAHO

We used 10 years of nest box survey data to test hypotheses about the effect of lead pollution, stream flow, and time on reproductive performance of hooded mergansers (*Lophodytes cucullatus*, HOME) and wood ducks (*Aix sponsa*, WODU). We conducted the study at the Coeur d'Alene River WMA (CDARWMA), a high lead exposure area, and the Boundary-Smith Creek WMA (BSCWMA), a reference area. We measured reproductive performance as nest success, hatchability, and clutch size. We observed support for the hypothesis that HOME are more vulnerable to lead exposure than WODU. AICc weight-averaged models identified a large species by lead exposure interaction. When HOME nested within the CDARWMA, their nest success odds declined by 79.6% (OR=0.204, 95% CI: 0.045, 0.917) compared to BSCWMA. Odds of WODU success at CDARWMA, however, did not vary between the 2 WMA's (OR=0.939, 95% CI: 0.301, 2.933). We also observed support for the hypothesis that predicted variable reproductive success over time. We observed constant HOME success and hatchability from 2009-2012, but between 2012-2018, success odds increased 10.7 times (95% CI: 1.73, 66.43) and hatchability odds increased 5.8 times (95% CI: 2.18, 15.18). When HOME reproduction was constant during the early study years, WODU success odds increased 2.6 times (95% CI: 1.032, 6.497) and hatchability odds increased 2.3 times (95% CI: 1.181, 4.290). During the later years when HOME reproduction increased, WODU success declined by 65.0% (OR=0.350, 95% CI: 0.137, 0.897) and hatchability declined by 58.5% (OR=0.415, 95% CI: 0.218, 0.788). Our study demonstrates that environmental lead exposure can have negative, population-wide effects on cavity nesting duck production. Furthermore, we observed evidence that hooded merganser populations are more vulnerable to lead pollution than wood ducks. Our work also highlights the need for extensive, population-wide environmental lead monitoring in polluted wetlands, and the biota that rely on them.

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RESPONSES OF AVIAN COMMUNITIES TO RIPARIAN RECOVERY ALONG A SMALL MOUNTAIN STREAM

In 2005, Idaho Power Company (IPC) purchased the 10,212-acre Daly Creek Ranch, located in eastern Oregon, as partial mitigation for relicensing the Hells Canyon Hydroelectric Project. Restricting livestock grazing and water diversion for agriculture in the Daly Creek drainage, aided by rapidly expanding beaver activities, resulted in tripling of tree and shrub cover, a 7-fold increase in tree density, and a 4-fold increase in stream shading along Daly Creek during 2007–2018. I hypothesize that increasing complexity of riparian vegetation along the Daly Creek drainage and an expanding, connected riparian corridor would positively influence the abundance and diversity of avian communities. Starting in 2012 through 2018, annually up to 20 permanent sample sites (15-20 m radius) were monitored for 8-min each in *Forested Wetland* (n = 4) and *Scrub-Shrub Wetland* (n = 16) cover types along Daly Creek. Changes to the avian abundance and diversity were weak and changes in avian community composition modest. I postulate that the narrow and fragmented riparian (woody) vegetation, limited woody riparian

expansion into the floodplain, and lack of large, mature trees (*Populus trichocarpa*) restricts spatial and structural habitat diversity resulting in a weak response in abundance, diversity and composition of avian communities.

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MODELING ELK PARTURITION HABITAT IN IDAHO USING MOVEMENT PATTERNS OF ADULT FEMALES

Understanding where and when elk give birth is important to reduce anthropogenic impacts during calving periods and for managing habitat to meet population objectives. A common approach to develop this understanding is via resource selection functions (RSFs) built from observed calving locations. Vaginal implant transmitters (VITs) is a proven technology for obtaining these locations, however, this approach is logistically difficult, costly, and involves a substantial time commitment from field personnel. We used an alternative approach based on the movement patterns of adult females to infer calving locations. We used GPS location data of 1,091 female elk from 2007-2020 and associated movement patterns to identify putative parturition locations. We estimated parameters of RSFs for 6 populations at 2 scales: a broad-scale analysis to determine the characteristics within the general area that elk chose and a local-scale analysis that considered habitat characteristics in the immediate vicinity of the parturition site. We identified 314 partition events with most (64%) occurring during the last week of May through the first week of June (mean parturition date was 2 June). Most of the best models for predicting calving habitat at the broad scale contained covariates related to cover type, elevation, distance to snow, and slope. At the local scale, there were few covariates, beyond the cover type and distance to developed areas, that were consistently in the top model across populations. Our models performed well based on measures of sensitivity (i.e., model predicted habitat where parturition sites occurred) and specificity (i.e., model predicted non-habitat where parturition sites did not occur). By utilizing an extensive dataset on female elk locations not originally intended for this purpose, we were able to predict calving habitat across the state with comparably far fewer resources than it would have taken based on traditional approaches.

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DYNAMICS OF SMALL POPULATIONS: A CASE STUDY WITH BIGHORN SHEEP

In ungulate populations, adult survival is frequently high and contributes little to variation in lambda (λ, the finite rate of population growth). In contrast, neonate survival can vary markedly and, as a result, can be an important determinant of population growth rates. Although this paradigm has been repeatedly demonstrated in ungulate populations that are stable or increasing, whether and to what degree these patterns hold in small or declining populations is largely unknown. We used demographic data from a small herd (~60 individuals) of bighorn sheep (*Ovis canadensis*) in the Hells Canyon metapopulation to parameterize a stage-specific population model for life stage simulation analysis (LSA). We used that model to (1) estimate the relative contributions of different vital rates to variation in lambda; and (2) quantify the relative influence

of intrinsic (e.g., nutritional condition) versus extrinsic (e.g., spring precipitation) factors on key vital rates. We measured rates of pregnancy, parturition, and juvenile and adult survival for 30 adult females and their offspring from 2019–2022. Rates of pregnancy and parturition were high but variable ($\bar{x}$ = 0.85 range = 0.68-1.00). Juvenile survival rates also varied considerably across years (range = 0.5-1.0), whereas adult survival was consistently high ($\bar{x}$ = 0.865 ± 0.074). Despite being less variable, however, LSA indicated that adult survival was the strongest driver of variation in λ–all other vital rates had negligible effects. Our findings suggest that in small or declining ungulate populations that are vulnerable to stochasticity, variation in adult survival may be a more important driver of population growth than variation in neonate survival. This result has important implications for management of bighorn sheep and other species that currently occupy only a fraction of their historic range and often occur in small and/or isolated populations.

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SIDE CHANNEL RESTORATION AT THE DIANE MOORE NATURE CENTER, BOISE RIVER, IDAHO

We restored a historic side channel of the Boise River at the Intermountain Bird Observatory's Diane Moore Nature Center in Boise, Idaho, to improve water quality, enhance fish and wildlife habitat, conduct community outreach, and manage public access. After more than 10 years of planning, fundraising, design, permitting, and implementation, wildlife and habitat response to this restoration effort was immediate. Establishment of community partnerships allowed for completion and expansion of the project, while volunteer efforts continue to be an invaluable contribution. Managing public access is an ongoing challenge and threatens long-term suitability of this area for wildlife. Knowledge gaps were identified, and an adaptive management approach is being embraced. Long-term goals for the nature center are to demonstrate best practices in urban habitat restoration and conduct community outreach to provide information about coexisting with wildlife in an urban setting.

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SUCCESS OF OUTPLANTED ANTELOPE BITTERBRUSH SEEDLINGS TO ENHANCE MULE DEER WINTER RANGE ON AGRICULTURAL LANDS NEAR THE TETON RIVER CANYON

The Teton River Canyon is one of the most important big game winter ranges in Eastern Idaho supporting up to 2000 mule deer, some coming from Yellowstone National Park. Because the landscape is isolated, security for game is high. Historically vegetation was a mosaic of sagebrush steppe, aspen and mountain brush. Today much of the landscape is in small grains and alfalfa, tame grasses enrolled under the Conservation Reserve Program and limited unfarmed native habitat concentrated on steep rocky terrain. Private landowners are increasingly interested in conserving mule deer and enhancing transitional and winter habitat. Because antelope bitterbrush is a key forage plant for wintering big game, especially mule deer, managers are interested in prescriptions to increase bitterbrush. Seeding results have been poor. In this study we evaluated the success of outplanted seedlings under several management treatments and site conditions. Herbivory, soil moisture, and competition are knowm barriers to establishment. To

assess these factors, we set up test plots with three levels of herbivore protection (fenced, protected with tube shelters, and unprotected) on SW and NE facing slopes and with or without weed matting. Nearly 1000 bitterbrush were planted in May 2022 (81 plants for each of twelve site/treatment combinations). Plant survival was measured on five dates. Overall survival at the end of one growing season was 55%, with worst losses in first three months. Site aspect and fencing did not affect initial survival. Weed mats had a small positive effect. Protective tubes had a small negative effect. Initial results suggest that installing more plants may have more value than investing in plant protection, but effects of both large herbivores and rodents are likely to be greater over the winter and spring. Post-winter sampling in 2023 may tell a different story.

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LEVELING THE PLAYING FIELD: IMPLEMENTING NOVEL FIELD TACTICS TO MORE EFFECTIVELY MANAGE INVASIVE PLANTS IN THE UPPER SNAKE RIVER PLAIN

Invasive plants have arrived, established, and negatively impacted habitat throughout the Snake River Plain, including at Camas National Wildlife Refuge. Despite considerable investment of staff time and resources devoted to invasive plant management, few documented successes exist for either the early detection of new invaders or the control of established species at Camas. Although insufficient resources played a role, the Refuge also lacked the necessary programmatic infrastructure to achieve progress. The program did not include 1) precise and standardized geospatial documentation of Refuge-wide invasive weed distributions and chemical treatments, 2) a dedicated methodology for EDRR surveillance, or 3) assessment of management action outcomes on the vegetation community. Previous tactics emphasized short-term, opportunistic chemical suppression, but we sought a strategic and comprehensive strategy that measured success in native habitat integrity and resilience. In 2020, we deployed a revised invasive weed management program built upon the foundation of a geospatial rectangular grid. It included a dedicated surveillance effort for EDRR species and a long-term focus on rescuing, restoring, and building resilience of the Refuge's native habitats. In the first three years of the projected five year roll out, we surveyed 39% of the Refuge for 18 established species and 27 species not known to occur on the refuge. From these surveys, we detected 3 incipient invaders, annually monitored and treated the entire known distribution of 2 EDRR species, and strategically implemented treatments for areas degraded by cheatgrass and Canada thistle with an eye towards protecting our highest quality native upland and wet meadow habitats. These new field tactics provide quantitative measures of invasive weed infestations and management efficacy as well as a path towards building resilient native habitat that is of higher value to wildlife and more resistant to repeat invasion.

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DO BIRDS OF A FEATHER FLOCK TOGETHER? USING SPATIAL ECOLOGY TO IDENTIFY POTENTIAL SHORTFALLS IN ASSESSING IDAHO TRUMPETER SWANS

Idaho is one of the three mountain west states that supports the U.S. segment of the Rocky Mountain Trumpeter swan population. The Idaho flock is listed at the highest level of conservation concern by the state. Annual flock counts reveal a consistent lack of growth compared to the Montana and Wyoming flocks over the last four decades. More concerning, nest initiation data suggests a decline in reproductive attempts across the state. Whereas we have intensive census data used to estimate population trends, we have little information on spatial ecology of this subpopulation outside of the summer season. Understanding movements across annual cycles that may help explain these concerning trends. Therefore, we deployed a total of ten Ornitela OrniTrack-N62 GPS-GSM tracking collars to molting swans across four National Wildlife Refuges in eastern Idaho and southwest Montana during 2019 and 2020 to document important migratory and wintering locations, and summer site fidelity. These tracking data show that some individuals conduct their annual life cycle within a 30-mile radius, whereas others travel hundreds or thousands of miles between their winter and summer habitats. We also observed some significant interannual variation in summer habitat site fidelity with some individuals venturing into Canada during subsequent years. All these data are critical for understanding the population trends, distribution, and dynamics of the Idaho Trumpeter swan flock and how they relate to the larger Rocky Mountain Trumpeter swan population. These are also vital to understanding outcomes of previous translocation efforts, future conservation needs, and this populations' resilience to climate change.

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USING LANDSCAPE SCALE NUTRITION MODELS TO PRIORITIZE AND MAXIMIZE USE OF ELK HABITAT TREATMENTS ON THE NEZ PERCE-CLEARWATER NATIONAL FOREST

Evidence from recent studies demonstrated the importance of summer nutrition to elk, both for habitat selection and to support productivity. Additionally, elk research has long emphasized the importance of avoidance behavior to disturbances such as open roads and motorized trails. We used previously developed landscape nutrition models overlaid with Forest Service motorized route data to identify and prioritize where habitat treatments would provide the most benefits to elk based on two principles, providing adequate nutrition within watersheds to meet the needs of reproductive elk, and maximizing use of that nutrition. We sought to answer four questions: 1) Do existing summer habitat conditions provide adequate levels of nutrition? 2) Do watersheds not currently providing adequate usable nutrition have the potential to provide adequate nutrition after treatments? 3) How much treatment would be needed Forest-wide to provide adequate nutrition in each watershed? 4) Which watersheds should be prioritized for elk habitat treatments? Based on published literature, we assumed high-quality nutrition is needed on at least 10% of sub-watersheds and, to maximize use, nutrition should be located further than ½ mile of open motorized routes. Ignoring motorized routes, all watersheds have potential to

provide adequate nutrition. A total of 220 of 238 sub-watersheds currently have adequate nutrition, while 18 have insufficient nutrition because of lack early seral conditions. When motorized routes are considered, 78 sub-watersheds currently do not provide sufficient nutrition outside of ½ mile of motorized routes. Of those, 60 have sufficient nutrition but use may be reduced because nutrition is within ½ mile of motorized routes. Forest-wide only 160 sub-watersheds currently have adequate nutrition outside the influence of motorized routes. We present the sub-watersheds to be prioritized for treatments and acres of treatments needed to provide adequate nutrition.

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FINE-SCALE EFFECTS OF AGRICULTURE AND LIVESTOCK GRAZING ON NITROGEN FLUXES IN A SHRUB-STEPPE ECOSYSTEM

We used fine-scale sampling and stable isotope analysis of plant tissues to identify determinants of nitrogen isotopic signatures of sage-steppe plant species, and to ascertain constraints to nitrogen availability for herbivores in areas adjacent to agricultural fields. We sampled vegetation for analysis at two large and similar sagebrush-steppe sites adjacent to agricultural (alfalfa and wheat) fields in Central Idaho, USA. These sites had different grazing regimes: one ungrazed by livestock for 70 years; and one with historical and current grazing. Three abundant shrub species, big sagebrush (*Artemisia tridentata*), green rabbitbrush (*Chrysothamnus viscidiflorus*), and winterfat (*Krascheninnikovia lanata*); and two grass species, Indian ricegrass, (*Achnatherium hymenoides*) and squirreltail grass (*Elymus elymoides*), were sampled at 100-m intervals to a distance of 2 km from the edge of agricultural sites. The grazed site was more nitrogen limited than the ungrazed site, and plants occurring at greater distances from agricultural fields also were increasingly nitrogen limited. We used Principal Component Analysis (PCA) to determine the $\delta^{15}N$ and C:N characteristics of plant species as related to sites and distances from agricultural fields. We concluded that $\delta^{15}N$ was influenced most by site (grazed or ungrazed) and secondly by distance from agricultural fields, whereas C:N was influenced primarily by distance and then by site. Our fine-scale sampling revealed how N fluxes at small scales may be related to landscape-level patterns associated with cattle grazing and inputs from agricultural fields.

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USING VEGETATION DATA TO ASSESS RELATIVE VALUE OF HABITAT FOR WILDLIFE: EXAMPLES FROM 3 WILDLIFE MANAGEMENT AREAS

Habitat managers need tools for using vegetation data to assess habitat quality for wildlife. Numerous efforts to model and quantify forage biomass or energy value of vegetation for wildlife, such as elk or waterfowl, have occurred. While these are valuable, models may be geographically specific, time consuming to produce, and focused on small numbers of plant

species. This project sought to simply estimate the relative wildlife food value provided by habitats monitored on IDFG Wildlife Management Areas (WMAs) based on the cover and frequency of plant species. Vegetation monitoring to assess change after disturbance (e.g., wildfire), management (e.g., forest thinning, water management, livestock grazing), or restoration, provides a valuable dataset that can be applied to estimating wildlife value. Literature review and best professional judgment was used to assign relative food value (high, medium, low, negligible or no known use, or numerically 3, 2, 1, 0) for elk of 1,514 plant species recorded during grassland, shrub-steppe, and forest monitoring at Craig Mountain and Blackfoot River WMAs. Relative food values for waterfowl of 108 plants recorded during marsh monitoring at Fort Boise WMA were also assigned. The food value for each plant was determined by averaging its rank for protein, metabolizable energy, and known use (for elk or waterfowl, as applicable). The food value of a plant community is holistic and can be obtained in multiple ways, such as by summing the product of the numeric food value of a plant species by its mean frequency in a community, or by summing the mean cover of plant species by food value class. The plant community food value can be used to compare habitats pre- or post-disturbance or management change. This approach is not a substitute for quantifiable methods and is a first attempt requiring further review, revisions, and ranking of plants.

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EFFECTS OF THE CHEATGRASS-FIRE CYCLE ON REPTILE OCCUPANCY IN SAGEBRUSH STEPPE

Reptiles inhabiting shrub steppe ecosystems of the Intermountain West have adapted to harsh, unpredictable desert conditions, but a legacy of human land use and recent changes in disturbance regimes may put species at risk. In southwest Idaho, cheatgrass (*Bromus tectorum*) has altered the fire regime resulting in vast conversion of shrub steppe to mostly annual grasslands that burn too frequently to allow shrublands to recover. We examined how repeat fires and changes in sagebrush steppe habitats influenced native lizards and snakes. We predicted that occupancy of reptiles that prefer shrublands would decline with increased number of times burned and cheatgrass cover. We used a combination of trapping and visual encounter surveys to quantify the effect of previous wildfires, cheatgrass, and other habitat metrics on reptile occupancy. Preliminary results indicated that occupancy of most reptile species was negatively affected by wildfire frequency but the effects of cheatgrass cover on reptile occupancy varied. We concluded that the effect of the cheatgrass-fire cycle may be species specific, with winners and losers depending on a combination of habitat associations, life history, and environmental sensitivities.

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BREEDING PRAIRIE FALCON (*FALCO MEXICANUS*) FORAGING MOVEMENT AND HABITAT SELECTION IN ALTERED SAGEBRUSH STEPPE OF SOUTHWEST IDAHO

Habitat loss and degradation are primary drivers of global species declines and extinction. The reverberating effects of habitat change pose complex challenges for conservation. When plant communities are altered, prey abundances and distributions may shift, requiring top predators to adapt. We evaluated how current habitat in Idaho's sagebrush steppe has influenced individual predator foraging behavior within the Morley Nelson Snake River Birds of Prey National Conservation Area. We deployed twenty GSM-GPS telemetry units on adult Prairie Falcons and tracked their movement during the breeding seasons of 2021 and 2022. Individual falcons travel widely different daily distances from their nesting sites to foraging areas. As a result, their breeding home range size varies substantially, although movement behaviors are similar among individuals. We removed GPS locations in close proximity to each falcon's nest site to isolate movement associated with outbound travel, foraging, and inbound travel. We used Hidden-Markov Models to classify relocations at 5-second resolution into one of two behavioral states, foraging or traveling, while the falcon is in flight. We assessed the effects of vegetation cover (obtained from satellite imagery) on parameters of step length and turning angle distributions, and on transition probabilities that estimate the likelihood of falcons switching between states. Preliminary results suggest Prairie Falcons are more likely to forage in open habitat lacking dense shrub cover and show more directional flight, consistent with traveling, as shrub cover increases. These findings are congruent with preliminary findings of prey abundances, which suggest that current Paiute ground squirrel abundance is higher in areas with greater herbaceous cover. Project findings can therefore guide future management to ensure the benefits of habitat recovery can scale up, from plants to top predators.

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HOW DO INDIVIDUAL ATTRIBUTES PREDICT BIRD CONSERVATION BEHAVIORS AMONG BIRDERS IN THE UNITED STATES?

There is a serious disconnect between birder interests, the needs for bird conservation, and public policies for bird conservation in the United States. An estimated 45 million Americans feed and/or watch birds. At the same time, 233 species of birds (22% of all native species) need conservation action, and 70 species are at a tipping point. Numerous studies have shown long-term declines in the number of hunters, fishers, and other consumptive users. Despite these megatrends, the policies of public agencies are fixated on the past. To better respond to evolving public values and bird conservation needs, it is necessary to gain an understanding of the values, motivations, and behaviors of birders. A survey of 5502 birders across the U.S. revealed that, 1) 42% of respondents scored bird conservation second only to acquiring more skills in identification among their top priorities, 2) < 5% were members of major ornithological societies, 3) age and interest in bird conservation were inversely correlated, 4) females were

more interested in bird conservation than males, 5) all age groups would like to get more information about bird conservation, 6) birders tend strongly liberal, 7) early childhood experiences were scored as important but were not predictive of adult behaviors, 8) 30-40% of respondents were not familiar with bird conservation initiatives, and 9) bird conservation messages were important, but those from conservation organizations were much more effective than those from public agencies. There is a huge opportunity for bird conservation initiatives to increase communication directly to birders.

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INFLUENCES OF INTERANNUAL SNOW CONDITIONS ON THE DYNAMICS OF MULE DEER WINTER RANGE HABITAT SELECTION

Winter range is among the most critical habitats for migrating ungulates as it can be crucial to survival, predominantly for young individuals, during their most vulnerable time of year. Understanding how winter habitat use varies under different conditions is essential for managers to identify potential areas to conserve and anticipate possible population declines. This is even more important considering the forthcoming effects of less predictable and more extreme weather events resulting from climate change. We used random forest models to build resource selection functions for wintering mule deer (*Odocoileus hemionus*) across Idaho Department of Fish and Game's (IDFG) twelve data analysis units (DAUs). Annual winter range predictions were then generated for each DAU to examine the habitat suitability dynamics as they related to snow conditions. For each annum prediction, we calculated the total suitable area defined by the models' best thresholds for predicting use versus availability. This was then compared to the actual snow measures during that annum to assess trends. This was repeated for two additional snow scenarios including mild (20-year minimum snow conditions) and severe (20-year maximum snow conditions) snow years to assess how the relationship would hold during extreme events. We found that suitable winter range tended to increase when snow accumulation was lower and duration of snow cover was shorter but decreased when snow accumulation was greater and duration of snow cover was longer. These insights can be useful for managers to anticipate changes in habitat suitability as a function of snow conditions and guide spatial understanding of mule deer movement patterns during winter. Future work will examine summer range habitat selection in relation to draught conditions and expand the assessment of how both seasonal ranges relate to abundance and population demographics.

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ESTIMATING UNGULATE DENSITY WITH CAMERA TRAPS: AN OVERVIEW OF IDFG'S EFFORTS TO DATE

Since 2018, Idaho Department of Fish and Game has implemented several large-scale camera trap deployments with the goal of estimating abundance of unmarked wildlife populations. To date, we have primarily focused on testing the applicability of the space-to-event (STE) and instantaneous sampling (IS) models described by Moeller et al. (2018). In early trials, we deployed unique camera arrays to estimate abundance of a single ungulate species on winter

range, often using a resource selection function developed from winter GPS-collar data to inform camera distribution. Across one winter camera deployment for mule deer, two for elk, and one for moose, we had mixed results suggesting the method had potential, but logistics associated with winter estimation were limiting its potential (e.g., misalignment between camera array and animal distribution due to changes in winter severity, lack of moose detections due to restricted winter movement). We also wanted to increase efficiency by looking toward multispecies estimation with a single camera array. Given there were obvious limitations for multispecies estimation during winter, we continued our testing with camera arrays designed to produce concurrent multispecies estimates by deploying cameras during summer across entire IDFG Game Management Units (GMU). Most of our multispecies estimation efforts have been focused in GMUs 1, 6, and 10A in north Idaho, areas dominated by coniferous forest that make aerial surveys difficult. In 2021, estimates of summer (July–August) density ranged from 7–9 deer/km^2 (17–23 deer/mi^2), 2–6 elk/km^2 (4–15 elk/mi^2), and 0.1–0.6 moose/km^2 (0.2–1.5 moose/mi^2) depending on GMU and model used. The STE and IS summer density estimates were similar in most GMU/species combinations, with IS point estimates usually being slightly higher than STE point estimates. Both models seem capable of producing reasonable ungulate density estimates from a summer camera array designed for multispecies estimation.

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EXPLORING HUNTING ACCESS AS A PHENOMENON IN IDAHO

Compared to other states, hunters in Idaho have a plethora of publicly available hunting space. Idaho hunters can hunt nearly all the state's public land (66% of the state's total land area) and hold various opportunities to hunt large publicly accessible corporate timberlands and small private land parcels. Idaho's Department of Fish and Game also invests millions of dollars and thousands of hours in pursuit of opening new hunting access opportunities. Despite the relatively large quantity of available hunting space, investments in sustaining access, and investments in opening new hunting access, Idaho hunters perceive a decrease in hunting access. This finding is concerning to state hunting managers and catalyzes questions into how hunters think about access. However, access is a complex concept with diverse conceptualizations across management and research contexts. Therefore, we use a qualitative exploratory research approach to understand what access means to hunters and their experiences with hunting access. We employed a descriptive phenomenological approach that treated access as an experience. In this presentation, we outline the methodology associated with the project, discuss how qualitative social inquiry can benefit wildlife management, and share preliminary results of over 40 hunter interviews that illustrate divergent and shared meanings of hunting access in Idaho.

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IDENTIFICATION AND PRIORITIZATION OF RAVEN NESTING HOT SPOTS TO AID IN DECISION MAKING FOR THE BENEFIT OF GREATER SAGE-GROUSE

For the past eight years (2014–2021), the number and location of common raven (*Corax corax*) nests on powerlines, towers, and at facilities have been monitored at the Idaho National

Laboratory Site in southeastern Idaho. We analyzed this dataset to identify areas where ravens nested repeatedly during the eight-year period (i.e., hot spots), and we ranked hot spots based on their proximity to active greater sage-grouse leks and sagebrush habitat. Our primary objective was to provide guidance to the INL and other entities as to where they could perform mitigation activities on infrastructure to deter raven nesting in areas most likely to be used by greater sage-grouse for nesting. To identify hot spots, we used a GIS and applied a distance threshold generated from empirical data. To prioritize hot spots, we identified the number of greater sage-grouse leks within 2 km (higher priority) and 7 km (lower priority) of hot spot nests and the percentage of sagebrush lands within 2 km of hot spot nests. Of 296 documented raven nests, we identified 33 hot spots, 20 of which were on power lines, nine at facilities, and four on towers. A single hot spot at a facility was identified as the highest priority for mitigation because four greater sage-grouse leks were nearby, and 91% of the area within 2 km of the raven nests was comprised of sagebrush communities. Nine hot spots were classified medium priority, and 11 were classified low priority. Our analysis provides a decision-support tool that managers can use to take action to reduce the potential impacts of raven predation on greater sage-grouse nest success.

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FACTORS INFLUENCING SURVIVAL OF TRANSLOCATED NUISANCE BEAVERS IN SOUTHERN IDAHO

American beavers (*Castor canadensis*) alter riparian habitat and hydrological systems through their dam-building and wood-cutting activities. Managers have been using translocated beaver as a riparian habitat restoration tool in Idaho for several decades. The factors influencing survival of relocated individuals is not clearly understood and releases are often unsuccessful. We trapped and relocated 121 nuisance beavers during the summer and autumn of 2020 and 2021 in south-central and south-western Idaho. We attached VHF transmitters to 75 beavers and subsequently documented movements, mortality, and signs of habitat alteration. After assessing several release variables, we found the most influential include individual mass, seasonal timing of release, presence of Beaver Dam Analogs (BDAs), and number of individuals released together. Our results show the probability of survival of small individuals (<26 lbs) released alone is low (0.14), but releasing larger individuals (>34 lbs) into sites that include BDAs greatly increases the probability of survival (0.80) and ultimately, beaver establishment.

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ELECTION FOR SECURITY: FACTORS THAT INFLUENCE HABITAT SELECTION BY A LEPORID AT RISK OF PREDATION

Prey species select for habitat that provides security from predators. Two important properties of habitat related to security are concealment (i.e., how well an individual is hidden by structure from visual detection by others) and visibility (i.e., visual information available to an individual relative to habitat structure). Although these properties are not direct inverses, they are often

negatively correlated. However, in habitats with heterogeneous vegetation structure, animals might be able to select for both concealment and visibility simultaneously. To test the hypothesis that prey species select for both increased visibility and increased concealment, we investigated habitat selection by pygmy rabbits (*Brachylagus idahoensis*). We identified sagebrush patches currently occupied by rabbits based on evidence of use (burrows, fresh pellets, fresh digging) and selected paired unused patches. At each patch, we estimated viewsheds (i.e., visibility) and density of habitat structure using terrestrial lidar data, and concealment using photographic analyses. As expected, rabbits consistently selected for dense vegetation. Contrary to expectations, we documented no selection for concealment and simultaneous selection for smaller average viewsheds. These results suggest that rabbits might not perceive or select for concealment per se, but instead might select for proxies such as lower overall visibility and dense vegetation. However, despite using patches with lower average visibility, rabbits also selected patches with highly variable viewsheds that included access to sightlines that penetrated surrounding vegetation structure. These results suggest a more nuanced relationships between habitat structure and predation risk and underscore the need to incorporate animal perception into habitat selection studies.

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PREDICTING SPACE USE AFTER RAPID ENVIRONMENTAL CHANGE: MEGAFIRE AND GREATER SAGE-GROUSE IN EASTERN IDAHO

Rapid environmental change is a ubiquitous consequence of global shifts to climate, land use, and disturbance regimes. Such changes have altered the nature and severity of disturbances. For example, high intensity megafires that drastically alter habitat available to wildlife across broad landscapes are increasingly common. Yet, we know surprisingly little about how large-scale, high-severity fires alter patterns of habitat use for sensitive species. Resource selection functions (RSFs) are commonly used to predict intensity of habitat use across large areas, yet RSFs developed under pre-fire conditions may not be effective in post-fire landscapes. To address this issue, we studied space use of breeding greater sage-grouse (*Centrocercus urophasianus*) before and after a >40,000 ha megafire that burned in eastern Idaho in 2018. We used generalized functional response models to incorporate the effects of fire-induced changes in habitat availability into RSFs, and to map intensity of habitat use before and after the fire. We also assessed the temporal transferability of models fit using pre-fire data, when used to predict intensity of post-fire habitat use. Megafire had strong effects on the distribution of available resources and resulted in context-dependent space use that was heterogeneous across different components of sage-grouse habitat (shrubs and herbaceous vegetation). Functional responses in use and selection of nesting habitat were common and shaped by the overarching effect of megafire on vegetation. Importantly, RSFs built using pre-fire data had poor transferability for predicting intensity of post-fire habitat use. These results have strong implications for understanding and predicting how animals respond to rapid environmental change, given the capacity of megafire events to rapidly reshape ecosystems. Moreover, our results demonstrate

that functional responses in space use can be a useful lens for understanding and predicting wildlife habitat use in a rapidly changing world.

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FITNESS CONSEQUENCES OF MEGAFIRE ARE MITIGATED BY BEHAVIORAL RESPONSES OF GREATER SAGE-GROUSE IN EASTERN IDAHO

Climate change and invasive species are reshaping disturbance regimes across the western U.S., increasing the scale, severity, and frequency of wildfire in sagebrush ecosystems. Recent studies within the Great Basin suggested greater sage-grouse may exhibit maladaptive habitat selection in the aftermath of wildfire, whereby pulses of herbaceous vegetation or sagebrush islands within fire perimeters are selected despite reduced fitness in these areas. We demonstrated that sage-grouse within more mesic, high-elevation areas of eastern Idaho exhibited context-dependent space use that changed after the Grassy Ridge fire, a >40,000 ha, high-severity megafire that burned in 2018. However, the consequences of post-fire behavioral responses for sage-grouse fitness remain unclear. We used data collected from 269 females over a 6-year period under a before-after-control-impact study design to test the hypothesis that sage-grouse mitigated fitness consequences of megafire through adaptive responses to space use. We deduced predictions from this hypothesis at the population and individual levels and tested predictions using behavioral, demographic, and life history traits that contribute to fitness (7 metrics at each level), including: 3 nesting metrics, 2 brood rearing metrics, survival, and body condition at capture. Thirteen of 14 predictions were supported, demonstrating that post-fire behavioral responses by sage-grouse were adaptive and helped mitigate demographic consequences of the fire. Short-term consequences of the Grassy Ridge fire on sage-grouse populations in eastern Idaho included the elimination of nesting and brood rearing habitat and subsequent shifts to the distribution of usable space during the breeding season. However, sage-grouse have the capacity to adapt their space use to avoid short-term demographic consequences of megafire, at least where high-quality habitat remains adjacent to the fire. These results suggest that behavioral and demographic consequences of megafire on sage-grouse are context-dependent and could be impacted by attributes of the fire and post-disturbance landscape.

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RECOLONIZATION OF GRASSLANDS IN CENTRAL NEW MEXICO BY ONE-SEED JUNIPER: WHO LEFT THAT SEED THERE?

We conducted a two-year study to determine the role of birds, lagomorphs, mesocarnivores, and porcupines in one-seed juniper (*J. monosperma* (Englem.] Sarg.) seed dispersal in woodland and grassland habitats. Birds deposited the highest number of seeds/ha under the canopy of cone-bearing trees. Mesocarnivores were responsible for the highest average seed dispersal in all other habitats. Seeds deposited by lagomorphs were observed in plots across all sampled habitats. Lagomorphs deposited seeds widely in relatively high numbers across all habitats and are likely responsible for the greatest number of one-seed juniper seeds deposited on the studied landscape. We also tested one-seed juniper seed germination success after gut passage by the same animal assemblage. Germination of bare seeds was the highest (70.8% ± 7.4%) for seeds digested by mesocarnivores and was 63.9% ± 5.7% for porcupines, which was higher ($P < 0.05$) than germination of seeds from bird pellets (33.3% ± 7.7%). Germination of seeds from all frugivores, including lagomorphs (51.4% ± 7.2%), was higher ($P < 0.05$) than for seeds encased in cones (berries) (9.7 ± 3.2%). The germination percentage of seeds still encased in frugivore pellets or scats was highest for birds (40.1 ± 4.2) and was lower ($P < 0.05$) for other frugivores. Germination success differences can influence the nature of one-seed juniper woodland infill and recolonization into bordering grasslands.

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INVESTIGATION OF BROWN BEAR POACHING IN MONGOLIA USING GENETIC SAMPLES.

Bears are often killed due to their real and/or perceived threat and for their valuable body parts (e.g., inner organs, paws, and skin). Illegal hunting effects on brown bears have not been evaluated in Mongolia. Our goal was to check the origin of illegally hunted bears and determine hunting pressure in each region and on each sex. We collected 81 samples from brown bears illegally killed and confiscated by Mongolian officials and 144 bears of known geographic origin, including the Gobi Desert, Altai, Sayan, Khentii, and Ikh Khyangan mountains in Mongolia, and Genbank data. We sequenced 927 bp of mitochondrial DNA and genotyped 13 nuclear (nDNA) microsatellite loci and a sex marker for all samples. We identified 31 individual bears from the illegally hunted samples. We ran STRUCTURE and principal component analysis for nDNA data and phylogenetic analysis for mtDNA sequence data to find potential geographic locations by comparing them with the genetic information from the known regions. We detected illegally killed brown bears from Altai (n = 3), Sayan (n = 4), Khentii (n = 20), and Buteel Mountains (n = 3) ridges but none from the Gobi Desert. Brown bears in Khentii and Sayan

mountains were the most persecuted populations. This work provides an initial baseline for estimating illegal take and improving future conservation efforts and recommendations for brown bears in Mongolia.

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RAPTOR SHOOTING ASSOCIATED WITH POWER LINES IN IDAHO POWER'S SERVICE TERRITORY

Idaho Power has conducted risk assessment surveys throughout our service territory to identify raptor electrocution risk with the goal of prioritizing where poles should be modified to prevent electrocution. However, as part of these surveys we have identified avian mortalities due to shooting in 14 counties in Oregon and Idaho. Idaho Power has surveyed more than 56,000 poles from 2012-2022 and found that shooting occurred more often on federal and state land than on private land. Shooting vandalism of power line infrastructure including poles, insulators, and wires was frequently observed in areas with raptor shooting mortalities. This work highlights the need for determining cause of death of birds found near power lines and may help focus law enforcement efforts.

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DEMOGRAPHIC TRENDS OF MOOSE IN IDAHO: VARIABLE CALF RECRUITMENT AND IMPLICATIONS FOR FUTURE POPULATION GROWTH

Hunter harvest data and aerial survey counts suggest that some moose populations in Idaho have been declining since the mid-1990s. However, longitudinal demographic data spanning their range within the State are lacking. We initiated a multi-year project in January 2020 to quantify spatiotemporal variation in demographic parameters for populations across the diversity of habitats occupied by moose in Idaho. During January-March 2020 and 2021, we fitted 148 adult females and 17 9-month-old calves with GPS collars in 5 study areas. We monitored collared moose since capture to evaluate survival and facilitate investigation of mortalities. To document calf production and summer calf survival, we conducted observations of parturient collared females during May-August. We used a hierarchal Bayesian framework to estimate survival and reproductive rates. We then used a life stage simulation analysis (LSA) to explore how these demographic parameters influence growth of moose populations. Initial findings suggest that spatial and temporal variation in summer calf mortality and relatively high overwinter calf mortality resulted in low and variable calf recruitment that is likely influencing observed trends in moose populations across Idaho. These trends are further amplified by spatial variation in reproduction and adult female survival. These analyses provide the first statewide demographic assessment for moose in Idaho, help to identify life stages for focused research, and lay the foundation for evaluating the ecological factors contributing to possible population declines.

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IDENTIFYING INDIVIDUAL POLAR BEARS FROM DNA IN FOOTPRINTS

Polar bears (*Ursus maritimus*) are listed as "threatened" under the ESA due to anticipated loss of sea ice in their rapidly warming Arctic habitat. Conservation and management of polar bears has also become much more challenging due to increasingly unreliable sea ice conditions. Further, animal welfare concerns have been expressed by Indigenous peoples and others over invasive research methods. Thus, there is a need for less invasive research methods that are applicable to changing Arctic conditions. Previous studies have successfully identified carnivore species from mitochondrial DNA obtained from footprints, but attempts to amplify nuclear DNA for individual and sex identification have been less successful. To assess whether individual identity and sex could be determined from DNA extracted from polar bear footprints, we collected and analyzed snow from 5-10 footprints of 13 individual polar bears and two associated negative control samples. Snow samples were thawed and filtered to collect any cells captured from polar bear foot pads. Filters were stored in ethanol until DNA extraction. Multi-locus microsatellite genotypes and sex identification were obtained for 8 of 13 (61.5%) of the polar bear samples and negative controls showed no polar bear DNA. Further refinement is needed to improve methods and establish best practices; however, these results suggest that individual and sex identification from footprints in snow is possible. Thus, this method holds promise for genetic population monitoring of polar bears and potentially other species that occupy habitats with snow.

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STATUS OF CHRONIC WASTING DISEASE IN IDAHO; WHAT WE KNOW AFTER THE FIRST YEAR

Chronic wasting disease (CWD) is a transmissible spongiform encephalopathy that affects members of the cervidae family. It is a 100% fatal highly contagious infectious disease, with no treatment or cure available. Since the first reported case in 1967, CWD has spread infecting captive and free-ranging cervids in 30 US states and 4 Canadian provinces. CWD was first detected in Idaho in two adult male mule deer harvested by hunters in October 2021 in the Slate Creek drainage near Lucile in Idaho's Game Management Unit (GMU) 14. Additional CWD samples were collected from hunter-harvested white-tailed deer and mule deer in and around GMU 14 during ongoing hunts and emergency CWD surveillance hunts in December 2021. Six animals tested positive for CWD in GMU 14 in 2021 – 2 hunter-harvested mule deer, 2 hunter-harvested white-tailed deer, one suspect white-tailed deer, and one suspect elk. Hunt structure in GMU 14 was modified for the 2022 hunting season to increase deer harvest over the status quo and CWD sample submission became mandatory for all hunters harvesting a deer, elk, or moose in GMUs 14 and 15. As of early January 2023, 14 deer tested positive for CWD for the sample period beginning July 1, 2022, all in Unit 14 – 10 hunter-harvested white-tailed deer, 3 hunter-harvested mule deer, and one suspect white-tailed deer. We will present an overview of CWD sampling to include CWD distribution and prevalence rates in Idaho. We will also discuss

management approaches and implications for managing ungulates and disease prevalence within the CWD management zone in Idaho.

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USING PALEOZOOLOGICAL RECORDS TO INFORM THE CONSERVATION OF GREATER SAGE-GROUSE (*CENTROCERCUS* UROPHASIANUS): A CASE STUDY FROM HOMESTEAD CAVE

The Greater Sage-Grouse (*Centrocercus urophasianus*) is an icon of the sagebrush steppe communities in the American West. Unfortunately, these communities have been steadily deteriorating since historic times due to human disturbances and climate change, in turn leading to a dramatic decline in the abundance and distributional range of Greater Sage-Grouse. The conservation of Greater Sage-Grouse and their sagebrush habitats has subsequently become one of the most prominent and controversial wildlife conservation issues in the west, resulting in the implementation of a number of conservation programs and several broad scale, multi-million-dollar, state- and federally sponsored management plans. However, these plans are often formulated using only historic data—a record spanning less than 200 years and marked by extensive anthropogenic impacts that undoubtedly played a significant, if not primary, role in shaping the current distribution of the species. Thus, the long-term range shifts of sage-grouse in relation to different environmental variables in the absence of human influence remain largely unknown. This study links the late Pleistocene and early Holocene paleontological record of Greater Sage-Grouse from Homestead Cave to other datasets indicative of past local environments to examine the environmental conditions that affected sage-grouse distribution in the past. The results of this analysis indicate that while sage-grouse are indeed inextricably tied to sagebrush, their distribution is further limited by climate. This information could assist in identifying areas conducive to successful reintroductions, which should be of interest to those involved in developing management plans and legislation designed to protect these iconic birds and their unique habitats. Ultimately, this case study demonstrates the value of paleontological and archaeological datasets to inform modern-day wildlife management and conservation.

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CHARACTERIZATION AND COMPARISON OF GUT MICROBIAL COMMUNITIES IN A THREATENED HERBIVORE

The microbiomes of herbivores can serve important roles in host health and local adaptation. For example, the Greater Sage-grouse (*Centrocercus urophasianus*), whose diet consists of chemically defended plants (e.g., sagebrush, *Artemisia spp.*), may have locally-adapted gut microbial communities that are involved in the digestion and detoxification of consumed plants. We use 16S amplicon sequencing to investigate and characterize the microbial communities in gut compartments of Greater Sage-grouse using non-invasively collected fecal and cecal samples. Samples were collected in spring of 2019 across two sites in central Washington: Sagebrush Flat, a vegetation recovery site surrounded by agricultural wheat fields, and Mary Jane, an area central to one of the few large leks remaining in native habitat. Here, we characterize differences in microbial communities between fecal and cecal samples and between sites to identify the potential role of microbes in a locally adapted herbivore experiencing land use changes. Characterizing microbiomes of Greater Sage-grouse across both native habitat as well as "recovered" or "managed" habitat may help us identify a functional mechanism for adaptation. Results may reveal the significance of considering microbial relationships and local adaptation when applying management methods as species face habitat loss, fragmentation, climate change, and human disturbance.

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GENETIC MONITORING AND ASSESSMENT OF MEXICAN WOLVES (*CANIS LUPUS BAILEYI)* VIA NON-INVASIVE SAMPLING

In the wake of European colonization, the Mexican gray wolf subspecies along with its northern counterparts were eradicated from the lower 48 states. Since reintroduction to the southwestern United States, the subspecies has struggled with a substantial genetic crisis; with the most recent reported numbers having inbreeding coefficients at 0.2 and a high chance of extinction within the next 100 years. Approaches such as cross-fostering captive-bred pups have been used to try and bolster the wild population's genetic viability. The purpose of this research is to examine the current genetic health of the Mexican wolf population through non-invasive genetic sampling (NGS) and determine the success of non-invasive scat sampling at detecting cross-fostered & unknown individuals using scat collected from the Blue Range Wolf Recovery Area. Success rates will be compared to prior years and parentage reconstruction will be completed with the program CERVUS. The pedigree will be used to estimate inbreeding coefficients. In the summer of 2022, 78 fecal samples were collected at dens, rendezvous sites, feeding areas and

trails in the Mexican wolf recovery area. DNA has been extracted from all samples. Species and individual identification are ongoing.

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FECAL DNA ANALYSIS OF THE COLUMBIA BASIN PYGMY RABBIT TO DETERMINE SEX AND SPECIES ID

The pygmy rabbit (*Brachylagus idahoensis*) is a sagebrush obligate that occupies the sagebrush ecosystems of the western United States. As a result of a decline in the sagebrush steppe due to cropland and development conversion in central Washington State; the Columbia Basin pygmy rabbit (CBPYRA) was added to the list of endangered species under the US Endangered Species Act (ESA) in 2001. The remaining 16 members of the CBPYRA population were added to a captive breeding program, along with four rabbits from Idaho to mitigate inbreeding. In 2011, the rabbits were moved to a semi-wild breeding enclosure in the recovery area and additional rabbits were added to the breeding pool from various locations across the western United States. Since 2011, over 2,000 pygmy rabbit juveniles have been released into the wild on the Sagebrush Flat Wildlife Area, Beezley Hills and Malone Farms. Fecal DNA from samples collected between December 2021-Febrauary 2022 will be used to monitor these CBPYRA populations. 206 samples were collected during those months. The goals of this project are: (1) to determine species identification for each pellet sample collected using a mitochondrial DNA fragment analysis test, and (2) sex identification through the amplification of a portion of the Y chromosome. All samples that are identified as pygmy rabbit will be analyzed using a Genotypes by thousand (GT-Seq) single nucleotide polymorphism (SNP) panel consisting of 497 loci to determine individual identity, parentage, as well as genetic estimates of ancestry. Success rates for species and sex ID were 99.51%. Out of the successful amplifications, 83.98% were pygmy rabbits and 55.43% were female. This data will be used to help guide conservation and management efforts for the CBPYRA populations in Washington State.

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PROCESS-BASED MEADOW RESTORATION IN TOURMALINE HABITATS MEADOW, LATAH COUNTY, ID

Past and present agriculture, logging, and channel straightening activities, coupled with climate change and the removal of beavers, have led to largely dewatered meadow systems in the Potlatch River Watershed of the Clearwater River Basin in north-central Idaho. The 2007 Potlatch River Watershed Management Plan establishes the following goals: 1) reconnect degraded meadow streams with their historical floodplain, 2) hydrate meadows by promoting annual overbank flow during typical spring runoff events, 3) store spring flows within existing meadows to allow for longer release into meadow streams, 4) remove channels from artificially straightened ditches and increase channel length and planform to resemble historical conditions, and 5) reestablish riparian vegetation that is native to wet meadow systems. These Watershed

Management Plan goals focus on restoring processes that will benefit the ecosystem, including restoration of a more natural hydrologic process. The Tourmaline Habitats Meadow Restoration project (Tourmaline) provides an example of restoration strategies that effectively reconnect floodplains and promote increased water retention later in the season. The Tourmaline project is on the Middle Fork Big Bear Creek, which is a tributary to the Potlatch River in Latah County, ID. By reconnecting 49 acres of floodplain and treating 1.28 stream miles, the project aims to restore hydrologic and meadow processes and reestablish riparian vegetation. The objectives are enhanced stream summer baseflows, maintenance of cool stream temperatures, and reduced fine sediment delivery to benefit the ESA-listed steelhead trout downstream of the project. In addition, restoring hydrologic processes in this headwaters reach is anticipated to have positive effects on the hydrologic function in downstream reaches. The Tourmaline project was constructed in 2021 to move the flow out of the straightened active ditch into the historic channel alignment. In the upper meadow, the existing, straightened, and incised channel was filled to enhance floodplain access, restore wetland hydrologic processes, and improve potential habitat for steelhead. In the lower meadow, two incised ditches were plugged periodically to add hydraulic complexity and to enhance floodplain access. Beaver dam analogs and large woody debris were also installed to enhance habitat complexity, slow flow, and capture debris. Project performance during the spring 2022 high flow event showed improved wetland hydrologic processes through increased out-of-bank flooding.

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LANDSCAPE CONSERVATION DESIGN IN THE HIGH DIVIDE REGION

The High Divide Collaborative is currently undertaking a Landscape Conservation Design (LCD) process, which brings diverse partners together to produce a shared, long-term, strategic landscape vision that is representative of people living, working, and recreating in the region. Thus far, the LCD Leadership Team (LT) has identified a set of eight important features in the High Divide, including connectivity, recreation, sagebrush ecosystems, and wildfire management, each of which has distinctive current conditions and threats to its future success. These conditions and threats, which the LT has conceptually modeled for each feature, will be spatially quantified through collecting, vetting, and scoring attribute layers based on their relevance and accuracy. The layers will be then compiled in Marxan utilizing a cost-benefit analysis to ultimately create a model that identifies conservation potential across the High Divide. A long-term conservation strategy will accompany this model to support local and regional decision-making and fundraising. Thus far, the LCD has been a unique case study of how spatial analysis can be effective within a collaborative framework. Although it can be challenging to engage in a highly technical, scientific process, conservation interests are invested because they are building a shared landscape vision that can support confident conservation action moving forward.

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CHUKARS IN THE CLASSROOM: A 'CURE' FOR TRAINING A COMPETENT WORKFORCE AND SUPPORTING WILDLIFE MANAGEMENT

Challenges facing the future of state wildlife agencies include a reduction in funding to support research and changes in perceptions of hunting by the public. We demonstrate how chukar hunters, Idaho Department of Fish and Game, and undergraduates in an Animal Physiology and Nutrition course are co-beneficiaries of a Course-based Undergraduate Research Experience ('CURE'). In general, hunters donate chukars to the classroom, students analyze the morphology, physiology, and behavior of chukars, and resultant data is shared with hunters and agencies. Hunters benefit undergraduate education by donating chukars used to train students in use-inspired discovery, hypothesis testing, teamwork, and communication, and by sharing local knowledge to interpret classroom data. Idaho Department of Fish and Game practitioners benefit undergraduate education by training students in aging and sexing Galliformes and co-developing research questions that could be answered by data generated in the classroom. Students benefit hunters and agencies by monitoring changes in diet and health of chukars after habitat disturbances that may influence conservation and management practices. Overall, 'Chukars in the Classroom': 1) makes classroom learning relevant to students; 2) generates data that can meet research needs of wildlife agencies; 3) identifies science-informed practices that may benefit hunters, wildlife agencies, and education; and 4) changes the perception of hunters and hunting for a young and diverse cohort of stakeholders.

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ASSESSING THE IMPACT OF ANCESTRY, PLOIDY LEVEL, SIZE, AND ENVIRONMENT ON ARTHROPOD RICHNESS FOR TWO SUBSPECIES OF BIG SAGEBRUSH

The sagebrush steppe ecosystem is home to over 300 arthropod species that depend on the foundation species big sagebrush (*Artemisia tridentata*). Characteristics within their sagebrush host affect the composition of arthropod communities. Subspecies of big sagebrush with differing genomes occupy diverse ecological niches. Hybridization events and variations in ploidy level manifest as chemical, physical and phenological differences between plants, including size and secondary metabolites. Genetic variation in big sagebrush could form the basis of an extended phenotype for the community, and larger community structures and ecosystem processes may be affected by these heritable differences. This study explored the influence of ancestry and ploidy level on arthropod community richness, represented by unique arthropod taxonomic groups collected on plants, as well as the impact of size, elevation, and latitude across three natural sagebrush steppe study areas in Idaho and a common garden plot. Study sites were predominantly inhabited by two big sagebrush subspecies: mountain (*A. t. vaseyana*) and Wyoming big sagebrush (*A. t. wyomingensis*) as well as hybrids. Over two years

of sample collections, no significant correlations between sagebrush genetics or environment and arthropod taxonomic richness were found, and sagebrush steppe habitats could not be confirmed as a model ecosystem for landscape community genomics. Nevertheless, this study provides a path forward for exploring sagebrush steppe ecosystems through the lens of landscape community genomics. It reveals a potential need for analysis of genera and species-specific interactions between arthropods and big sagebrush subspecies in future studies and elucidates what elements of the environment may be confounding variables in continued landscape community genomics research.

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ESTIMATING IN VIVO DIGESTIBILITY IN A WILD AVIAN HERBIVORE: THE GREATER SAGE-GROUSE

Successful conservation of wildlife requires an understanding of the nutritional quality of selected food sources. Many methods have been used to evaluate digestibility, diet composition, and other aspects of herbivore nutrition, but in vivo approaches often require specialized feeding trials which exclude natural variation in diet and in vitro approaches do not capture the natural digestive capacity of wildlife. Fecal mean particle size analysis uses a wet-sieving method that distributes particles from fecal droppings among sieves of different pore size to estimate in vivo digestibility of vertebrate herbivores. Fecal particle size has been validated in various herbivore species and used to predict chewing efficiency, intake, retention time, and fiber digestibility, but has not been applied to free-ranging herbivores or any avian species. We developed a simplified, rapid, and inexpensive method of fecal particle size analysis and used this method to compare in vivo digestibility of forage by free-ranging Greater sage-grouse (*Centrocercus urophasianus*). We demonstrated that the proportion of fecal particles retained on the largest sieve could accurately estimate the validated method of mean fecal particle size that uses multiple sieves. Our simplified method offered a more repeatable estimate of relative digestibility.

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AMPHIBIAN OCCURRENCE AND BREEDING SITE SELECTION ON STERLING WILDLIFE MANAGEMENT AREA

There is limited information on Northern leopard frog (*Lithobates pipiens, NLF*) and Boreal chorus frog (*Pseudacris maculata, BCF*) breeding sites in wetland habitats on the Sterling Wildlife Management Area (SWMA), Aberdeen, ID, USA. As a species of greatest conservation need, NLFs are a key wetland dependent species and have to be considered for future wetland management projects. To assist IDFG in understanding more about the SWMA amphibian populations, we wanted to discover the WMA locations for both species of amphibians, determine where they are breeding, and learn the environmental conditions at breeding sites. We

developed driving surveys to listen for calling behavior in April 2022 across five wetland locations to develop a baseline understanding of amphibian occupancy. We also set up two audio recorders, one stationary as a reference, and one mobile recorder. We conducted visual encounter surveys June-July 2022 across the same five locations. Water temperature data and surface weather conditions were collected, vegetation and hydrology information were acquired from IDFG. Varying life stages of BCFs were found between all five sites (egg mass, larvae, metamorphs, adults). NLF adults were found at two sites, and only larvae and one juvenile were found at one of those sites. Water temperatures and surface weather conditions were found to not vary substantially between sites; however, the area experienced a severe drought over the summer, and climate, vegetation, and wetland hydrology data is being looked at for final analysis to compare different sites. Previous NLF surveys conducted 10 years prior suggest lower detections of NLFs on the SWMA, but more extensive surveys are needed to determine if this is substantiated or just driven by current habitat conditions. We were also unable to find more life stages for NLFs, this survey needs to be repeated to determine more breeding site information.

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USING EBIRD TO EXAMINE THE AUTUMN DEPARTURE TIMING OF NORTH AMERICAN MIGRATORY RAPTOR SPECIES

The onset of autumn migration in raptors is an ecologically interesting event that presents an opportunity for continued exploration to further our understanding of bird migration and improve species conservation. Many raptor migration studies take place at count sites or with relatively few tracked individuals, but these methods do not address questions about the local factors affecting the timing of departure and the variation in departure timing under diverse conditions across a broad scale. Citizen science data allows for a broad view of which bird species are present where and when and has been used to study the timing of spring arrival in several migratory bird species. We used observational data from eBird, a global citizen science project created and maintained by the Cornell Lab of Ornithology, to examine the spatial and temporal presence of 22 migratory raptor species in their North American breeding areas in all years with available data (2002-present). We then used Generalized Additive Models (GAMs) to estimate departure dates for each species, each year, based on the relative decline in lists reporting the species in the second half of the year. This allows us to examine trends in the variation of departure timing between species, regions, and years. Additionally, we completed several exploratory analyses on trends in data availability and species detection rates that may affect the precision and accuracy of the departure dates we determined. Results from our analyses will demonstrate the benefits and disadvantages of using eBird as a tool for studying the migratory timing of raptor species in North America, ultimately contributing to our ability to understand the factors affecting raptor migration.

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WHAT'S ON THE MENU? IDENTYING POTENTIAL WINTER FORAGE AREAS USING COLLARED TRUMPETER SWANS OF THE ROCKY MOUNTAIN POPULATION.

Over half of the Rocky Mountain Population (RMP) of Trumpeter Swans winter in the Greater Yellowstone Ecosystem. During this part of the annual cycle, their foraging ecology determines overwinter survival and subsequent reproductive success. In recent decades, observers have noted that some individuals are engaging in field feeding, a novel behavior for this species. While field feeding can help wintering swans meet nutritional requirements, there may be costs associated such as exposure to novel contaminants including pesticides, powerlines, and predation. Given recent declines in survival and nest success among the Greater Yellowstone subpopulation of RMP trumpeter swans, we wanted to understand 1) where these individuals were wintering, and 2) threats they may be exposed to during this part of their annual cycle. We deployed ten Ornitela OrniTrack-N62 GPS-GSM tracking collars to molting swans across four National Wildlife Refuges in eastern Idaho and southwest Montana. We used movement data from 2019 to 2022 to identify wintering grounds and quantify what proportion of those were agricultural areas. During the winter, collared individuals regularly occurred in the Snake River Plain between Rexburg and American Falls Reservoir, between Grace and Preston, at Bear Lake NWR, and south of Palisades Reservoir. By overlaying stationary locations onto a USDA crop map, we identified the associated land cover type. During the day, swans spent ~39% of their stationary time in agricultural fields and ~52% of their time in wetlands or open water areas. These data strongly suggest that some GYE birds are spending time in agricultural fields during the winter and spring. We need to better understand this part of their annual cycle in order to explain declining trends within the GYE subpopulation; this requires movement data from more individuals. We aim to increase the number of collared swans to further elucidate trends in winter foraging.

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CREATING A SPECIES INVENTORY AND CHARACTERIZING ACTIVITY PATTERNS OF BATS IN THE UNIVERSITY OF IDAHO EXPERIMENTAL FOREST USING ACOUSTIC MONITORS

Did you know that bats comprise almost 20% of all mammalian species? There are over 1,400 species of bats worldwide which range in their size, habitat preferences, dietary needs, and echolocation abilities. They play an important role in providing ecosystem services, including pollination, seed dispersal, and mitigating insect populations that damage crops and spread disease. Most bats use ultrasonic echolocation to navigate and forage for food, which allow many species to occupy a unique niche that nocturnally predate flying insects. This is the case for all 14 species that are found in Idaho. Each species of bat has their own specialized echolocation call, which allows researchers an opportunity to non-invasively study bats using acoustic data. This study used fourteen AudioMoth monitors selectively stationed in the University of Idaho Experimental Forest to be representative of the three bat habitat types and maximize detections.

These monitors collected recordings from May 27th to August 9th, 2022, after which the monitors were removed, and data was compiled. The recordings were processed through Kaleidoscope Pro which automatically assigned a species identification. Each species identification was verified manually, and a comprehensive species inventory was created. The data was then analyzed for activity patterns related to precipitation, temperature, habitat type, reproduction season, and other factors. A preliminary species inventory and analysis has found that thirteen Idaho-native species were detected in the Experimental Forest, with *Lasionycteris noctivagans* having the highest number of detections. Further findings are expected to provide insight into what elements most effect the activity of the bat species found in northern Idaho. This information is important for wildlife and habitat managers of areas that these fourteen species occupy.

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DEVISE: AN INTERFACE TO ENABLE WILDLIFE MANAGERS TO USE WEATHER AND ENVIRONMENTAL DATA

Harnessing the data revolution has been particularly arduous for on-the-ground land and wildlife managers because of the data skills necessary to download, organize, visualize, and synthesize large amounts of data. For instance, while weather is often key to determining harvest quotas, wildlife managers must often rely on their GIS departments to create maps or spatially explicit graphs of how metrics such as summer max temperature, winter precipitation, or date of spring run-off all have changed over the last few years or decades. Yet, the data for such analyses are freely available. Over the last 2 years, we have been developing DEVISE (Derived Environmental Variability Indices Spatial Extractor; https://devise.uwyo.edu/) to overcome the disconnect between the data revolution and on-the-ground application by developing a database and analytical system to calculate derived metrics from federated data products and algorithms. DEVISE summarizes several weather and environmental products for different management units in selected states (including Idaho). We have built a front-end, easy-to-use interface for users to download and visualize metrics. For example, the user can plot results on maps, view results in a graph, and compare results across different years and management units. Our initial effort has yielded an alpha-version of an integrated data system, developed in close consultation with our state partners, to streamline how environmental data can be used by land managers and biologists, which ultimately will facilitate informed decision making such as where to conduct habitat restoration, how many animals to harvest, and optimal placement of future development projects.

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ENVIRONMENTAL EDUCATION IS WHAT MOVES US: THE WORK OF THE IDAHO ENVIRONMENTAL EDUCATION ASSOCIATION

The Idaho Environmental Education Association (IdEEA) is dedicated to the advancement of environmental education is Idaho. We support and promote the activities of all educators working to clarify our understanding of the natural world and our role in it. To this end, we

provide monthly blog posts on our website, a quarterly newsletter to our mailing list, local in-person events, and partnerships with continuing education workshops and conferences around the state. We invite you to connect with other environmental advocates and educators around Idaho to expand our network and collective impact: you can find us online at idahoee.org, where you can sign up for our newsletter; you can become a member and join our members-only Facebook group; you can register for a conference for more in-depth learning; and you can apply to be a Board Member to strengthen our organization as a whole. We welcome your participation and input on how to better serve scientists, advocates, and educators working in the environmental field.

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AN UP-TICK IN INFESTATION: UNDERSTANDING WINTER TICK TRENDS ON MOOSE IN IDAHO

Winter ticks (*Dermacentor albipictus*) have been associated with severe metabolic consequences in moose (*Alces alces*) in North America, and growing evidence suggests that ticks are an important factor in mortality in some populations. Moose with high infestations of winter ticks often damage their pelage in attempts to remove ticks, resulting in hair loss across the neck, shoulder, and rump, and hair loss severity is assumed to reflect relative tick infestation. We used three indices to evaluate levels of winter tick infestation on moose across Idaho. First, we counted ticks on 100-cm^2 sections of hide collected from hunter harvested moose (n=487) and natural mortalities (n=10) during August-November of 2020 and 2021. Second, similar tick counts were conducted on live moose during immobilization for radio collaring. Third, we quantified and categorized hair loss severity using photographs of the collared moose with ImageJ software. A generalized additive model using Poisson distribution revealed significant regional differences in tick densities on samples from hunter harvested animals. Across regions, tick densities were significantly higher in 2021 than 2020. The counts also documented a distinct increase in tick density through October, which is consistent with the timing when moose acquire questing larval ticks. These results suggest that hide sample counts provide a reliable index of relative intensity of tick infestation against which we can compare other indices and that can serve as a response for analyses evaluating the relationship between environmental parameters and winter ticks on moose across Idaho.

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SNAPSHOT USA: AN ANNUAL CAMERA TRAP SURVEY OF THE UNITED STATES

The Snapshot USA project is an annual collaborative effort between scientists and citizen scientists to sample mammal populations with camera traps across the United States. Every year, Snapshot collaborators use a standardized protocol to sample sites stratified across habitats and development zones within the USA from September through October. These data provide a

snapshot of the mammal community for each year and are useful for exploring the drivers of spatial and temporal changes in relative abundance and distribution, as well as the impacts of species interactions on daily activity patterns. In 2021, data were collected across 109 camera trap arrays in 47 states and consisted of 1,711 camera sites, 1,833 camera deployments, and 71,519 camera trap nights. All data were managed and identified within the Wildlife Insights cloud-based platform, which uses Artificial Intelligence to assist with identifications and enables collaboration with people all over the country. Since the inception of this project in 2019 through this year, 2022, we have recorded over 440,000 observation sequences of free-ranging mammals. This year alone, we collaborated with 92 different institutions in 44 states to collect data. This continually growing Snapshot dataset has a wide range of potential uses, including tracking wildlife populations' responses to changes in land use, land cover, and climate across spatial and temporal scales. With this in mind, we are seeking to expand the Snapshot USA network and in 2023 welcome many new collaborators to this project.

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USING GIS SUITABILITY MODELING TO IDENTIFY POTENTIAL REINTRODUCTION SITES FOR BOREAL WOODLAND CARIBOU IN MINNESOTA

We investigated habitat suitability for potential for boreal woodland caribou (*Rangifer tarandus caribou*) reintroduction to the Boundary Waters Canoe Area Wilderness (BWCAW) of Minnesota, USA. Boreal woodland caribou are a historically important herbivore of the northern boreal forest ecosystem, playing a key role in nutrient cycling and maintaining vegetative community composition. Following a period of unregulated logging and caribou's concurrent disappearance from most of the Great Lakes region by the 1940s, the region's old-growth boreal forests have exhibited increasing homogenization and conversion to deciduous forests. Beyond their ecological and cultural importance as the primary deer species of North America's boreal forests, restoration of caribou is consistent with restoration and conservation of remaining boreal forest. We used the suitability modeler tool in ArcGIS Pro to identify suitable habitat within the BWCAW based on broad selection preferences including stand age, landcover, and forest type. We found a 52,000-hectare area with high suitability that could support an estimated herd size of 100-200 caribou. This modeling result considered known threats to caribou survival, including a meningeal worm transmitted by white-tailed deer (*Odocoileus virginianus*) and predation by gray wolves (*Canis lupus*). Our findings together with previously established strategies for caribou translocation and reintroduction, we judge that if carried out, the potential for successful reintroduction at this site we identified is high.

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WHY BARN OWL ROADWAY MORTALITY INVOLVES MORE FEMALES THAN MALES

Wildlife-vehicle collisions (WVC) kill billions of animals every year. Among birds, WVC is particularly high for Barn Owls (*Tyto alba*) throughout their widespread range, especially during the nonbreeding season. One common pattern is that female Barn Owls outnumber males in WVC. For instance, Boves and Belthoff (2012) reported 1.4 times more road killed females than

males in Idaho, and Moore and Mangel (1996) found dead females 2.8 times more frequently than males in California. Reasons for this disparity remain poorly understood. We evaluated the hypothesis that female-biased mortality is caused by wider-ranging behavior, more frequent road crossings, and greater proximity to roads by females. We tracked male and female Barn Owls with GPS data loggers during two winters (2019 and 2020) in southern Idaho, U.S.A., where high rates of road mortality are reported. Male Barn Owls traveled farther per night and crossed more roads than females and, when standardized to road crossings per km traveled, there was no difference in crossing rate between males and females. Finally, there was no difference in proximity to roads between males and females. Thus, there was no evidence that females encountered, crossed, or stayed in proximity to roads more than males. Indeed, males ranged more widely and crossed more roads per night than females. Thus, we are able to reject the hypothesis that female-biased road mortality is related to higher rates of road crossings for females. Instead, it is possible that when females do cross roads they are more susceptible to WVC because of their larger size and/or lower agility than males. Or perhaps higher numbers of WVC in females reflect a population sex ratio biased toward females.