TENTH BIENNIAL

10

WESTERN STATES & PROVINCES

DEER & ELK WORKSHOP

MONTANA ★ 2013

Montana Fish, Wildlife & Parks

Workshop Proceedings

Editors
Michael Mitchell
Jay Newell
Justin A. Gude
Kelly M. Proffitt
Kristina Skogen

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Artwork by
Ky Zimmerman, Cover, MFWP
Luke Duran, Workshop Logo, MFWP
Jay Lightbody, Program Publication, MFWP

Webpage Design
Cheryl Aldrich, MFWP

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10th Biennial Western States & Provinces Deer & Elk Workshop
Missoula, MT - May 6-9, 2013

Workshop theme: *"The influences of habitat, nutrition, weather, carnivores and hunters on deer and elk populations and management."*

Abstracts, Presented Papers - Alphabetical by Senior Author

Abstracts, Status Reports - Alphabetical by State, Province or Country

Abstracts, Poster Session - Alphabetical by Senior Author

Papers - Alphabetical by Senior Author

Not presented at the 2013 workshop but submitted for inclusion in Proceedings.

Time	Monday, May 6	
1:00-5:00 p.m.	Mule deer working group meeting	
5:00-8:00 p.m.	Registration	
5:00-6:00 p.m.	Poster Session	
6:00-8:00 p.m.	EVENING SOCIAL (included with registration)	
Time	**Tuesday, May 7**	
7:30-10:00 a.m.	Registration continues	
7:00-8:00 a.m.	BREAKFAST (included with registration)	
	Session 1 Room A - Plenary Session, Moderator Mark Hebblewhite	
8:00-8:30 a.m.	Opening remarks/welcome Jeff Hagener, Director Montana Fish, Wildlife & Parks	
8:30-8:35 a.m.	Introduction to plenary session and participants	
8:35-9:05 a.m.	Bruce Johnson - Influence of habitat, weather, nutrition, carnivores, and hunting in limiting elk populations in a relatively mild and variable weather environment with a limited complement of large carnivores: Oregon	
9:05-9:35 a.m.	Bob Garrott - A synthesis of elk research on Yellowstone's central and northern ranges over the past two decades	
9:35-10:05 a.m.	Eric Bergman – Influence of habitat, weather, nutrition, carnivores, and hunting in limiting mule deer populations in a relatively mild weather environment, a limited complement of carnivores, and management focused on quality hunting experiences	
10:05-10:35 a.m.	Mark Hurley - Influence of habitat, weather, nutrition, carnivores, and hunting in limiting mule deer populations in a variable weather environment, a full complement of carnivores, and management focused on providing hunter opportunity	
10:35-11:05 a.m.	Ken Hamlin - History of deer and elk management in Montana, with reference to how habitat, nutrition, weather, hunting, and carnivores have been considered, as an example of the evolution of management in the contiguous states	
11:05-11:35 a.m.	Jim Allen - History of deer and elk management in Alberta, Canada, with reference to how habitat, nutrition, weather, hunting, and carnivores have been considered, as an example of the evolution of management in Canada.	
11:35-12:00 p.m.	Questions and discussion	
12:00-1:00 p.m.	LUNCH (included with registration)	
	Session 2 Room A - State & Province Status Updates, Moderator: Mike Mitchell	**Session 2 Room B - State & Province Status Updates, Moderator: John Vore**
1:00-1:25 p.m.	Rob Corrigan - Status of deer and elk populations in Alberta	Carlos López-González – Abundance of mule deer in northern Sonora and Chihuahua, México
1:25-1:50 p.m.	Eric Bergman - Colorado deer and elk population and inventory summary	Stewart Liley - Status of deer and elk in New Mexico, 1995-2011
1:50-2:15 p.m.	Quentin Kujala - Status of deer and elk populations in Montana, 1960-2012	Shawn Gray - Status of deer and elk populations in Texas, 2005-2011
2:15-2:40 p.m.	Will Schultz – Status of deer and elk in Wyoming, 1990-2013	Anis Aoude - Status of deer and elk in Utah, 2000-2013
2:40-3:05 p.m.	Andy Lindbloom - Status of deer and elk populations in South Dakota, 2002-2011	Brian Wakeling - Status of deer and elk in Arizona, 2013
3:05-3:25 p.m.	BREAK	BREAK
	Session 3 Room A - State & Province Status Updates, Moderator: Bruce Johnson	**Session 3 Room B - State & Province Status Updates, Moderator: Vanna Boccadori**
3:25-3:50 p.m.	Toby Boudreau - Status of deer and elk populations in Idaho, 2000-2013	Lloyd Fox and Matt Peek - Status of deer and elk populations in Kansas
3:50-4:15 p.m.	Daryl W. Lutz - Mule deer management in Wyoming: The paradigm of a public owned resource	Kit Hams - Status of deer and elk populations in Nebraska
4:15-4:40 p.m.	Gerald Kuzyk - Challenges to increasing mule deer abundance in British Columbia	Terri Weist – Status of deer and elk populations in California, 2000-2012

Time	Tuesday, May 7 (Continued)	
4:40-5:00 p.m.	Don Whittaker – Status of deer and elk populations in Oregon.	Tony Wasley - Current Status of deer and elk populations in Nevada
5:00-6:00 p.m.	State & Provincial Business Meeting	
6:00-8:30 p.m.	DINNER (on your own)	
Time	**Wednesday, May 8**	
7:00-8:20 a.m.	BREAKFAST (included with registration)	BREAKFAST (included with registration)
	Session 4 Room A - Elk Habitat, Moderator: Mark Hebblewhite	**Session 4 Room B - Harvest, Survey and Management, Moderator: Mike Thompson**
8:20-8:40 a.m.	Mary Rowland - Modeling elk nutrition and habitat use across large landscapes: New methods of meta-analysis	Paul Krausman – Effects of harvest, culture, and climate on trends in size of horn-like structures in trophy ungulates
8:40-9:00 a.m.	Evelyn Merrill – Forage dynamics related to changing forest practices at Mount St. Helens, Washington	Eric Freeman - Effects of male-biased harvest on mule deer: implications for rates of pregnancy and synchrony/timing of parturition
9:00-9:20 a.m.	Kelly Proffitt – Effects of hunter access and habitat security on elk habitat selection	Mike Lewis – Selected results from resident and nonresident mule deer hunter preferences surveys conducted by Montana Fish, Wildlife & Parks
9:20-9:40 a.m.	Robert Anderson - Theoretical elk habitat change in response to prescribed burning in west-central Alberta	Craig White – 2012 Idaho elk hunter opinions and attitude survey
9:40-10:00 a.m.	Dana Seidel - Influence of foraging behavior on home range development in elk	Victoria Edwards - Managing the North Hills/Evaro elk herd in the wildland-urban interface of Missoula, MT- adaptive management responses to shifting elk distribution and behavior
10:00-10:20 a.m.	BREAK	BREAK
	Session 5 Room A - Neonate Elk, Moderator: Peter Zager	**Session 5 Room B - Human-Ungulate Interactions, Moderator: Vickie Edwards**
10:20-10:40 a.m.	Mark Hebblewhite - Evaluating bottom-up and top-down effects on elk survival and recruitment in the Bitterroot Valley: year two update	Steven Belinda - A paradigm shift for mitigation on public lands – Landscape mitigation, mitigation banking, and conservation credits: will mule deer and elk benefit?
10:40-11:00 a.m.	Nicole Tatman Quintana – Elk calf survival and the effectiveness of black bear removal in north-central New Mexico	Marcus Blum - Impacts of Mining on Mule Deer Migrations in Nevada
11:00-11:20 a.m.	Lance Bernal - Cause-specific mortality and survival rates of neonatal elk (*Cervus elaphus*) on the Valles Caldera National Preserve, New Mexico	Jeffrey Gagnon – Evaluation of an animal activated elk crosswalk and highway fencing retrofit to reduce elk-vehicle collisions in Arizona, USA.
11:20-11:40 a.m.	Mike Ebinger - Geo-statistical methods for detecting elk parturition sites from global positioning system collar data	Jenny Jones - Influence of winter feeding on migration strategies of elk (*Cervus elaphus*) in west-central Wyoming.
11:40-12:00 p.m.	Stewart Liley – Preliminary observations and discussion on elk parturition above timberline in north-central New Mexico	Colleen Arnison – Pervasive human influences in a terrestrial food web centered on elk
12:00-1:00 p.m.	LUNCH (included with registration)	LUNCH (included with registration)
	Session 6 Room A - Population Dynamics and Predation, Moderator: George Pauley	**Session 6 Room B - Disease and Other Topics, Moderator: James Heffelfinger**
1:00-1:20 p.m.	Colleen Arnison - Understanding and managing elk decline in Jasper National Park	Paul Rogers – Relative impacts of elk, mule deer, and cattle on aspen habitat in the Book Cliffs, Utah and Colorado

Time	Wednesday, May 8 (Continued)	
1:20-1:40 p.m.	Scott Eggeman - Should I stay or should I go? Variation in migratory behavior balances fitness in a partially migratory elk population	Paul Cross – Elk contact patterns and potential disease transmission
1:40-2:00 p.m.	Victoria Edwards - The collapse of the Burdette Creek elk herd in western Montana	Julee Shamhart – Elk movements and brucellosis transmission risk in southwest Montana
2:00-2:20 p.m.	Scott McCorquodale - Abundance, productivity, condition, and survival of Mount St. Helens elk, 2009-2013, and current elk management challenges	Evelyn Merrill – Incorporating movement based-landscape connectivity into assessments of chronic wasting disease risk in the prairie provinces of Canada
2:20-2:40 p.m.	Cody Schroeder - Migration behavior, body condition, and sex differences in survival of mule deer	Teagan Hayes – Elk habitat use on degraded rangeland in the Sapphire Mountains, MT
2:40-3:00 p.m.	BREAK	BREAK
	Session 7 Room A - Mule Deer Habitat, Moderator: Mark Hurley	**Session 7 Room B - Genetics and Other Topics, Moderator: Paul Cross**
3:00-3:20 p.m.	Sophie Gilbert – Population dynamics of a forest ungulate respond to winter severity and habitat alteration	Kenneth Warheit – Genetic structure and diversity of elk (*Cervus elaphus*) in Washington State
3:20-3:40 p.m.	Lisa Shipley – Effects of spring cattle grazing on the nutrition of mule deer in a bluebunch wheatgrass community	James Heffelfinger - Hybrid swarm between divergent lineages of mule deer (*Odocoileus hemionus*)
3:40-4:00 p.m.	Grant Sorensen - Nutritional condition of adult mule deer following habitat enhancements in north-central New Mexico	James Heffelfinger - Development of genetic markers to identify Coues, Carmen mountain, and other whitetails
4:00-4:20 p.m.	Sonja Smith - Winter habitat use by mule deer in Idaho and Montana	Brock Hoenes - Development of a standardized survey protocol for mule deer herds that winter in the Columbia Plateau ecoregion
4:20-4:40 p.m.	Andy James - A habitat selectivity index for desert mule deer in the Apache Mountains of Trans-Pecos, Texas	Adam Gaylord – Ungulate activity classification: calibrating dual-axis activity monitor GPS collars for Rocky Mountain elk and mule deer
6:00-8:30 p.m.	BANQUET (included with registration) Presentation of the Wallmo Award Banquet Speaker: Susan Flader - Leopold's 'Thinking Like a Mountain' Revisited	

Time	Thursday, May 9
7:00-8:30 a.m.	BREAKFAST (included with registration)
	Session 8 Room A – Plenary Presentation/Panel Discussion, Moderator: Julie Cunningham
8:30-9:30 a.m.	Wildlife managers and administrators: Jim Hayden, Jerry Nelson, Stewart Liley, Mike Thompson, Thomas Thornton, & Brian Wakeling – Restoring deer and elk again, in the era of overabundance – Is there a will, and what will it take?
9:30-10:00 a.m.	BREAK
	Session 9 Room A - Elk and Deer Presentations, Moderator: Sonja Smith
10:00-10:20 a.m.	Tom Toman - Habitat enhancement strategy changes in elk country
10:20-10:40 a.m.	Eric Bergman - Effect of habitat management on overwinter survival of mule deer fawns in Colorado
10:40-11:00 a.m.	Julie Cunningham - Bottom-up and top-down effects on northern Yellowstone elk pregnancy and recruitment rates
11:00-11:20 a.m.	Pete Zager - Untangling Rocky Mountain elk ecology and population dynamics: a regional synthesis across the northwestern U.S.
11:20-11:40 a.m.	Paul Lukacs - The Montana deer and elk hunting population: Importance of cohort group, license price, and population demographics on hunter retention, recruitment, and population change
11:40-12:00 p.m.	Simone Ciuti - Trade-offs between predation risk and food quality re-distribute elk across a road network: not all roads are equal
12:00-1:00 p.m.	LUNCH (included with registration)

Conference Theme and Plenary Session

The theme of the 2013 Western States and Provinces Deer and Elk Workshop focused on the interacting influences of habitat, nutrition, weather, carnivores, and hunters on deer and elk populations and management. The main plenary session on Tuesday, May 7 included 6 invited presentations focused on this theme.

Bruce Johnson and Bob Garrott provided an objective view of how habitat, nutrition, weather, carnivores, and human harvest influence elk populations. They synthesized and contrasted data on elk population dynamics and limiting factors in Oregon, a relatively mild and variable weather environment with a limited complement of large carnivores, and the Greater Yellowstone Area, a harsh weather environment with a full complement of large carnivores.

Eric Bergman and Mark Hurley provided a similar overview of how habitat, nutrition, weather, carnivores, and human harvest can interact to drive mule deer population dynamics. They synthesized and contrasted data on mule deer population dynamics in Colorado, a relatively mild weather environment with a limited complement of carnivores and management focused on quality hunting experiences, with data from Idaho, a variable weather environment with a full complement of carnivores and management more focused on providing hunter opportunity.

Ken Hamlin provided a historical synopsis of the history of deer and elk management in Montana, which now hosts the full complement of native carnivores after decades of extirpated or very small carnivore populations. They emphasized how knowledge of habitat, nutrition, weather, carnivores, and human harvest, gained through scientific study, has been incorporated into the Montana deer and elk management program.

Jim Allen provided a similar review of the history of deer and elk management in Alberta, where the full complement of large carnivores was never extirpated in the northern part of the province, in contrast to the southern part of Alberta where the history of carnivores is similar to that in the states. Alberta has been managing deer and elk in this context throughout the history of professional wildlife management, and Allen discussed how Alberta's approach to big game management contrasts with other jurisdictions without such a history.

The Wednesday banquet speaker was Susan Flader, a recognized Aldo Leopold scholar and Professor Emerita of History at the University of Missouri. Among numerous writings, Professor Flader is a co-editor of "The River of the Mother of God and other Essays by Aldo Leopold," as well as author of the book "Thinking Like a Mountain: Aldo Leopold and the Evolution of an Ecological Attitude toward Deer, Wolves, and Forests." This latter work, an analysis of the back-story of Leopold's essay of the same title, explores how and why he changed his thinking on issues of predation and the interrelationships between deer, wolves, and forests, and was the basis for her presentation. Leopold's approach to wildlife management and conservation evolved during his experiences restoring deer populations in the Southwestern United States, his study of the German system of forest and wildlife management, and his efforts to combat the overpopulation of deer as a conservation commissioner in Wisconsin, prior to wolf extirpation.

On the final day of the workshop, wildlife managers articulated how research can help them with management decisions. The assembled panel of wildlife professionals was responsible for deer, elk, and carnivore management, including hunting season proposals, habitat conservation and management, surveys, and public involvement in various states across the west. These managers gave us a sense of current, real-world instances of managing top-down and bottom-up limiting factors on deer and elk populations, how research is informing those approaches, where management programs need to head, and where future research should be directed to help inform management programs.

Abstracts, Presented Papers

THEORETICAL ELK HABITAT CHANGE IN RESPONSE TO PRESCRIBED BURNING IN WEST-CENTRAL ALBERTA

ROBERT B. ANDERSON, Alberta Conservation Association, PO Box 1139, Blairmore, AB, Canada T0K 0E0.

SHEVENELL M. WEBB, Alberta Conservation Association, 101 - 9 Chippewa Road, Sherwood Park, AB, Canada T8A 6J7. 780-410-1999, shevenell.webb@ab-conservation.com

DOUG MANZER, Alberta Conservation Association, PO Box 1139, Blairmore, AB, Canada T0K 0E0. 403-562-3287, doug.manzer@ab-conservation.com

Abstract: In 2005, a stakeholder input process was undertaken to establish the values and objectives for a prescribed-burn-focused forest management plan for Alberta's Bighorn Backcountry. Representatives of the hunting community expressed their desire for future prescribed burns to maintain or improve the value of ungulate winter and summer habitat. Using a GIS-based habitat disturbance planning tool, developed in collaboration with the University of Alberta and Alberta Sustainable Resource Development, we assessed a series of options for prescribed burn planning in terms of the expected impact on elk summer and winter habitat. Following the completion of a 5,700 ha burn, we re-evaluated the theoretical elk habitat value using the tool and found that the prescribed burn produced an increase in safe (source) habitat that surpassed the predicted values based on the proposed burn unit boundary. The amount of summer habitat within the watershed increased most significantly in area of risky (sink) habitat; however, the patches of source habitat did become larger and more continuous. The models suggested that winter source habitat increased by roughly 30%, as opposed to the initially-predicted 20%, while winter sink habitat increased by 4%. We discuss these results, their limitations, and the need to assess this theoretical habitat change with ground-based monitoring.

Presenter: ROBERT B. ANDERSON, Alberta Conservation Association

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UNDERSTANDING AND MANAGING ELK DECLINE IN JASPER NATIONAL PARK

COLLEEN ARNISON, Masters Candidate, Faculty of Environmental Design, University of Calgary, 2500 University Drive NW, Calgary, Alberta, T2N 1N4. (403) 852-0195, carnison@gmail.com

MARCO MUSIANI, PhD. Associate Professor, University of Calgary, 2500 University Drive NW, Calgary, Alberta, T2N 1N4. (403) 220-2604, mmusiani@ucalgary.ca

JOHN WILMSHURST, PhD. Resource Conservation Manager, Jasper National Park, Parks Canada, P.O. Box 10, Jasper AB T0E 1E0. (780) 852-6186, John.Wilmshurst@pc.gc.ca

MARK BRADLEY, Wildlife Biologist, Jasper National Park, Parks Canada, P.O. Box 10, Jasper AB, T0E 1E0. (780) 852-4042, Mark.Bradley@pc.gc.ca

LALENIA NEUFELD, Caribou Biologist, Jasper National Park, Parks Canada, P.O. Box 10, Jasper AB, T0E 1E0. (780) 883-0394, Layla.Neufeld@pc.gc.ca

Abstract: Identifying the ecological factors driving population distribution is an interest to wildlife managers in order to determine the actions needed for a particular outcome. In the Canadian Rocky Mountains, elk (*Cervus elaphus*) are a ubiquitous mega fauna esteemed for sport hunting, wildlife viewing opportunities and conservation value. Since the introduction of elk in Jasper National Park, Alberta in 1920 populations have fluctuated over time due to predation, food availability and climate, yet from the mid 1990s Parks Canada has observed a steady population decline. This study examines the mechanisms of decline of elk in Jasper National Park. More specifically, it incorporates wolf and elk telemetry data with existing biophysical data. Akaike Information Criteria will be used to construct generalized linear models to explain the resources that are critical to elk. Spatial patterns of resource selection by elk are proven to depend upon wolf predation risk, human activity, and other habitat characteristics. This approach allows for the disentanglement of top-down (predator and human driven) and bottom-up (food or resource-limited) processes and the examination of the specific causes of decline. Additionally, data from a multi-year vegetation management program are used to assess what habitat characteristics can and are being modified to increase elk populations, which will be presented. The presence of elk populations can have ecological, social and economic benefits and can cause conflicts with humans. By unraveling the relative roles of different ecological forces in determining population change, this study will contribute to managing and conserving sustainable elk populations in Jasper and other National Parks.

Presenter: COLLEEN ARNISON, Masters Candidate, University of Calgary

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A PARADIGM SHIFT FOR MITIGATION ON PUBLIC LANDS – LANDSCAPE MITIGATION, MITIGATION BANKING, AND CONSERVATION CREDITS: WILL MULE DEER AND ELK BENEFIT?

STEVEN R. BELINDA, Beartooth Strategies, LLC, PO Box 1945, Red Lodge, MT 59068. (307) 231-3128, sbelinda@beartoothstrategies.com

Abstract: In an attempt address a boom in industrial energy development, the Department of Interior has proposed changing the way energy projects are mitigated from an on-site basis to one that works within the landscape perspective. The Final Programmatic Environmental Impact Statement and Record of Decision for Solar Energy Development for the SW US put into policy the use of "Regional Mitigation Plans" to offset the impacts from industrial solar development in the17 identified Solar Energy Zones. This action has led to a potential paradigm shift about how mitigation can be more effective in dealing with energy development including wind, oil shale, shale gas, and traditional oil and gas development. Key components of what constitutes landscape mitigation are being developed and some organizations are promoting mitigation banking and the establishment of conservation credit trading systems. Traditional approaches to mitigation banking and conservation credits have focused on wetlands and species protected under the Endangered Species Act. Biodiversity is also being contemplated as the metric to base mitigation "credits." The Mule Deer Foundation, TRCP and other organizations are working to ensure that mule deer and other big game species, which are common and hunted, are not overlooked as important in the development of these approaches. The challenge will be to make sure

that habitat and population management and current scientific knowledge is incorporated into these approaches so that healthy and sustainable populations of big game are a result of this approach and are not sacrificed to the needs of other species.

Presenter: STEVEN R. BELINDA, Beartooth Strategies, LLC

EFFECT OF HABITAT MANAGEMENT ON OVERWINTER SURVIVAL OF MULE DEER FAWNS IN COLORADO

ERIC J. BERGMAN, Colorado Parks and Wildlife, 317 W. Prospect Road, Fort Collins, CO, 80526. (970) 472-4415, eric.bergman@state.co.us

CHAD J. BISHOP, Colorado Parks and Wildlife, 1313 Sherman St., Denver, CO 80203.

DAVID J. FREDDY (Retired), Colorado Parks and Wildlife, 317 W. Prospect Road, Fort Collins, CO, 80526.

GARY C. WHITE, Department of Fish, Wildlife and Conservation Biology, Colorado State University, Fort Collins, CO, 80523.

PAUL F. DOHERTY, JR., Department of Fish, Wildlife and Conservation Biology, Colorado State University, Fort Collins, CO, 80523.

Abstract: Wildlife managers are often compelled to identify the primary limiting factor to population growth in populations. Due to their iconic status, mule deer (*Odocoileus hemionus*) exemplify this need. Habitat management, in the form of mechanical or chemical manipulation of the vegetative landscape, has been utilized as a population management strategy to bolster mule deer populations. Yet evaluation of this strategy in the form of deer population response has been lacking. To address a knowledge gap and to evaluate the effectiveness of habitat management as a deer population management strategy, we conducted a 4-year study that measured the overwinter survival of mule deer fawns on study units that had experienced different levels of habitat management efforts. When partitioned into different levels of treatment intensity, mule deer fawns inhabiting winter range that received both traditional treatments and follow-up treatments experienced higher survival ($\hat{S}$ = 0.768, SE = 0.0849) than fawns on units that experienced only traditional treatments ($\hat{S}$ = 0.687, SE = 0.108), which in turn experienced higher survival than fawns in areas that had received no habitat treatments ($\hat{S}$ = 0.669, SE = 0.113). When study unit differences in overwinter fawn survival were incorporated into a population matrix model, finite population growth rates increased from 1.098 to 1.151 in study units that had received multiple habitat treatments. Our study provides evidence supporting the long-held view that habitat management is a viable population management strategy for mule deer in pinyon pine (*Pinyon edulis*) - Utah juniper (*Juniperus osteosperma*) ecosystems.

Presenter: ERIC J. BERGMAN, Colorado Parks and Wildlife

CAUSE-SPECIFIC MORTALITY AND SURVIVAL RATES OF NEONATAL ELK (*CERVUS ELAPHUS*) ON THE VALLES CALDERA NATIONAL PRESERVE, NEW MEXICO

LANCE J. BERNAL, Department of Natural Resources, Texas Tech University, Box 42125, Lubbock, TX 79409

STEWART LILEY, New Mexico Department of Game and Fish, 1 Wildlife Way, Santa Fe, NM 87507

SARAH R. KINDSCHUH, Valles Caldera Trust, P.O Box 359, Jemez Springs, NM 87025

MARK A. PEYTON, Valles Caldera Trust, P.O Box 359, Jemez Springs, NM 87025

ROBERT R. PARMENTER, Valles Caldera Trust, P.O Box 359, Jemez Springs, NM 87025

PHILIP GIPSON, Department of Natural Resources, Texas Tech University, Box 42125 Lubbock, TX 79409

MARK C. WALLACE. Department of Natural Resources, Texas Tech University, Box 42125 Lubbock, TX 79409

WARREN B. BALLARD, Department of Natural Resources, Texas Tech University, Box 42125 Lubbock, TX 79409

Abstact: For the past decade, low calf:cow ratios of elk (*Cervus elaphus*) have been recorded on the Valles Caldera National Preserve (VCNP) in northern New Mexico. In this study, we addressed the hypothesis that the observed low calf:cow ratios on the VCNP may be the result of unusually high calf mortality rates. We radio marked elk calves (*n* = 140) born within the VCNP from 2009-2011 to determine cause-specific mortality and used known fate models in Program MARK to estimate survival. We used biological covariates to model survival for 14 days post capture and weekly summer survival (*t* = 13 weeks). Predation accounted for 94.8% of the known deaths. Black bears (*Ursus americanus*) were the highest source of predation (47.3%, *n* = 26) and overall mortality (40.6%). Coyotes (*Canis latrans*) were the second highest source of predation (41.8%, *n* = 23) and overall mortality (35.9%). Age at capture was the best biological covariate at predicting survival. Fourteen day survival was 0.57 (SE = 0.05, 95% CI: 0.48-0.66), summer survival was estimated to be 0.37 (SE = 0.05, 95% CI 0.28-0.47). Our results are comparable to other studies which investigated low calf:cow ratios. Therefore the predation of elk calves is likely additive and causing suppressed recruitment rates in the elk population on the VCNP. However, we highly recommend a population estimate of the large predators prior to any large predator management action to ensure populations of large predators are not reduced to a level from which they cannot recover.

Presenter: LANCE J. BERNAL, Department of Natural Resources, Texas Tech University

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IMPACTS OF MINING ON MULE DEER MIGRATIONS IN NEVADA

MARCUS E. BLUM, Natural Resources and Environmental Science, University of Nevada Reno, Reno Nevada 89557, USA. (979) 450-3092, m.blum1107@yahoo.com

KELLEY M. STEWART, Natural Resources and Environmental Science, University of Nevada Reno, Reno Nevada 89557, USA. (775) 784-4314, kstewart@cabnr.unr.edu

CODY SCHROEDER, Natural Resources and Environmental Science, University of Nevada Reno, Reno Nevada 89557, USA. (775) 233-2090, cschroeder@cabnr.unr.edu

TONY WASLEY, Nevada Department of Wildlife, 1001 Valley Road, Reno, NV 89512. (775) 688-1659, twasley@ndow.org

Abstract: Over the past century, mule deer (*Odocoileus hemionus*) have suffered dramatic declines throughout the western United States due, in part, to loss of wintering habitat and migratory corridors. An increase in mineral exploration across Nevada has raised the level of concern over the protection of ungulate migration routes throughout the state. In January of 2012, the Nevada Department of Wildlife (NDOW) and University of Nevada, Reno (UNR) captured and applied radio collars to 12 female mule deer in the proximity of an active mine in the Ruby Mountains of eastern Nevada. Collars were scheduled to collect locations at 1 hour intervals during migrations to give an accurate depiction of migratory behavior in and away from mining facilities. We used Brownian Bridge Movement Models (BBMM) to delineate stopover sites for each individual during both the fall and spring migration periods. We calculated route efficiency and movement rate between stopover locations and throughout the mining area to determine the effects of the mine on movement patterns during migration. We hypothesized that mule deer would show higher route efficiency and movement rates between stopovers than through the mining complex. Mule deer showed an increase in route efficiency and movement rate between stopover locations when compared with movement through the mining facilities. These results suggest an increase in energy expenditures of mule deer forced to navigate these mining complexes, which may negatively impact migratory behavior.

Presenter: MARCUS E. BLUM, Natural Resources and Environmental Science, University of Nevada Reno

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2012 IDAHO ELK HUNTER OPINIONS AND ATTITUDE SURVEY

TOBY A. BOUDREAU, Idaho Department of Fish and Game, 600 S. Walnut St., Boise, ID 83707. (208) 287-2746, toby.boudreau@idfg.idaho.gov

BRUCE ACKERMAN, Idaho Department of Fish and Game, 600 S. Walnut St., Boise, ID 83707

NICK SANYAL, University of Idaho, College of Natural Resources Department of Conservation Social Sciences, Moscow, ID 83844

ED KRUMPE, University of Idaho, College of Natural Resources Department of Conservation Social Sciences, Moscow, ID 83844

ALEXANDRIA MIDDLETON, University of Idaho, College of Natural Resources Department of Conservation Social Sciences, Moscow, ID 83844

SUMMER CREA, Idaho Department of Fish and Game, 600 S. Walnut St., Boise, ID 83707

STEVE NADEAU, Idaho Department of Fish and Game, 3101 S. Powerline Road, Nampa, ID 83686

MARC PORTOR, Idaho Department of Fish and Game, 1345 Barton Road, Pocatello, ID 83204

JON RACHAEL, Idaho Department of Fish and Game, 600 S. Walnut St., Boise, ID 83707

LAURA WOLF, Idaho Department of Fish and Game, 2885 W. Kathleen Ave., Coeur d'Alene, ID 83815

CRAIG WHITE, Idaho Department of Fish and Game, 600 S. Walnut St., Boise, ID 83707. (208) 287-2799, craig.white@idfg.idaho.gov

Abstract: A statewide random survey of Idaho's elk hunters was contracted to the University of Idaho's Department of Conservation Social Sciences from the College of Natural Resources in early 2012. The random survey was mailed to 6,200 hunters who purchased a general Idaho elk tag in 2011; over 2,786 elk hunters responded to the survey. The objective of the survey was to measure current hunter demographics, elk hunting preferences and motivations, and attributes of a quality elk hunting experience. This study was the first comprehensive investigation of Idaho elk hunters since a similar study was conducted by the University of Idaho over 20 years ago in 1987. Results from the survey indicate that what is important to Idaho elk hunters is the opportunity to hunt elk every year, to hunt with family and friends, to see a harvestable elk, and to hunt for mature bulls. Further, we were able to compare some questions from the 2012 survey with the 1987 survey. The median age of elk hunters today is 50 years compared to 40 years in 1989. In 2012, 77% of survey respondents said they would miss Idaho elk hunting a great deal if they could not participate, compared to just 54% in 1987. In 2012, 43% of the people surveyed said it was extremely important to hunt elk with family, compared to just 28% in 1987. The results of the 2012 survey are being used by the Idaho Department of Fish and Game to revise its Elk Management Plan.

Presenter: CRAIG WHITE, Idaho Department of Fish and Game

TRADE-OFFS BETWEEN PREDATION RISK AND FOOD QUALITY RE-DISTRIBUTE ELK ACROSS A ROAD NETWORK: NOT ALL ROADS ARE EQUAL

SIMONE CIUTI, Dept. of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9 Canada ciuti@ualberta.ca

TYLER B MUHLY, Alberta Innovates – Technology Futures, Vegreville, AB, T9C 1T4 Canada tyler.muhly@albertainnovates.ca

JEREMY E BANFIELD, Wildlife Division, Montana Fish Wildlife & Parks, Forsyth, MT 59327 USA jbanfield@mt.gov

MARCO MUSIANI, Faculty of Environmental Design, University of Calgary, Calgary, AB, T2N 1N4 Canada mmusiani@ucalgary.ca

MARK S BOYCE, Dept. of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9 Canada boyce@ualberta.ca

Abstract: Roads do not have universal effects on behavior of wildlife: differences in the response of elk to roads could depend on trade-offs between predation risk and food quality. The study occurred in SW

Alberta-Canada, and encompassed three different land types: protected areas, public and private lands. We quantified perception of humans as a predator by elk (vigilance data), distribution of food quality (NDVI), and we showed that natural predators were more abundant far from roads (camera data). We combined satellite telemetry data with a unique dataset on traffic volumes to predict selection for roads by elk (n = 128) using RSFs. In the national park humans were scarcely perceived as a risk by elk, and vegetation quality was higher far from roads. Male elk selected best feeding areas far from roads. Females showed high selection for roads implying that they traded high-quality vegetation for security provided by humans. Humans on public and private lands were perceived as a risk by elk (hunting permitted), and both sexes showed strong avoidance of roads during the day. High quality vegetation was widespread on private lands, but was more abundant close to roads in public lands. Elk exploited areas with low vegetation quality during the day in public lands: they compensated for this at night by increasing selection for roads with low traffic volumes. Perception of humans as predators, the presence of natural predators, and distribution of food appear to be the main drivers that must be considered to anticipate the effect of roads on wildlife.

Presenter: SIMONE CIUTI, Dept. of Biological Sciences, University of Alberta

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ELK CONTACT PATTERNS AND POTENTIAL DISEASE TRANSMISSION

PAUL C. CROSS, U.S. Geological Survey, Northern Rocky Mountain Science Center. 2327 University Way, Suite 2, Bozeman, MT 59715

TYLER G. CREECH, Oregon State University, Department of Fisheries and Wildlife, 140 Nash Hall, Corvallis, OR 97331

MICHAEL R. EBINGER, Montana State University, Institute on Ecosystems, 106 AJM Johnson Hall, Montana State University, Bozeman, MT 59717

KEZIA MANLOVE, Pennsylvania State University, Department of Biology, Huck Institutes of the Life Sciences, 201 Life Sciences Building, University Park, PA 16802

KATHRYN IRVINE, U.S. Geological Survey, Northern Rocky Mountain Science Center. 2327 University Way, Suite 2, Bozeman, MT 59715

JOHN HENNINGSEN, University of Wyoming, Wyoming State Veterinary Laboratory, 1174 Snowy Range Road, Laramie, WY 82070

JARED ROGERSON, Wyoming Game and Fish Department, 432 E Mill Street, Pinedale, Wyoming 82941, USA

BRANDON M. SCURLOCK, Wyoming Game and Fish Department, 432 E Mill Street, Pinedale, Wyoming 82941, USA

SCOTT CREEL, Montana State University, Department of Ecology, 310 Lewis Hall, Bozeman, MT 59717

Abstract: Understanding the drivers of contact rates among individuals is critical to understanding disease dynamics and implementing targeted control measures. We studied the interaction patterns of

149 female elk (*Cervus elaphus*) distributed across five different regions of western Wyoming over three years, defining a contact as an approach within one body length (~2m). Using hierarchical models that account for correlations within individuals, pairs and groups, we found that pairwise contact rates within a group declined by a factor of three as group sizes increased 30-fold. Meanwhile, per capita contact rates increased with group size due to the increasing number of potential pairs. The increase, however, was non-linear and not as strong as would be expected for a purely density-dependent model of disease transmission. We found similar patterns for the duration of contacts. Supplemental feeding of elk had a limited impact on pairwise interaction rates and durations, but increased per capita rates more than two times higher. Variation in contact patterns were driven more by environmental factors such as group size than either individual or pairwise differences. Female elk in this region fall between the expectation of contact rates that linearly increase with group size (as assumed by pseudo-mass action models of disease transmission) or are constant with changes in group size (as assumed by frequency dependent transmission models). Our statistical approach decomposes the variation in contact rate into individual, dyadic, and environmental effects, which provides insight those factors that are important for effective disease control programs.

Presenter: PAUL C. CROSS, U.S. Geological Survey, Northern Rocky Mountain Science Center

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BOTTOM-UP AND TOP-DOWN EFFECTS ON NORTHERN YELLOWSTONE ELK PREGNANCY AND RECRUITMENT RATES

JULIE CUNNINGHAM, Montana Fish, Wildlife and Parks, 1400 South 19th Street, Bozeman, MT 59718

KELLY PROFFITT, Montana Fish, Wildlife and Parks, 1400 South 19th Street, Bozeman, MT 59718

KENNETH HAMLIN, Montana Fish, Wildlife and Parks, 1400 South 19th Street, Bozeman, MT 59718

Abstract: Declines in calf recruitment in some western Montana elk populations have raised concerns that recovering carnivore populations may be limiting elk population growth. However, a suite of bottom-up and top-down factors likely affect recruitment, and better understanding the relative effects of these factors on pregnancy rates and calf survival is needed to determine appropriate management responses to poor recruitment. We conducted a retrospective analysis to evaluate the effects of wolf (*Canis lupus*) and grizzly bear (*Ursus arctos*) numbers, winter severity and summertime drought on northern Yellowstone elk yearling pregnancy rates, adult pregnancy rates, juvenile-at-heel in late autumn, and recruitment using data collected during 1985-2007. We found no influence of any covariate on adult pregnancy rates, that drought and grizzly numbers influenced calf survival between birth and late autumn, and that wolf numbers and winter severity influenced juvenile survival through winter. The results provide context to how predation and density-independent variables affect elk recruitment through the year.

Presenter: JULIE CUNNINGHAM, Biologist, Montana Fish, Wildlife and Parks

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GEO-STATISTICAL METHODS FOR DETECTING ELK PARTURITION SITES FROM GLOBAL POSITIONING SYSTEM COLLAR DATA

MIKE EBINGER, Institute on Ecosystems, Montana State University, 310 Lewis Hall, Montana State University, Bozeman, MT 59717-3460. (406) 579-6509, MREbinger@hotmail.com

PAUL C. CROSS, U.S. Geological Survey, Northern Rocky Mountain Science Center. 2327 University Way, Suite 2, Bozeman, MT 59715. (406) 579-6509, pcross@usgs.gov

BRANDON SCURLOCK, Wyoming Game and Fish Department, P.O. Box 850 Pinedale, WY 82941. (307) 367-4353, brandon.scurlock@wyo.gov

JARED ROGERSON, Wyoming Game and Fish Department, P.O. Box 850 Pinedale, WY 82941. (307) 367-4353, jared.rogerson@wyo.gov

JOHN HENNINGSEN, Wyoming Game and Fish Department, P.O. Box 67 Jackson, WY 83001. (307) 367-4353, john.henningsen@wyo.gov

ERIC MAICHAK, Wyoming Game and Fish Department, P.O. Box 850 Pinedale, WY 82941. (307) 367-4353, Eric.maichak@wyo.gov

DALINDA DAMM, Wyoming Game and Fish Department, P.O. Box 850 Pinedale, WY 82941, USA. (307) 367-4353, dalinda.damm@wyo.gov

SCOTT CREEL, Department of Ecology, Montana State University, 310 Lewis Hall, Montana State University, Bozeman, MT 59717. (406) 994-7033, screel@montana.edu

Abstract: There is an increasing awareness of the importance of juvenile survival in ungulate population dynamics and the accurate prediction of parturition timing and location may help in understanding the role of birth site selection on neonate survival. Detecting birth sites in a statistically rigorous way, however, often requires intensive field efforts that may not be possible for all studies. We developed a method for detecting parturition timing and location based on daily movements and space-use metrics derived from GPS collar locational data from 67 elk which were simultaneously fitted with Vaginal Implant Transmitters (VITs). Assuming the timing and location of VIT expulsion represented parturition, we used logistic regression and cross validation (10 fold; 10 replications) to assess the temporal and spatial prediction accuracy of different candidate models. Our top model predicted the correct parturition date (MSE = 0) for 73% (+/- 3) of the test elk (n = 67), and 83% (+/-2) of prediction dates fell within 3 days of the VIT date. Of the remaining elk that were poorly estimated, roughly elk (~80%) selected a date ≤ 3 days of the VIT parturition date as the second most likely parturition date. When the day was correctly predicted spatial errors between the VIT and the predicted location were extremely low (median = 9.9 m +/- 0.4 m). When including all elk with prediction errors ≤ 3 days, the median error was still < 100 m. We discuss the application of our results to current and future elk research related to parturition ecology.

Presenter: MIKE EBINGER, Institute on Ecosystems, Montana State University

THE COLLAPSE OF THE BURDETTE CREEK ELK HERD IN WESTERN MONTANA.

VICTORIA EDWARDS, Montana Fish Wildlife and Parks, 3201 Spurgin Road, Missoula, MT 59804. (406) 542-5515, vedwards@mt.gov

GEORGE PAULEY, Montana Fish, Wildlife and Parks, 1420 East Sixth Avenue, Helena, MT 59620. (406) 444-3940, gpauley@mt.gov

MICHAEL THOMPSON, Montana Fish, Wildlife and Parks, 3201 Spurgin Road, Missoula, MT 59804. (406) 542-5516, mthompson@mt.gov

Abstract: A century since the first reintroductions of Rocky Mountain elk (*Cervus elaphus)* from Yellowstone National Park, Montana and Idaho are re-experiencing near extirpations of backcountry elk populations in portions of the Bitterroot Range, including the Burdette Creek elk herd. Hypotheses of environmental stochasticity, declining habitat quality, and overharvest do not adequately explain these declines. The declines in the Burdette Creek elk population are reflective of similar population trends of intensively studied elk in the Kelly Creek and Cayuse survey units in adjacent Game Management Unit (GMU) 10 in Idaho, a known seasonal range for portions of the Burdette Creek elk herd and other elk in the Fish Creek drainage. Since 1996, Idaho Fish and Game personnel have conducted extensive research on elk population dynamics in GMU 10 and elsewhere. In these areas, elk numbers show no sign of stabilizing at lowered, sustainable levels in the face of recovered predation pressure. With the documented connectivity between GMU 10 and the Fish Creek drainage, we compare the Burdette Creek elk herd in Montana with Kelly Creek and Cayuse elk populations and research results from Idaho. If elk are to persist in numbers supporting predation by the historic suite of large carnivores and a moderated level of recreational hunting, wildlife managers must be aware that the traditional view of elk populations rebounding will not serve in recovered predator-prey systems. In addition, management response to subtle indicators of calf recruitment declines must be prompt and substantive to continue to maintain sustainable elk populations.

Presenter: VICTORIA EDWARDS, Montana Fish Wildlife and Parks

MANAGING THE NORTH HILLS/EVARO ELK HERD IN THE WILDLAND-URBAN INTERFACE OF MISSOULA, MT—ADAPTIVE MANAGEMENT RESPONSES TO SHIFTING ELK DISTRIBUTION AND BEHAVIOR

VICTORIA EDWARDS, Montana Fish, Wildlife and Parks, 3201 Spurgin Road, Missoula, MT 59804. (406) 542-5515, vedwards@mt.gov

MICHAEL THOMPSON, Montana Fish, Wildlife and Parks, 3201 Spurgin Road, Missoula, MT 59804. (406) 542-5516, mthompson@mt.gov

Abstract: Wildlife biologists with Montana Fish, Wildlife and Parks have worked cooperatively with private landowners, non-governmental organizations, and federal and local governments to conserve important elk winter range and habitat connectivity within the wildland-urban interface of the Missoula Valley in western Montana. From a biological perspective, we have been extremely successful in managing for the persistence of elk populations. However, protecting winter range adjacent to and fragmented by human development has additional management challenges and costs, including limited hunter access and opportunity. Since 1982, the North Hills/Evaro elk herd in the Missoula Valley has

grown an average of 10% annually, with the greatest increase occurring between 2000 and 2007 from 188 to 398 elk observed. From 2007 to 2012, elk abundance has been high but relatively stable, with the most recent count at 454—well above the population objective of 300. Without effective harvest, the population is expected to double in 7-years. In the last 2-years, we have observed an increase in the number of elk becoming more resident and more visible throughout the year on their winter range. While portions of the herd remain migratory, they continue to migrate to their winter range earlier and leave later in the spring. To continue to keep elk wild, managers must reassess current management of the North Hills/Evaro elk herd. This presentation includes a discussion on the adaptive management approaches utilized by wildlife managers, the efficacy of those strategies, and potential "outside-the-box" opportunities to improve elk management in the wildland-urban interface.

Presenter: VICTORIA EDWARDS, Montana Fish, Wildlife and Parks

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SHOULD I STAY OR SHOULD I GO? VARIATION IN MIGRATORY BEHAVIOR BALANCES FITNESS IN A PARTIALLY MIGRATORY ELK POPULATION

SCOTT EGGEMAN, Wildlife Biology Program, University of Montana, Missoula, MT 59812. (406) 243-5292, scott1.eggeman@umconnect.umt.edu

MARK HEBBLEWHITE, Wildlife Biology Program, University of Montana, Missoula, MT 59812. (406) 243-6675, mark.hebblewhite@ mso.umt.edu

EVELYN MERRILL, Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada T6G 2R3. (780) 492-2842, emerrill@ualberta.ca

Abstract: Within migratory species, individuals that migrate are expected to enhance lifetime fitness through exposure to higher quality forage and avoidance of predation to a greater degree than non-migratory conspecifics. Partially migratory populations, with migratory and non-migratory individuals, are expected to be maintained by balancing fitness between migrant and non-migrant phenotypes. However, recent studies acknowledge variability in migratory behavior that occurs along a gradient between migratory and non-migratory strategies. We tested for variability in migratory behavior in a partially migratory elk (*Cervus elaphus*) population near Banff National Park, in Alberta, Canada. We used net squared displacement (NSD) from 223 radio-collared elk over a 10 year period measured from the winter range and plotted over time in combination with spatial displays in a Geographic Information System (GIS) to quantify annual movements. Second, we used Kaplan-Meier estimates of survival for 104 adult female mortalities combined with estimates of calf survival using a sight-resight design and pregnancy rates to build a population matrix model for calculating lambda of migrants and non-migrants. We found 15% of elk switched annually between migrant and non-migrant strategies as a density dependent response, where at high winter densities elk switched from non-migrant to migrant, and reversed that pattern at lower elk densities. We found little differences in adult female survival and lambda for migrant and non-migrant strategies across the entire study period. Our conclusion is that elk within this population make real-time changes in migratory strategies that balance fitness between non-migrant and migratory elk.

Presenter: SCOTT EGGEMAN, Wildlife Biology Program, University of Montana

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EFFECTS OF MALE-BIASED HARVEST ON MULE DEER: IMPLICATIONS FOR RATES OF PREGNANCY AND SYNCHRONY/TIMING OF PARTURITION

ERIC D FREEMAN, Department of Plant and Wildlife Sciences, Brigham Young University, 275 WIDB Provo, UT 84602. edfreeman1@gmail.com

RANDY T LARSEN, Department of Plant and Wildlife Sciences, Brigham Young University, 275 WIDB Provo, UT 84602. randy_larsen@byu.edu

KENT R HERSEY, Utah Division of Wildlife Resources, 1594 W North Temple, Salt Lake City, UT 84114. kenthersey@utah.gov

MARK E PETERSON, Department of Fish, Wildlife, and Conservation Biology, Colorado State University, 1474 Campus Delivery Fort Collins, CO 80523. mark.peterson313@gmail.com

CHARLES R ANDERSON JR., Colorado Parks and Wildlife, 711 Independent Ave. Grand Junction, CO 81505. Chuck.Anderson@state.co.us

BROCK R MCMILLAN, Department of Plant and Wildlife Sciences, Brigham Young University, 275 WIDB Provo, UT 84602. brock_mcmillan@byu.edu

Abstract: Mule deer (*Odocoileus hemionus*) are an iconic western species, but most populations have declined over the past several decades. Evaluating how management practices influence population dynamics will enhance conservation of this species. For example, changes in sex ratio due to male-biased harvest alter rates of pregnancy, synchrony of parturition, and timing of parturition if inadequate numbers of males are present to breed females during their first estrous cycle. If rates of pregnancy or parturition are influenced by decreased buck:doe ratios, recruitment may be reduced (e.g., fewer births, later parturition resulting in lower survival of fawns, and a less synchronous parturition that potentially increases predation of neonates). Our objectives were to compare rates of pregnancy, synchrony of parturition, and timing of parturition between mule deer populations with a relatively high (Piceance Basin, CO; 28 bucks per 100 does) and a relatively low (Monroe Mountain, UT; 14 bucks per 100 does) sex ratio. We determined pregnancy rates via ultrasonography and synchrony/timing of parturition via vaginal implant transmitters. We found no differences in rates of pregnancy (98.6% and 96.6%; $p = 0.437$) or synchrony of parturition (CV = 3.7% and 4.8%; $p = 0.282$) between Monroe Mountain and Piceance Basin, respectively. The low buck:doe ratio of Monroe Mountain were not associated with a protracted period of parturition suggesting that low buck:doe ratios typical of exploited populations do not influence population dynamics via rates of pregnancy or via synchrony/timing of parturition.

Presenter: ERIC D. FREEMAN, Brigham Young University

EVALUATION OF AN ANIMAL ACTIVATED ELK CROSSWALK AND HIGHWAY FENCING RETROFIT TO REDUCE ELK-VEHICLE COLLISIONS IN ARIZONA, USA.

JEFFREY W. GAGNON, Research Biologist, Arizona Game and Fish Department, 5000 W. Carefree Highway, Phoenix AZ, 85086. (928) 814-8925, jgagnon@azgfd.gov

SCOTT C. SPRAGUE, Research Biologist, Arizona Game and Fish Department, 5000 W. Carefree Highway, Phoenix AZ, 85086. ssprague@azgfd.gov

CHAD D. LOBERGER, Research Specialist, Arizona Game and Fish Department, 5000 W. Carefree Highway, Phoenix AZ, 85086. cloberger@azgfd.gov

SUSAN BOE, GIS Analyst, Arizona Game and Fish Department, 5000 W. Carefree Highway, Phoenix AZ, 85086. Sboe@azgfd.gov

RAYMOND E. SCHWEINSBURG, Arizona Game and Fish Department, 5000 W. Carefree Highway, Phoenix AZ, 85086. rschweinsburg@azgfd.gov

Abstract: Ideally, wildlife crossings are the best available solution to reduce ungulate-vehicle collisions while maintaining habitat connectivity. However, in many cases, innovative solutions need to be considered in order to address wildlife-vehicle collisions in a timely, cost-efficient manner. From 2007 to 2012, Arizona Game and Fish Department (AGFD) evaluated the effectiveness of a 4 km retrofit of existing right-of-way highway fencing designed to funnel animals to bridges and a "crosswalk" intended to reduce incidence of elk-vehicle collisions. The crosswalk was equipped an animal detection system identify wildlife and activate signs to alert motorists. We determined location of the crosswalk and fencing with GPS. Overall, we documented a 97% reduction in collisions with elk. Elk permeability decreased 70%. Motorist reduced their speeds 14 km/hr and 68% of motorists braked when the signs were activated versus only 8% when the signs were off. The crosswalk system performed properly during 93% of test visits (n = 275) and video surveillance documented activation of signs when wildlife were present 98% of the time. Overall, increased traffic volumes reduced probability elk crossing the highway at the crosswalk. Following extensive monitoring we determined the installation an electrified wildlife guard (ElectraMat) was essential to keep animals from entering the right of way on the road surface and evaluation of its effectiveness is ongoing. Innovative solutions like these represent viable options to reduce wildlife-vehicle collisions, while allowing large ungulates, like elk, to access essential resources.

Presenter: JEFFREY W. GAGNON, Arizona Game and Fish Department

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UNGULATE ACTIVITY CLASSIFICATION: CALIBRATING DUAL-AXIS ACTIVITY MONITOR GPS COLLARS FOR ROCKY MOUNTAIN ELK AND MULE DEER

ADAM GAYLORD, Oregon State University, Department of Fisheries and Wildlife, 1401 Nash Hall, Corvallis, OR 97331. (941) 920-4712, adam.gaylord@oregonstate.edu

DANA SANCHEZ, Oregon State University, Department of Fisheries and Wildlife, 1401 Nash Hall, Corvallis, OR 97331. (541) 740-5166, dana.sanchez@oregonstate.edu

JOHN VAN SICKLE, Oregon State University, Department of Fisheries and Wildlife, 1401 Nash Hall, Corvallis, OR 97331. (541) 752-0283, vansicklej@peak.org

Abstract: Direct observation of free ranging ungulates is prohibitively difficult, making their behavior difficult to study. Collars equipped with motion-sensitive activity monitors provide a means to monitor animal behavior remotely. Differences in motion among species necessitate species specific calibration models. To date, no calibrations have been conducted for Lotek 4400 GPS collars featuring dual-axis activity monitors for Rocky Mountain elk (*Cervus elaphus nelsoni*) or mule deer (*Odocoileus hemionus*). Calibration consisted of pairing detailed behavioral observations of captive collared animals with collar data over a programmed sampling interval to determine what activities were associated with what activity monitor values. During this process we discovered several sources of time-keeping error that can result in mismatches between behavior observations and collar data. We developed a correction technique which allowed us to improve average classification rates up to 61.7%. We then built and compared a series of models for each species featuring different behavior groupings using discriminant function analysis. Models were constructed using (pure) intervals containing only a single behavior and compared to models constructed using all (mixed) intervals. Classification models that used only pure intervals resulted in misclassification rates of up to 40% for some behaviors. Final mixed interval models allow classification of up to 4 behavior categories for elk and 3 for deer with >70% accuracy. Our calibration models will be made available on-line, allowing managers and researchers to interpret collar data for use in ongoing and future studies of ungulate ecology and management.

Presenter: ADAM GAYLORD, Oregon State University, Department of Fisheries and Wildlife

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FORAGE DYNAMICS RELATED TO CHANGING FOREST PRACTICES AT MOUNT ST. HELENS, WASHINGTON

ANDREW B. GEARY, Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9, Canada. ageary@ualberta.ca

EVELYN H. MERRILL, Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9, Canada. emerrill@ualberta.ca

JOHN G. COOK, National Council for Air and Stream Improvement, 1401 Gekeler Lane, La Grande, OR 97850, USA. cookjg.ncasi@gmail.com

RACHEL C. COOK, National Council for Air and Stream Improvement, 1401 Gekeler Lane, La Grande, OR 97850, USA. rachierae@gmail.com

SCOTT M. MCCORQUODALE, Washington Department of Fish & Wildlife, 1701 S 24th Avenue, Yakima, WA 98902 USA. Scott.McCorquodale@dfw.wa.gov

Abstract: In the Pacific Northwest use of silvicultural herbicides to suppress vegetation that competes with tree seedlings may alter forage resources and contribute to low body fat levels of elk (*Cervus elaphus*) in some populations. We explore his hypothesis in a nutritionally explicit context for elk. We used a paired, retrospective vegetation sampling design to assess the influence of herbicides and herbivory on early (<13 yrs) seral forage availability in forests around Mount St. Helens. We found herbicides initially reduced total biomass and the proportion of plants shown to be selected or eaten randomly by elk ("Accepted" forages) and available digestible energy (DE), but for only two years after planting seedlings. Between 10-13 years, total forage and plants not selected by elk ("Avoided" forages) continued to increase in untreated sites, but on treated sites. At exclosures, total and accepted biomass was more abundant inside exclosures after 3 years related to shrub abundance and this translated into lower availability of DE to ungulates outside exclosures after the first two years. Our results provide a basis for quantifying changing nutritional resources under different timber harvest alternatives on

private and public lands in the Mount St. Helens area for relating habitat conditions to elk population numbers.

Presenter: EVELYN H. MERRILL, Department of Biological Sciences, University of Alberta

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POPULATION DYNAMICS OF A FOREST UNGULATE RESPOND TO WINTER SEVERITY AND HABITAT ALTERATION

SOPHIE GILBERT, Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, AK, 99775. (907) 699-8988, slgilbert@alaska.edu

DAVID PERSON, Division of Wildlife Conservation, Alaska Department of Fish and Game, Ketchikan, AK, 99901, (907) 225-2475. david.person@alaska.gov

KRIS HUNDERTMARK, Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, AK, 99775. (907) 474-7159, kris.hundermark@alaska.edu

CHRISTINE HUNTER, Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, AK, 99775, (907) 474-6743, christine.hunter@alaska.edu

Abstract: Changes to habitat and climate have become ubiquitous and can strongly influence wildlife population dynamics, including species of high ecological and economic importance such as ungulates. These effects often impact vital rates differentially, as certain life history processes are more vulnerable than others. We examine the effect of timber harvest and variable winter weather on a long-lived vertebrate, deer in the coastal temperate rainforest of Southeast Alaska. Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) are the dominant herbivore, and a key resource for subsistence hunters. Timber harvest plans for the Tongass National Forest incorporate deer density into management goals, but exclude environmental variability from calculations. We derived vital rates from life history data for 63 adult and 154 juveniles, and population growth rates from matrix-based life table response experiments. Timber-harvested areas produced a lower population growth rate than unharvested areas (λ = 1.06 and 1.12), explained primarily by variability in adult female fecundity and juvenile survival. Winter severity had a larger effect, with population growth rates ranging from 1.19 to 0.84, driven primarily by variability in juvenile survival. Climate models predict increasing winter precipitation and stochasticity, which along with continuing timber harvest may reduce future deer populations. Timber managers calculate deer carrying capacity using average winter severity. Instead, such plans should incorporate and monitor changing climate in an adaptive-management framework to ensure sustainable deer populations.

Presenter: SOPHIE GILBERT, Institute of Arctic Biology, University of Alaska Fairbanks

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ELK HABITAT USE ON DEGRADED RANGELAND IN THE SAPPHIRE MOUNTAINS, MT

TEAGAN HAYES, MPG Ranch, 1001 S. Higgins Ave #A3, Missoula, MT. (920)979-9009, thayes@mpgranch.com

PHILIP RAMSEY, MPG Ranch, 1001 S. Higgins Ave #A3, Missoula, MT. (406)546-0699, pramsey@mpgranch.com

Abstract: We monitored winter range use by elk in the Northern Sapphire Mountains of the Bitterroot Valley, Montana over the winters of 2011-2012 and 2012-13. The goal of the project is to acquire data on elk habitat use and grazing preference on a former cattle ranch. A herd of around 300 spends most of the winter on or near the study site. The highest wintering elk numbers were recorded in November 2011, with 426. Vegetation surveys were conducted on a grid pattern across the property during 2010 – 2012. Of the 3,845 hectares within the property boundary, 2,130 hectares of rangeland include altered plant communities due to intensive grazing, exotic forage grass seeding, and herbicide applications. Cheatgrass (*Bromus tectorum*) dominates 32% of the rangeland area. Seeded exotic forage grasses dominate 20% and perennial invaders dominate 6.8%. Pristine or less-degraded plant communities dominated by native grasses cover 681 hectares. We collected additional data for this project through observation, scat density surveys, diet analysis, and forage availability estimates through biomass collection. By March 2013, we conducted over 150 elk survey days with more than 450 spatially precise locations between two field seasons. Elk locations and frequency of observation were assessed using habitat selectors that include dominant vegetation, slope, aspect, elevation, and insolation. Preliminary analyses of the data gathered to date will provide insights in assessing elk response to restoration efforts that seek to replace many weed-dominated communities with diverse native vegetation.

Presenter: TEAGAN HAYES, MPG Ranch

EVALUATING BOTTOM-UP AND TOP-DOWN EFFECTS ON ELK SURVIVAL AND RECRUITMENT IN THE BITTERROOT VALLEY: YEAR TWO UPDATE

MARK HEBBLEWHITE, Wildlife Biology Program, University of Montana, Missoula, MT, 59812

KELLY PROFFITT, Montana Fish, Wildlife, and Parks, Bozeman, MT, 59718

BEN JIMENEZ, Montana Fish, Wildlife, and Parks, Missoula, MT, 59804

MIKE THOMPSON, Montana Fish, Wildlife, and Parks, Missoula, MT, 59804

DANIEL EACKER, Wildlife Biology Program, University of Montana, Missoula, MT, 59812

JUSTIN GUDE, Montana Fish, Wildlife and Parks, Helena, MT, 59620

Abstract: Understanding the contribution of recruitment to population growth rate in ungulates is a fundamental challenge to wildlife managers attempting to integrate carnivore and ungulate management. Like much of western Montana, in the southern Bitterroot Valley, the decline of elk (*Cervus elaphus*) populations and calf recruitment occurred concurrently with wolf (*Canis lupus*) recovery. However, a multitude of abiotic, bottom-up and top-down factors likely affect calf survival, and ultimately, these factors may even compete in their effects on population growth rate of elk. We studied cause-specific mortality of elk calves to understand the role of competing mortality risk on calf recruitment in the East Fork and West Fork of the Bitterroot Valley, Montana. A total of 66 and 76 neonatal elk calves were captured in spring 2011 and 2012, respectively, and an additional 31 and 29 six

month olds in late November 2011 and 2012. We estimated Kaplan-Meier non-parametric survival rates, preliminary factors affecting calf survival using Cox-proportional hazards models, and estimated cause-specific mortality using cumulative incidence functions in a competing risks framework. Preliminary analyses for the first 20 months of the research surprisingly indicate mountain lions as the leading cause of mortality for elk calves during both summer and winter, and little evidence for compensatory mortality between wolves and lions in late winter calf mortality. We also evaluated the role of summer range nutritional resources on maternal body condition, lactation performance, and calf birth weights. Preliminary results from nutritional work demonstrate potential bottom-up differences that may influence resilience of elk populations to top-down predation. Our study fills a critical knowledge gap regarding the role of summer vs winter mortality in elk and the role of nutrition in first year survival. The study will complement previous studies on elk population dynamics and help wildlife managers integrate carnivore and ungulate management across western Montana following carnivore recovery.

Presenter: MARK HEBBLEWHITE, Wildlife Biology Program, University of Montana

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DEVELOPMENT OF GENETIC MARKERS TO IDENTIFY COUES, CARMEN MOUNTAIN, AND OTHER WHITETAILS

JAMES R. HEFFELFINGER, Arizona Game and Fish Department, 555 N. Greasewood Rd., Tucson, AZ 85745. jheffelfinger@azgfd.gov

RENEE PRIVE, Wildlife Genetics International, P.O. Box 274, Nelson, BC, V1L 5P9. rprive@wildlifegenetics.ca

DAVID PAETKAU, Wildlife Genetics International, P.O. Box 274, Nelson, BC, V1L 5P9. dpaetkau@wildlifegenetics.ca

ROY LOPEZ, Rocky Mountain Research Station, USFS, Flagstaff Lab, 2500 S. Pine Knoll Drive, Flagstaff, AZ 86001. rglopez@fs.fed.us

CARLOS ALCALÁ-GALVÁN, Consulting Wildlife Biologist, Congreso 365, Hermosillo, Sonora, 83100. Mexico, sr.alcala@gmail.com

RANDY DEYOUNG, Caesar Kleberg Wildlife Research Institute, 700 University Blvd., MSC 218, Texas A&M University – Kingsville, Kingsville, TX, 78363. randall.deyoung@tamuk.edu

KARLA LOGAN-LOPEZ, Caesar Kleberg Wildlife Research Institute, 700 University Blvd., MSC 218, Texas A&M University – Kingsville, Kingsville, TX, 78363. karlalogan@gmail.com

Abstract: The Coues white-tailed deer (*Odocoileus virginianus couesi*) is separated geographically from other subspecies for most of its range. This smaller subspecies is phenotypically different than other whitetails in the United States, but blends into other small subspecies at the southern extent of its range in Mexico. The closely-related Carmen Mountains white-tailed deer (*O. v. carminis*) occurs between the Coues and the larger Texas subspecies to the east (*O. v. texanus*). We used a suite of 21 microsatellite markers to evaluate their usefulness in differentiating the southwestern subspecies from other North American whitetails. Using only 8 microsatellite markers we were able to differentiate Coues from most

other whitetail subspecies, but there was some overlap with the related Carmen Mountains whitetail. To refine the Coues-Carmen separation, we increased the suite of markers to 16 and used more sophisticated analytical techniques. We achieved acceptable separation of Carmen and Coues whitetails, satisfying our objective of developing a test to separate Coues white-tailed deer from other types of whitetails north of the Tropic of Cancer. Also, in the course of this work, we included a few southwestern mule deer samples and they separate quite obviously from all whitetail. Interestingly, known whitetail X mule deer hybrids plot directly between clusters of mule deer and whitetail, resulting in an easy way to test for very recent hybridization (at least F_1) using even old skin, bone, or antler shavings.

Presenter: JAMES R. HEFFELFINGER, Arizona Game and Fish Department

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DEVELOPMENT OF A STANDARDIZED SURVEY PROTOCOL FOR MULE DEER HERDS THAT WINTER IN THE COLUMBIA PLATEAU ECOREGION

BROCK HOENES, Washington Department of Fish and Wildlife, 48 Devonshire Road, Montesano, WA 98563. (360)-249-4628, Brock.Hoenes@dfw.wa.gov

MIKE ATAMIAN, Washington Department of Fish and Wildlife, 2315 N. Discovery Place, Spokane Valley, WA 99216. (509)-892-1001, Michael.Atamian@dfw.wa.gov

HOWARD FERGUSON, Washington Department of Fish and Wildlife, 2315 N. Discovery Place, Spokane Valley, WA 99216. (509)-892-1001, Howard.Ferguson@dfw.wa.gov

RICH FINGER, Washington Department of Fish and Wildlife, 1550 Alder Street NW, Ephrata, WA, 98823. (509)-754-4624, Richard.Finger@dfw.wa.gov

SARA GREGORY, Washington Department of Fish and Wildlife, 1550 Alder Street NW, Ephrata, WA, 98823. (509)-754-4624, Sara.Gregory@dfw.wa.gov

MIKE LIVINGSTON, Washington Department of Fish and Wildlife, 1701 S. 24th Avenue, Yakima, WA 98902. (509)-457-9325, Michael.Livingston@dfw.wa.gov

SCOTT MCCORQUODALE, Washington Department of Fish and Wildlife, 1701 S. 24th Avenue, Yakima, WA 98902. (509)-457-9322, Scott.McCorquodale@dfw.wa.gov

Abstract: Washington Department of Fish and Wildlife (WDFW) manages mule deer (*Odocoileus hemionus*) populations throughout eastern Washington. However, for mule deer populations that winter in the Columbia Plateau Ecoregion (CPE), variation in survey methodology among management districts resulted in data that were weakly linked to management objectives limiting management inferences. Therefore, our primary goal was to develop a standardized survey protocol that would generate unbiased and precise estimates of post-hunt population size, sex ratios, and age ratios across CPE management districts. To achieve that goal we employed a stratified random sample design and applied the Idaho mule deer sightability model. The number of mule deer wintering in the portion of the CPE we sampled in 2009, 2010, & 2011 was estimated to be 12,603 (90% C.I. ± 3,185), 11,977 (90% C.I. ± 1,818), and 13,589 (90% C.I. ± 2,199), respectively. Post-hunt age and sex ratios varied little among years; age ratios ranged between 76 (90% C.I. ± 26) and 77 (90% C.I. ± 17) fawns per 100 does

and sex ratios ranged between 20 (90% C.I. ± 7) and 23 (90% C.I. ± 5) bucks per 100 does. Our data also indicated low escapement of adult (≥ 2.5 years old) bucks that are legal to harvest under WDFW's 3-pt. minimum general hunting seasons. The number of adult legal bucks we estimated to be in the 2011 post-hunt population was only 247 (90% C.I. ± 54) individuals.

Presenter: BROCK HOENES, Washington Department of Fish and Wildlife

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A HABITAT SELECTIVITY INDEX FOR DESERT MULE DEER IN THE APACHE MOUNTAINS OF TRANS-PECOS, TEXAS

ANDY S. JAMES, Borderlands Research Institute, Natural Resource s Management, Sul Ross State University, P.O. Box C-16, Alpine, TX 79831. (432)-837-8488, Andy.James10@gmail.com

LOUIS A. HARVESON, Borderlands Research Institute, Natural Resource s Management, Sul Ross State University, P.O. Box C-16, Alpine, TX 79831. (432)-837-8488, Harveson@sulross.edu

Abstract: Habitat use of desert mule deer (*Odocoileus hemionus*) in the Trans-Pecos region of Texas is relatively unknown. We used ecological sites to construct a habitat selectivity index to identify habitat that may be preferred or not used by mature mule deer bucks. From 2006-2010 approximately 40 mature bucks (≥ 4.5 yrs. old) were captured using a helicopter and net gun from two study areas. One area was supplemental fed while the other was a non-fed site. Upon capture a global positioning system (GPS) radio collar was placed around the neck before being released. The radio collars were programmed to record each deer's location as well as a date and time every 5 hours. Deer were then recaptured annually to retrieve the GPS collars. Habitat availability was determined by the amount of each habitat type within an animal's 95% kernel home range while GPS locations were used to determine habitat use. Habitat use varied between the 2 study sites, but mule deer did select Draw sites more frequently in both areas. Draws, Gravelly, and Loamy ecological sites were regularly selected during the summer and fall while Limestone Hill and Mountains (Slope < 60%) and Limestone Hill Mixed Prairie (Slope < 20%) ecological sites were preferred during the spring and winter. Data suggest that deer may utilize areas that may not normally be preferred if supplemental feed stations are available in those areas.

Presenter: ANDY S. JAMES, Borderlands Research Institute

INFLUENCE OF WINTER FEEDING ON MIGRATION STRATEGIES OF ELK (*CERVUS ELAPHUS*) IN WEST-CENTRAL WYOMING.

JENNY JONES, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, 1000 E. University Avenue, Laramie, WY 82071. (406) 868-2637, jjones60@uwyo.edu

MATTHEW J. KAUFFMAN, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, 1000 E. University Avenue, Laramie, WY 82071. (307) 766-5415, mkauffm1@uwyo.edu

KEVIN L. MONTEITH, University of Wyoming, Wyoming Cooperative Fish and Wildlife Research Unit, 1000 E. University Avenue, Laramie, WY 82071. (307) 766-2322, kmonteit@uwyo.edu

BRANDON SCURLOCK, Wyoming Game and Fish Department, 432 E. Mill Street, Pinedale, WY 82941. (307) 367-4353, Brandon.Scurlock@wyo.gov

HANNON ALBEKE, Wyoming Geographic Information Science Center, University of Wyoming, Laramie, WY 82071. (307) 766-6207, salbeke@uwyo.edu

PAUL C. CROSS, USGS Northern Rocky Mountain Science Center, 229 AMJ Johnson Hall, Bozeman, MT 59717. (406) 994-6908, pcross@usgs.gov

Abstract: Long-distance ungulate migrations are increasingly threatened as their routes become impeded by development or influenced by resource subsidies. The Wyoming Game and Fish Department operates 22 elk (*Cervus elaphus*) winter feedgrounds that are adjacent to native winter range. Feedgrounds were designed to shortstop migration by preventing elk from migrating to low elevation private land, but their influence on year-round migration behavior is unknown. Migration behavior may be influenced by altered nutrition provided by the winter feeding, or by the location of the feedgrounds as an attractant for migrating elk. We deployed GPS collars on 159 fed and 92 unfed elk from January 2007 to February 2012. Nutritional condition of fed and unfed elk, as estimated by percent body fat, was measured in mid-March 2011 with a subset of 20 fed and 19 non-fed elk. Surprisingly, differences in percent body fat between fed and unfed elk were not significantly different, although fed elk had slightly higher fat levels (fed = 6.11%, SE = 0.46; unfed = 4.89%, SE = 0.56; p = 0.065). This difference, while slight, may still elicit differences in behavior. Body-fat differences did not influence forage time budgets on shared summer range (Feeding: 47% fed, 46% unfed, $p = 0.75$). To evaluate migration behavior, we used net squared displacement to evaluate movement type (migration, home range, ambiguous) and visual inspection in ArcGIS to determine migration timing (onset, termination), rate of travel, distance traveled, stopover use and duration on summer ranges. A principal components analysis of timing metrics showed that migration patterns differ most in the arrival and departure from summer range. We focused on the arrival and departure from summer range using time to event modeling in Program MARK to account for the effects of climate, plant phenology, winter feeding and individual covariates on migration patterns. Transitional ranges and extended stopovers were common for both fed and unfed elk, but used by more fed elk. Unfed elk followed more of a typical migration with consistent, directional movement between seasonal ranges. In contrast, fed elk displayed erratic behavior, characterized by inconsistent, meandering movement and multiple commuting trips between seasonal ranges. In addition, fed elk spent less time on summer range by arriving later and departing earlier. These results suggest that although feedgrounds are conventionally thought to simply shortstop migrations, they appear to influence year-round migration behavior as well.

Presenter: JENNY JONES, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming

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HYBRID SWARM BETWEEN DIVERGENT LINEAGES OF MULE DEER (*ODOCOILEUS HEMIONUS*)

EMILY K. LATCH, Behavioral and Molecular Ecology Research Group, Department of Biological Sciences, University of Wisconsin-Milwaukee, 3209 N. Maryland Ave., Milwaukee, WI 53211. latch@uwm.edu

ELIZABETH M. KIEREPKA, Behavioral and Molecular Ecology Research Group, Department of Biological Sciences, University of Wisconsin-Milwaukee, 3209 N. Maryland Ave., Milwaukee, WI 53211

JAMES R. HEFFELFINGER, Arizona Game and Fish Department, 555 N. Greasewood Rd., Tucson, AZ 85745. jheffelfinger@azgfd.gov

OLIN E. RHODES, JR., National Wildlife Research Center, 4101 LaPorte Ave., Fort Collins, CO 80521

Abstract: Studies of hybrid zones have revealed an array of evolutionary outcomes, yet the underlying structure is typically characterized as one of three types: a hybrid zone, a hybrid swarm, or a hybrid taxon. Our primary objective was to determine which of these three structures best characterizes a zone of hybridization between two divergent lineages of mule deer (mule deer and black-tailed deer). These lineages are morphologically, ecologically, and genetically distinct, yet hybridize readily along a zone of secondary contact between the east and west slopes of the Cascade Mountains (Washington and Oregon, USA). Using microsatellite and mitochondrial DNA, we found clear evidence for extensive hybridization and introgression between lineages, with varying degrees of admixture across the zone of contact. The pattern of hybridization in this region closely resembles a hybrid swarm; based on data from 10 microsatellite loci, we detected hybrids that extend well beyond the F1 generation, did not detect linkage disequilibrium at the center of the zone, and found that genotypes were associated randomly within the zone of contact. Introgression was characterized as bidirectional and symmetric, which is surprising given that the zone of contact occurs along a sharp ecotone and that lineages are characterized by large differences in body size (a key component of mating success). Regardless of the underlying mechanisms promoting hybrid swarm maintenance, it is clear that the persistence of a hybrid swarm presents unique challenges for management in this region.

Presenter: JAMES R. HEFFELFINGER, Arizona Game and Fish Department

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SELECTED RESULTS FROM RESIDENT AND NONRESIDENT MULE DEER HUNTER PREFERENCES SURVEYS CONDUCTED BY MONTANA FISH, WILDLIFE & PARKS

MIKE LEWIS, Human Dimensions Unit of Montana Fish, Wildlife & Parks, 1420 East Sixth Avenue, Helena, Montana 59620. (406) 444-4308, mlewis@mt.gov

Abstract: Following the 2010 general hunting season, FWP conducted surveys of resident and nonresident mule deer hunters to help evaluate Montana's mule deer management relative to hunting and harvest opportunities. Results from these surveys confirm that mule deer hunting is very important both resident and nonresident hunters. This tracks with the fact that deer hunting is by far the most popular hunting activity in Montana (in terms of overall numbers of deer hunters and hunter days). Overall, survey respondents were generally satisfied with the current mule deer hunting regulations and the timing of the current mule deer seasons in Montana. However, many resident mule deer hunters are concerned about a variety of hunting access related issues. Despite these concerns, respondent reported being generally satisfied with overall mule deer hunting opportunities in Montana. Furthermore, nearly half of the respondents rated opportunities to hunt large mule deer bucks in the state as being better than average. Mule deer are truly one of Montana's premier big game species. FWP intends to use results from this survey as an important piece of information in the consideration of future management for this significant game species that is so highly prized by hunters in the state.

Presenter: MIKE LEWIS, Human Dimensions Unit of Montana Fish, Wildlife & Parks

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PRELIMINARY OBSERVATIONS AND DISCUSSION ON ELK PARTURITION ABOVE TIMBERLINE IN NORTH-CENTRAL NEW MEXICO

STEWART LILEY, New Mexico Department of Game and Fish, 1 Wildlife Way, Santa Fe, NM 87507. (505) 467-8039, stewart.liley@state.nm.us

NICOLE TATMAN QUINTANA, Department of Natural Resources Management, Texas Tech University, Lubbock, TX 79409. (505) 720-0489, ntatman@gmail.com

Abstract: As part of a larger study on elk calf survival and mortality patterns in North-central New Mexico, crews captured 245 elk calves from 2009-2012. Most adult female elk gave birth in lower elevation valley bottoms (~2,800-3,100 meters) that had greater concealment cover for calves in their "hider" stage. However, we also observed a unique behavior of some adult females selecting to give birth above timberline (~3,600-3,900 meters) in an alpine environment. We were unable to find discussion of this behavior in any scientific literature. This raises the question: why did some elk in this area choose to give birth in this alpine environment? Possible reasons behind this behavior include; heat stress, escape from biting insects, available food sources, predator avoidance, or a combination of these. If elk are moving to higher elevations due to heat stress, increasing temperatures in the southwest may drive more individuals to exhibit this behavior. In fact, an increasing number of terrestrial species are already shifting ranges in latitude or elevation in response to a changing climate. Elk may also be moving to higher elevations as snow melts and plants begin to green-up. Alternatively, since the major cause of death for all elk calves in our area was black bear predation, we will discuss whether elk born above timberline have a survival advantage. We hope the early results discussed in this presentation will encourage researchers to consider this newly identified behavior and gather more data on the potential impacts this may have on elk, the alpine habitat in this semi-arid region, and other alpine dwelling herbivores.

Presenter: STEWART LILEY, New Mexico Department of Game and Fish

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ABUNDANCE, PRODUCTIVITY, CONDITION, AND SURVIVAL OF MOUNT ST. HELENS ELK, 2009-2013, AND CURRENT ELK MANAGEMENT CHALLENGES

SCOTT MCCORQUODALE, Washington Department of Fish and Wildlife, 1701 S. 24th Ave., Yakima, WA 98902. Scott.McCorquodale@dfw.wa.gov

PATRICK MILLER, Washington Department of Fish and Wildlife, 2108 Grand Blvd, Vancouver, WA 98661. Patrick.Miller@dfw.wa.gov

STEFANIE BERGH, Washington Department of Fish and Wildlife, 2108 Grand Blvd, Vancouver, WA 98661. Stefanie.Bergh@dfw.wa.gov

ERIC HOLMAN, Washington Department of Fish and Wildlife, 2108 Grand Blvd, Vancouver, WA 98661. Eric.Holman@dfw.wa.gov

KRISTIN MANSFIELD, Washington Department of Fish and Wildlife, 2315 N. Discovery Place, Spokane Valley, WA 99216. Kristin.Mansfield@dfw.wa.gov

RACHEL COOK, National Council for Air and Stream Improvement, 1401 Gekeler Lane, La Grande, OR 97850

Abstract: We studied a high-density elk population at Mount St. Helens, WA to refine monitoring, quantify abundance, and assess productivity and survival, 2009-2013. We radio-marked 151 adult elk (111 F, 40 M), and we used the logit-normal mark-resight estimator (LNE) to estimate elk numbers each winter, 2009-2012, using 2 replicated helicopter surveys. We explored variation in abundance at 2 spatial and 2 demographic scales. Our LNE estimates suggested a population decline, but winter severity appeared to affect annual estimates. Cow subpopulation estimates ranged 4,451 to 3,758 elk, 2009-2012; a Lincoln-Petersen estimate for 2013 was 2,990. Estimates for the branch-antlered bull subpopulation were relatively stable, but with wide confidence intervals. Mid-winter pregnancy was modest (67%) in this population, and individuals appeared to be strongly food-limited; across years, mid-winter ingesta free body fat (IFBF) averaged 4.74-6.08% for non-lactaters and 2.34-4.26% for fall lactaters. We rarely (< 4%) detected pregnancy in elk with evidence of late lactation. Kistner susbset scoring of organs from fall-harvested cow elk indicated mean IFBF estimates of about 10-13% for non-lactaters and 8-12% for lactaters, with spatial but not temporal variation clearly evident. Annual survival estimates for cows varied 0.55-0.85, with evidence of both spatial and temporal variation consistent with the harvest strategy in place 2009-2012; estimated mean bull survival was 0.54. Recently, segments of this herd have been increasingly affected by an ulcerative hoof disease with currently unknown etiology. We briefly describe recent work to better understand this condition, its impacts, and management options. Despite gains, this elk herd continues to present considerably complex management challenges.

Presenter: SCOTT MCCORQUODALE, Washington Department of Fish and Wildlife

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EFFECTS OF HARVEST, CULTURE, AND CLIMATE ON TRENDS IN SIZE OF HORN-LIKE STRUCTURES IN TROPHY UNGULATES

KEVIN L. MONTEITH, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Dept. 3166, 1000 E. University Ave, Laramie, WY 82071. (307) 766-2322, kmonteit@uwyo.edu

RYAN A. LONG, Department of Biological Sciences, Idaho State University, 921 S. 8th Ave., Stop 8007, Pocatello, ID 83209. (208) 283-5367, longryan@isu.edu

VERNON C. BLEICH, Sierra Nevada Bighorn Sheep Recovery Program, California Department of Fish and Game, 407 West Line Street, Bishop, CA 93514. (760) 937-5020, vcbleich@gmail.com

JAMES R. HEFFELFINGER, Arizona Game and Fish Department, 555 N. Greasewood Road, Tucson, AZ 85745. (520) 975-6322, j.heffelfinger@azgfd.gov

PAUL R. KRAUSMAN, Wildlife Biology Program, University of Montana, 32 Campus Drive, Missoula, MT 59812. (406) 243-6011, paul.krausman@umontana.edu

R. TERRY BOWYER, Department of Biological Sciences, Idaho State University, 921 S. 8th Ave., Stop 8007, Pocatello, ID 83209. (208) 282-4082, bowyterr@isu.edu

Abstract: In polygynous ungulates, mating success of males is correlated with body size and size of horn-like structures, which are biologically important and are of cultural interest. We evaluated trends in horn and antler size of trophy males recorded from 1900 to 2008 in *Records of North American Big Game*, which comprised >22,000 records among 25 trophy categories of species occupying North America. We used a weight-of-evidence approach based on differences among trophy categories in life-history characteristics, geographic distribution, morphological attributes, and harvest regimes to discriminate among competing hypotheses for explaining trends in horn and antler size of trophy ungulates. These hypotheses were young male age structure caused by intensive harvest of males, genetic change as a result of selective male harvest, a sociological effect, effects of climate, and habitat alteration. Trends in size of horn-like structures were negative and significant for 11 of 17 antlered categories and 3 of 8 horned categories. Mean predicted declines during 1950–2008 were 1.87 and 0.68% for categories of trophy antlers and horns, respectively. Our results were consistent with a harvest-based explanation, whereby harvest of males has gradually shifted age structure towards younger and smaller males. A harvest-induced reduction in age structure can increase the number of males that are harvested prior to attaining peak horn or antler size. Long-term trends in the size of trophy horn-like structures may provide the incentive to evaluate the appropriateness of the current harvest paradigm and pursue further investigations to disentangle the relative effects of nutrition and harvest.

Presenter: PAUL R. KRAUSMAN, Wildlife Biology Program, University of Montana

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PERVASIVE HUMAN INFLUENCES IN A TERRESTRIAL FOOD WEB CENTERED ON ELK

TYLER B. MUHLY, Ecosystem Management, Alberta Innovates - Technology Futures, Bag 4000, Hwy 16A & 75 Street Vegreville, AB T9C 1T4

MARCO MUSIANI, Faculties of Environmental Design and Veterinary Medicine, 2500 University Drive NW, University of Calgary, Calgary, Alberta T2N 1N4 Canada. (403) 220-2604, mmusiani@ucalgary.ca

MARK HEBBLEWHITE, Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, College of Forestry and Conservation, University of Montana, Missoula, Montana 59812 USA

DALE PATON, 2500 University Drive NW, University of Calgary, Calgary, Alberta T2N 1N4 Canada

JUSTIN A. PITT, Department of Biological Sciences, CW 405, Biological Sciences Building, University of Alberta, Edmonton, Alberta T6G 2E9 Canada

COLLEEN ARNISON, Masters Candidate, Faculty of Environmental Design, University of Calgary, 2500 University Drive NW, Calgary, Alberta, T2N 1N4. (403) 852-0195, carnison@gmail.com

MARK S. BOYCE, Department of Biological Sciences, CW 405, Biological Sciences Building, University of Alberta, Edmonton, Alberta T6G 2E9 Canada

Abstract: Ongoing debate about whether food webs (e.g. those involving elk) are primarily regulated by predators or by primary plant productivity, cast as top-down and bottom-up effects, respectively, may becoming superfluous. Given that most of the world's ecosystems are human dominated we broadened this dichotomy by also considering human effects in a terrestrial food-web centered on elk. We

therefore studied a multiple human-use system in southwest Alberta, Canada, as opposed to atypical protected areas where many previous terrestrial food web studies were conducted, which also had elk as dominant wild herbivore. Our system included humans, dominant predators (i.e., wolves) and prey (i.e., elk, but also domestic cattle) species, and herbaceous biomass (forage). Relationships were evaluated by taking advantage of pseudo-experimental temporal and spatial variation in human density, including: (a) day versus night, and (b) two landscapes with the highest and lowest human density in the study area. Here we show that forage-mediated effects of humans had primacy over predator-mediated effects in the food web. Spatial and temporal occurrence of humans was most correlated with occurrence of forage. Elk and cattle distribution were also correlated with forage, and the distribution of elk or cattle and wolves were positively correlated too. Our findings indicated that a number of studies on elk ecology and management that have typically focused on wild predators and natural plant communities should be re-interpreted. Humans now influence most food webs worldwide. Therefore, views of ecosystems focusing on forage-mediated effects of humans may subsume top-down or bottom-up views.

Presenter: Colleen Arnison, Masters Candidate, Faculty of Environmental Design, University of Calgary

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INCORPORATING MOVEMENT BASED-LANDSCAPE CONNECTIVITY INTO ASSESSMENTS OF CHRONIC WASTING DISEASE RISK IN THE PRAIRIE PROVINCES OF CANADA

BARRY R. NOBERT, Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9, Canada. brnobert@ualberta.ca

EVELYN H. MERRILL, Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9, Canada. emerrill@ualberta.ca

MARGO J. PYBUS, Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9 and Alberta Fish and Wildlife Division, Government of Alberta, Edmonton, AB T6H 4P2, Canada. margo.pybus@gov.ab.ca

TRENT K. BOLLINGER, Canadian Cooperative Wildlife Health Centre, Department of Veterinary Pathology, Western College of Veterinary Medicine, University of Saskatoon, Saskatoon, Saskatchewan, S7N 5B4, Canada. trent.bollinger@usask.ca,

YEEN TEN HWANG, Fish and Wildlife Branch, Saskatchewan Ministry of Environment, 12 Regina, Saskatchewan, S4S 5W6, Canada. yeenten.hwang@gov.sk.ca,

DAVID W. COLTMAN, Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9, Canada. david.coltman@ualberta.ca

Abstract: Chronic wasting disease (CWD) was first detected in free-ranging deer in Alberta in 2005 and is continuing to spread despite management efforts to contain the disease. To guide surveillance and management, we built a disease risk model (P_{IDM}) that predicted the probability of a hunter-harvested deer being CWD-positive based on deer species and sex, landscape characteristics, and connectivity to known sources of CWD using surveillance data collected in Alberta and Saskatchewan between 2000 and 2010. Landscape connectivity metrics were based on circuit theory and resistances derived from step-selection functions from movement responses of 58 GPS-collared deer. The best P_{IDM} included

extent of agricultural area, ruggedness of the area, distance to stream and roads, and connectivity to disease sources, and had an area under the receiver operating curve (AUC) of 0.85. Metrics of landscape connectivity based on deer movement behavior improved the prediction of disease risk over proximity based on Euclidean distance. The model was used to identify areas of high risk in currently "CWD-free" wildlife management units (WMUs) in Alberta along the border of Alberta and Saskatchewan.

Presenter: EVELYN H. MERRILL, Department of Biological Sciences, University of Alberta

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ELK CALF SURVIVAL AND THE EFFECTIVENESS OF BLACK BEAR REMOVAL IN NORTH-CENTRAL NEW MEXICO

NICOLE TATMAN QUINTANA, Department of Natural Resources Management, Texas Tech University, Lubbock, TX 79409. (505) 720-0489, ntatman@gmail.com

STEWART LILEY, New Mexico Department of Game and Fish, 1 Wildlife Way, Santa Fe, NM 87507. (505) 467-8039, stewart.liley@state.nm.us

Abstract: We studied elk calf survival and the effectiveness of black bear removal from 2009-2012 in North-central New Mexico. Crews captured 245 elk calves during the birthing season across all years. Calves were captured by hand and equipped with a VHF ear-tag transmitter to aid in determining the causes and timing of moralities. Calves averaged 2.6 days of age at capture and ranged from 0 to 6 days of age. We monitored calves daily during their first month of life and bi-monthly or monthly thereafter. Black bear populations were reduced on a portion of our study area in spring and summer during the second half of our study (2011-2012). We compared early (22-day) calf survival rates on treated and control areas both prior to and during bear removal. Prior to bear removal, the 22-day post-parturition survival rate was 53%. In contrast, when bears were actively being removed the 22-day survival rate on our treatment site increased to 70%. During this same time the survival rate on our control site was 58%. Black bears killed 25% of all marked calves during the first 22-days of life prior to removal, but only 15% of marked calves during removal on our treatment site. While bears were the most frequently identified cause of death across all years and treatments, they took proportionately less calves when they were actively being removed from calving areas. The second most frequently identified cause of death was coyote predation. Future work will assess whether bear predation acts as an additive or compensatory form of mortality in our study area.

Presenter: NICOLE TATMAN QUINTANA, Department of Natural Resources Management, Texas Tech University

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EFFECTS OF HUNTER ACCESS AND HABITAT SECURITY ON ELK HABITAT SELECTION

KELLY M. PROFFITT, Montana Department of Fish, Wildlife, and Parks, 1400 South 19th Avenue, Bozeman, MT 59718, USA

JUSTIN A. GUDE, Montana Department of Fish, Wildlife, and Parks, 1420 East 6th Avenue, Helena, MT 59620, USA

KENNETH L. HAMLIN, Montana Department of Fish, Wildlife, and Parks, 1400 South 19th Avenue, Bozeman, MT 59718, USA

M. ADAM MESSER, Montana Department of Fish, Wildlife, and Parks, 1420 East 6th Avenue, Helena, MT 59620, USA

Abstract: Traditional elk habitat management on public land has focused on providing security habitat for bull elk during the hunting season in order to provide for both adequate hunter opportunity and bull survival. This paradigm has given less consideration to adult female elk habitat use, patterns of adjacent land ownership, and hunter access. This paradigm also was developed when elk population sizes were much smaller in many areas. In many Rocky Mountain states, the focus of elk population management has recently shifted to reducing or maintaining elk population sizes, necessitating a better understanding of the implications of security habitat management, as well as patterns of adjacent land ownership and hunter access, on adult female elk. We addressed this need by testing the hypotheses that during the hunting season: 1) adult female elk selection for areas prohibiting or limiting hunter access is stronger than elk selection for publicly owned and managed elk security habitat, 2) these effects occur during the archery hunting period and intensify during the rifle hunting period, and 3) the effects of hunter access on selection are consistent among herds that occupy landscapes characterized by a matrix of public and private lands. Elk selection for areas with limited public hunting access and lower motorized road densities, combined with either differential adult female harvest pressure on herd segments that use areas with public hunting access or elk avoidance of areas used by hunters, has the potential to reduce the number of elk using public lands. Our results provide evidence that in landscapes characterized by a matrix of public and privately owned lands, traditional concepts of elk security habitat need to be expanded to also include areas that restrict hunter access in order to plan for elk population management that is regulated through adult female harvest. These results reinforce the need for wildlife managers to work closely with public land management agencies and private landowners to manage the size of elk herds.

Presenter: KELLY M. PROFFITT, Montana Department of Fish, Wildlife, and Parks

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RELATIVE IMPACTS OF ELK, MULE DEER, AND CATTLE ON ASPEN HABITAT IN THE BOOK CLIFFS, UTAH AND COLORADO

PAUL C. ROGERS, Western Aspen Alliance, Ecology Center, and Wildland Resources Department, 5230 Old Main Hill, Utah State University, Logan, Utah, 84322. (435)797-0194, p.rogers@usu.edu

CODY M. MITTANCK, CNL Environmental Consultants LLC, Salt Lake City, Utah, 84106. (801)367-2230, cody.mittanck@gmail.com

Abstract: Quaking Aspen (*Populus tremuloides*) provide crucial habitat for a large array of forest dwelling and transient species. These systems, however, are threatened by multiple human impacts, such as clear-felling, land development, water diversions, fire suppression, and both wild and domestic ungulate herbivory. Aspen is the most widespread tree species in North America, yet particularly in the arid Southwest these forests may be highly sensitive to combined impact and climate effects. We undertook a landscape-level assessment of aspen forest conditions with the goal of identifying key components of resilience. Seventy-seven one hectare plots were sampled for forest structure, composition, regeneration and recruitment, landscape features, browse level, and herbivore use. Use was determined by counting pellet groups by ungulate species at each sample location. We also tested the efficacy of a visual stand condition rating system. Results indicate that plots differed significantly by seral or stable aspen type, stand condition, and browse species use. Overall, aspen in our study landscape was highly vulnerable to collapse due to narrow environmental limitations and browse levels. Ordination analysis revealed that regeneration level and herbivore use were the strongest objective indicators of aspen stand conditions, while the stand condition rating proved a valuable subjective index of forest status. Our results describe long-term, landscape-level, aspen herbivory impacts where naturally slow growth, relatively dry conditions, and intense browsing predominate. We argue for collaborative wildlife and forest management to promote ecosystem resilience and avoid further degradation of this regionally valuable and highly biodiverse habitat.

Presenter: PAUL C. ROGERS, Western Aspen Alliance, Ecology Center, and Wildland Resources Department

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MODELING ELK NUTRITION AND HABITAT USE ACROSS LARGE LANDSCAPES: NEW METHODS OF META-ANALYSIS

MARY ROWLAND, U.S. Forest Service, Pacific Northwest Research Station, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6582, mrowland@fs.fed.us

MICHAEL WISDOM, U.S. Forest Service, Pacific Northwest Research Station, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6532, mwisdom@fs.fed.us

JOHN COOK, National Council for Air and Stream Improvement, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6536, cookjg.ncasi@gmail.com

RYAN NIELSON, Western EcoSystems Technology (WEST), Inc., 415 West 17th St., Suite 100, Cheyenne, WY 82001. (970) 484-3353, rnielson@west-inc.com

RACHEL COOK, National Council for Air and Stream Improvement, 1401 Gekeler Lane, La Grande, OR 97850. (541) 963-9275, rachierae@gmail.com

PRISCILLA COE, Oregon Department of Fish and Wildlife, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6550, priscilla.k.coe@state.or.us

JENNIFER HAFER, U.S. Forest Service, Pacific Northwest Research Station, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6527, jmhafer@fs.fed.us

BRIDGETT NAYLOR, U.S. Forest Service, Pacific Northwest Research Station, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6564, bnaylor@fs.fed.us

BRUCE JOHNSON, Oregon Department of Fish and Wildlife, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6556, bruce.k.johnson@state.or.us

MARTIN VAVRA, U.S. Forest Service, Pacific Northwest Research Station, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6561, martinvavra@fs.fed.us

Abstract: Elk (*Cervus elaphus*) are widely distributed across the Northwest, where they are an integral component of the landscape. Elk management and land-use plans often rely on models that do not reliably estimate suitable elk habitat. In our presentation we describe development, validation, and application of new landscape models of elk nutrition and habitat selection during summer for western Oregon and Washington (Westside). We developed a unique meta-analysis approach that leveraged existing, disparate telemetry and environmental covariate data sets from a variety of sources. Specifically, we developed two models, both spatially explicit and applicable across large landscapes: a nutrition model to estimate elk diet quality, and a habitat use model to predict relative use by elk. We used an intensive model selection process that considered >50 covariates to create a suite of potential covariates for inclusion in the final models. The model best supported by the data included elk dietary digestible energy, distance to open roads, slope, and distance to cover-forage edge as covariates to predict probability of elk use. The habitat use model validated well, with correlation coefficients >0.85 in 5 of 8 validation sites. The models can be used to evaluate current conditions for elk in Westside landscapes and future conditions based on alternative from management scenarios such as reduced road access or forest canopy cover. Our methods of meta-analysis provide a regional inference space that typically has not been achieved with past modeling efforts and thus offer a defensible basis for regional management use of the models.

Presenter: MARY ROWLAND, U.S. Forest Service, Pacific Northwest Research Station

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THE MONTANA DEER AND ELK HUNTING POPULATION: IMPORTANCE OF COHORT GROUP, LICENSE PRICE, AND POPULATION DEMOGRAPHICS ON HUNTER RETENTION, RECRUITMENT, AND POPULATION CHANGE

ROBERT A. SCHORR, Montana Cooperative Wildlife Research Unit, The University of Montana, Missoula, MT 59812, USA. robert.schorr@umontana.edu

PAUL M. LUKACS, Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, College of Forestry and Conservation, The University of Montana, Missoula, MT 59812, USA. paul.lukacs@umontana.edu

JUSTIN A. GUDE, Montana Fish, Wildlife and Parks, 1420 East 6th Avenue, Helena, MT 59620, USA. jgude@mt.gov

Abstract: Big game hunting is an invaluable resource for outdoor recreation opportunities, an economic driver for state and local economies, and a mechanism for funding wildlife management. Unfortunately, hunting license sales have been in decline. Contrary to many other regions, Montana experienced increased deer and elk license sales from 2002 – 2007. Despite this trend, understanding the mechanisms behind such increases, and diagnosing the persistence of such trends is necessary to anticipate license fund fluctuations. To address hunter recruitment and retention rates we analyzed >490,000 Montana deer and elk license records from 2002 – 2011. We used a mark-recapture framework to estimate hunter retention, recruitment, and population change, then used those estimates to forecast future hunter populations. Deer and elk hunter population size grew until 2006, and then declined because of dramatic reductions in hunter recruitment and decreases in hunter retention. Gender, age, and residency improved fit because of the overwhelming number of older resident male hunters that participate in hunting. Also, birth cohort and license price were valuable predictors that have ramifications for how Montana may structure recruitment and retention strategies.

Recruitment of young hunters appears to be successful as recruitment has increased for this group, but because Baby Boomers are a majority of the hunting population, the loss of recruitment and retention from this class is driving declines in the hunter population.

Presenter: PAUL M. LUKACS, Department of Ecosystem and Conservation Sciences, College of Forestry and Conservation, University of Montana

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MIGRATION BEHAVIOR, BODY CONDITION, AND SEX DIFFERENCES IN SURVIVAL OF MULE DEER.

CODY A. SCHROEDER, Department of Natural Resources and Environmental Science, University of Nevada, Reno, Reno, Nevada 89512

KELLEY M. STEWART, Department of Natural Resources and Environmental Science, University of Nevada, Reno, Reno, Nevada 89512

TONY WASLEY, Nevada Department of Wildlife, Reno, Nevada 89512

Abstract: Migration is an important adaptation for species inhabiting variable ecosystems. Many ungulate populations make seasonal migrations between summer and winter ranges; however, peer-reviewed literature indicates migration routes and distances travelled can be highly variable. Few studies have quantified these migration strategies in the context of true measures of fitness such as body condition or population-level effects on survival. We used data from 424 radio-collared mule deer (*Odocoileus hemionus*) to test hypotheses relating survival to body condition, sex, environmental conditions, and migratory strategy. We used a known-fate survival framework in Program Mark to obtain seasonal estimates of survival for each sex and age class in relation to body condition and migration distance. Adult survival was most parsimoniously explained by models containing covariates for sex, season, body condition and migration distance. Over-winter survival of juvenile mule deer was best explained by models containing covariates for sex, body mass, and a winter severity index. Adult and juvenile survival was lower for males than for females, even after accounting for mortality caused by human harvest. These results suggest population models may overestimate male survival outside of harvest reporting. We also provide preliminary results that suggest adult survival varies with respect to migratory behavior and body condition, which may have direct management implications for decisions affecting harvest quotas, habitat improvements, and energy development policies.

Presenter: CODY A. SCHROEDER, Department of Natural Resources and Environmental Science, University of Nevada

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INFLUENCE OF FORAGING BEHAVIOR ON HOME RANGE DEVELOPMENT IN ELK

DANA SEIDEL, Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9. (780) 492-6267, dpseidel@ualberta.ca

MARK S. BOYCE, Department of Biological Sciences, University of Alberta, Edmonton, AB T6G 2E9. (780) 492-0081, boyce@ualberta.ca

Abstract: Despite being documented across many taxa, home ranges and the mechanisms behind their development are not fully understood. The marginal value theorem combined with resource selection and memory has been proposed as a mechanism behind the emergence of stable home ranges, but these theories have seldom been tested. To explore the influence of foraging behavior on home range, we investigated how a large browsing herbivore uses and returns to particular areas of its home range throughout the growing season. Using GPS radiotelemetry data from 20 elk (*Cervus elaphus*) and a spatial-temporal clustering algorithm, areas of foraging were identified within natural home ranges in montane grasslands of Southwestern Alberta. Vegetation surveys were used to evaluate and compare selected foraging patches to other areas of the home range visited but not selected for foraging. We have documented patch selection throughout the growing season, highlighting fidelity and a cyclic return pattern through areas of the summer range. Investigation into the mechanisms of stable home range development can help us to anticipate and understand changes in home range and how these ranges are influenced by conspecifics, competitors, invaders, and land-use change.

Presenter: DANA SEIDEL, Department of Biological Sciences, University of Alberta

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ELK MOVEMENTS AND BRUCELLOSIS TRANSMISSION RISK IN SOUTHWEST MONTANA

JULEE SHAMHART, Montana Fish, Wildlife and Parks, Dillon, MT 59725. (406) 925-9545, jshamhart@mt.gov

KELLY PROFFITT, Montana Fish, Wildlife and Parks, Bozeman, MT 59718. (406) 994-6365, kproffitt@mt.gov

NEIL ANDERSON, Montana Fish, Wildlife and Parks, Bozeman, MT 59718. (406) 994-6358, nanderson@mt.gov

JENNIFER RAMSEY, Montana Fish, Wildlife and Parks, Bozeman, MT 59718. (406) 994-5671, jramsey@mt.gov

KERI CARSON, Montana Fish, Wildlife and Parks, Bozeman, MT 59718. (406) 994-6357, kcarson@mt.gov

JUSTIN GUDE, Montana Fish, Wildlife and Parks, Helena, MT 59620. (406) 444-3767, jgude@mt.gov

Abstract: The presence of *Brucella abortus* within free-ranging elk populations is an important conservation and management issue because of the risk of brucellosis transmission to livestock. In the winter of 2010-2011 Montana Fish, Wildlife and Parks initiated a multi-year targeted brucellosis surveillance project with the goals of delineating the geographical distribution of brucellosis in Montana elk populations, enhancing our understanding of how brucellosis functions in elk populations and providing wildlife managers with information to inform elk management where brucellosis is present. During each of the winters of 2011, 2012 and 2013, we targeted brucellosis surveillance in a different study area along the periphery of where brucellosis had previously been detected. In each study area, 100 adult female elk were captured and tested for exposure to brucellosis, and 30 elk were outfitted with GPS collars. All seropositive elk were outfitted with radiocollars for 5 years, repeatedly captured and tested each year, and any pregnant seropositive elk were outfitted with vaginal implant transmitters to monitor the fate of pregnancy. During 2011, 12 elk in the Sweetwater/Blacktail herd tested positive for exposure to brucellosis, 4 were outfitted with VITS, and no abortions were detected. During 2012, 5

elk in the Sage Creek area tested seropositive, and 8 elk from the Blacktail and Sage Creek areas were outfitted with VITs. Two elk aborted calves in April and May of 2012, and the remaining 6 elk delivered live calves. In 2013, no elk in the Pioneer herd tested positive for exposure to brucellosis. A total of 7 VITS were deployed, and to date no abortions have occurred. *B. abortus* was cultured from tissues or VITs associated with each of the 2 aborted calves in 2012. Although seropositive elk abortion rates are relatively low, the risk of transmission to livestock does exist. GPS location data is being used to develop and validate predictive models forecasting elk and livestock spatial overlap during the risk period, and to help mangers identify the areas of highest potential risk of elk to livestock transmission.

Presenter: JULEE SHAMHART, Montana Fish, Wildlife and Parks

EFFECTS OF SPRING CATTLE GRAZING ON THE NUTRITION OF MULE DEER IN A BLUEBUNCH WHEATGRASS COMMUNITY

LISA A. SHIPLEY, School of the Environment, 115 Johnson Hall, Washington State University, Pullman, WA 99164. (509) 335-9182, Shipley@wsu.edu

SARA J. WAGONER, School of the Environment, 115 Johnson Hall, Washington State University, Pullman, WA 99164. (509) 335-6166, dearsara@hotmail.com

RACHEL C. COOK, National Council for Air and Stream Improvement, Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 963-9275, rachierae@gmail.com

LINDA HARDESTY, School of the Environment, 115 Johnson Hall, Washington State University, Pullman, WA 99164. (509) 335-6632, lhardest@wsu.edu

Abstract: Domestic cattle and mule deer (*Odocoileus hemionus*) share bluebunch wheatgrass (*Pseudoroegneria spicata*) communities throughout western United States and Canada, but the effects of cattle grazing on the nutrient intake and nutritional carrying capacity of mule deer in these semi-arid rangelands is unclear. We expected that spring cattle grazing would decrease plant biomass available but increase the nutritional quality of forage by arresting the phenology of grasses, reducing the proportion of standing dead biomass of grasses, and promoting forbs. Using exclosures, we created 3 replicates of paired grazed and non-grazed treatments within 3 pastures in bluebunch wheatgrass communities in southeastern Washington. After cattle had grazed 1 of each pair of plots to 40% utilization in April-May, we sampled the biomass and measured the digestible energy (DE, kJ/g) of plants that spring and fall. Using hand-raised, tractable mule deer, bite count methods, and behavioral observations, we measured intake within each plot. When compared to non-grazed plots, grazed plots had less than half the total and live plant biomass in spring, and 25% less biomass in fall, whereas DE content of bluebunch wheatgrass and mule deer diets did not differ between grazing treatments. Daily DE intake of deer was lower in spring and fall in grazed than non-grazed plots, but nutritional carrying capacity did not vary between grazing treatments except for 1 pasture in fall, indicating that spring grazing by cattle in bluebunch wheatgrass communities did not improve the nutritional quality of deer diets enough to offset the overall loss of live forage biomass.

Presenter: LISA A. SHIPLEY, School of the Environment, Washington State University

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WINTER HABITAT USE BY MULE DEER IN IDAHO AND MONTANA

SONJA M. SMITH, P.O. Box 938, Lewistown, MT 5945, USA. (406) 538-4658, sonjasmith@mt.gov

PAUL R. KRAUSMAN, Boone and Crockett Program in Wildlife Conservation, College of Forestry and Conservation, University of Montana, Missoula, MT 59812. (406) 243-6011, paul.krausman@umontana.edu

GREG PAINTER, Habitat Biologist, Idaho Department of Fish and Game, Salmon, ID 83467. (208) 993-1295, greg.painter@idfg.idaho.gov

Abstract: Winter survival for Rocky Mountain mule deer (*Odocoileus hemionus hemionus*) depends on an energy conservation strategy where they use habitats at lower elevations and south facing slopes with adequate thermal or canopy cover. However, not all mule deer habitats are equivalent; these and weather conditions contribute to differences in habitat use patterns and behavior among wintering populations. We studied mule deer on the East Front of the Rocky Mountains, Montana and Warm Springs and Sink Creek, east-central Idaho to determine how weather and vegetation affect winter habitat use. We located radiocollared adult female mule deer and collected data on weather, landscape, cover and forage variables at deer use and random locations during winter 2010—2011. Using logistic regression, we found that deer use different habitat components on these different winter ranges. On the East Front, a combination of variables predicted probability of deer use, mainly related to cover, forage, and environmental conditions. Covariates changed in magnitude depending upon weather conditions and deer behavior. In Idaho, cover and forage variables were important predictors of mule deer habitat use. Mule deer habitat use also differed between Idaho study areas. In Warm Springs, covariates related to foraging predicted habitat use whereas in Sink Creek, covariates related to thermal or hiding cover predicted habitat use. Differences among all 3 study areas indicate that deer use different habitat components under different winter conditions. Discrepancies in habitat use among winter ranges are important when considering habitat requirements of mule deer.

Presenter: SONJA M. SMITH, Montana Fish, Wildlife and Parks

NUTRITIONAL CONDITION OF ADULT MULE DEER FOLLOWING HABITAT ENHANCEMENTS IN NORTH-CENTRAL NEW MEXICO

GRANT E. SORENSEN, Department of Natural Resources Management, Goddard Building, Texas Tech University, Lubbock, TX 79409. (307) 421-5692, grant.sorensen@ttu.edu

DAVID KRAMER, Department of Natural Resources Management, Goddard Building, Texas Tech University, Lubbock, TX 79409. (806) 742-2841, dwkramer@uga.edu

CHASE TAYLOR, Department of Natural Resources Management, Goddard Building, Texas Tech University, Lubbock, TX 79409. (806) 742-2841, chase.a.taylor@ttu.edu

MARK WALLACE, Department of Natural Resources Management, Goddard Building, Texas Tech University, Lubbock, TX 79409. (806) 742-2841, mark.wallace@ttu.edu

PHILIP GIPSON, Department of Natural Resources Management, Goddard Building, Texas Tech University, Lubbock, TX 79409. (806) 742-2841, philp.gipson@ttu.edu

ROBERT COX, Department of Natural Resources Management, Goddard Building, Texas Tech University, Lubbock, TX 79409. (806) 742-2841, robert.cox@ttu.edu

JAMES CAIN, U.S. Geological Survey, New Mexico Cooperative Fish and Wildlife Research Unit, Department of Fish, Wildlife, and Conservation Ecology, New Mexico State University, Las Cruces, NM 88003. (575) 646-3382, jwcain@nmsu.edu

WAYNE ARMACOST, NRA Whittington Center, U.S Hwy 64, Raton, NM 87740. (575) 445-3615, warmacost@nrawc.org

Abstract: Mule deer (*Odocoileus hemionus*) populations are declining throughout the western United States including New Mexico. Poor quality habitat, food availability, drought, and predation are factors indicated to limit mule deer populations in north-central New Mexico. The 33,000 acre National Rifle Association Whittington Center (WC) located south of Raton, NM implemented a habitat enhancement program intended to benefit mule deer. The objectives of this study were to determine the nutritional condition of mule deer and cause-specific mortality following habitat treatments. We radio marked 36 and 16 adult mule deer during the winter of 2011 and 2012 respectively. Each deer was monitored daily for survival and cause-specific mortality was determined for each death. Here we report on live animal indices including: body condition score, subcutaneous rump fat, body mass, chest girth, and total body length. Total ingesta-free body fat (IFBF) levels of adult deer in March ranged from 1.05% to 10.55%. Body mass ranged from 42.18 kg to 70.31kg. Predation was the most common cause of morality (85% n = 22) and mountain lion (*Puma concolor*) accounted for 68.2% of all predation events. There was no significant correlation (p = 0.3188) between IFBF and fate of adult mule deer thus indicating a weak role of IFBF in the mortality of mule deer on the WC. Our IFBF levels are congruent to those recorded on similar studies in the area prior to habitat enhancements. These results point to a stronger role of predation over nutritional condition in the survival of adult mule deer in north-central New Mexico.

Presenter: GRANT E. SORENSEN, Department of Natural Resources Management, Texas Tech University

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HABITAT ENHANCEMENT STRATEGY CHANGES IN ELK COUNTRY

TOM TOMAN, Rocky Mountain Elk Foundation, 5705 Grant Creek Rd., Missoula, MT 59808, USA

Abstract: The Rocky Mountain Elk Foundation (RMEF) over the past 28 years has provided grants for wildlife habitat enhancement projects on federal, state, tribal and private ownerships. The types of projects funded in the 1980s and 1990s were primarily prescribed burns and noxious weed treatments and most focused on the crucial winter ranges or winter range as delineated by the state wildlife agencies. The collective thinking at the time was that summer range was virtually unlimited and the winter range conditions were a limiting factor in getting elk through the rigorous winters of the western landscape. In the early 2000s the collective thinking shifted to the importance of transitional ranges for elk to maximize their body condition post-rut and before the winter conditions arrived. Habitat treatment projects continued to focus on winter ranges while some shifted to the transitional areas. Forests were even-aged with an understory of ladder fuels that lead to stand replacing fires in most conifer types. The primary habitat enhancement tool was forest thinning by mechanical means. New

research on elk nutrition pointed out the importance of summer range nutrition and its impact on breeding success, pregnancy rates and winter survival were identified. Use of the most recent science has directed the emphasis on wildlife habitat enhancement and developing science should drive future enhancement projects.

Presenter: TOM TOMAN, Rocky Mountain Elk Foundation

GENETIC STRUCTURE AND DIVERSITY OF ELK (*CERVUS ELAPHUS*) IN WASHINGTON STATE

KENNETH I. WARHEIT, Washington Department of Fish and Wildlife, 600 Capitol Way N., Olympia, WA 98501. (360) 902-2595, kenneth.warheit@dfw.wa.gov

SCOTT MCCORQUODALE, Washington Department of Fish and Wildlife, 1701 S. 24th Ave., Yakima, WA 98902. (509) 457-9322, scott.mccorquodale@dfw.wa.gov

JERRY NELSON, Washington Department of Fish and Wildlife, 600 Capitol Way N., Olympia, WA 98501. (360) 902-2519, jerry.nelson@dfw.wa.gov

Abstract: Elk in Washington State are divided into ten “herds,” and include Roosevelt and Rocky Mountain subspecies. Roosevelt elk are native, found on the Olympic Peninsula and in the southwest portion of the state. Although Rocky Mountain elk historically may have been native in Washington, existing populations in the Cascade, Blue, and Selkirk Mountains are now composed mostly of elk that are descendants of animals translocated from Montana and Wyoming. We examined the genetic structure and diversity of these elk populations using nine microsatellite loci, each with an average of six alleles per locus. Except for Mount St. Helens, herds are generally composed of either Roosevelt (two herds) or Rocky Mountain elk (seven herds); the Mount St. Helens herd includes both subspecies. There is significant genetic differentiation between the Roosevelt and Rocky Mountain herds, although elk from North Cascade herd, considered to be Rocky Mountain elk, appear equally distant genetically from all herds. If we ignore the geographic distribution and consider only genetic differentiation, Roosevelt elk are distributed as two populations: north and south, corresponding to the Olympic and Willapa Hills/Mount St. Helens herds, respectively. Although the Rocky Mountain elk are more widely distributed geographically than Roosevelt elk, genetically they resemble a single population, perhaps reflecting the recency of their translocations. Despite the genetic similarity among all Washington Rocky Mountain herds, elk from the contiguous Mount St. Helens, Yakima, and North and South Rainier herds are more similar genetically to each other than they are to the other Rocky Mountain herds.

Presenter: KENNETH I. WARHEIT, Washington Department of Fish and Wildlife

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UNTANGLING ROCKY MOUNTAIN ELK ECOLOGY AND POPULATION DYNAMICS: A REGIONAL SYNTHESIS ACROSS THE NORTHWESTERN U.S.

WESTERN ELK RESEARCH COLLABORATIVE (representatives from 7 state wildlife management agencies, 4 Cooperative Wildlife Research Units, 1 university, National Park Service)

PETE ZAGER, Idaho Department of Fish and Game, Lewiston, Idaho 83501.

Abstract: The Western Elk Research Collaborative (WERC) is a group of state and federal biologists and university faculty that is pooling Rocky Mountain elk data from 7 states to understand factors affecting elk population dynamics at broad spatial and temporal scales. These "value-added" analyses leverage the considerable investment collaborators made to develop their respective datasets. Our initial efforts pooled data from 12 elk populations to evaluate calf survival and cause-specific mortality (Journal of Animal Ecology 80:1,246-1,257) and 45 datasets to assess adult female survival and cause-specific mortality (Journal of Applied Ecology in press). We will briefly describe those findings. We also seek to understand how reproductive output varies across space and time as a function of factors such as weather, plant productivity, and predation. Therefore, we are assembling population and reproduction data from our 7 state study area. The spatial and temporal (up to 25 years) scales are unique and may provide insight into the effects of climate change on elk population dynamics. As a direct result of the exceptional cooperation and communication among collaborators … a signature success of WERC … we are developing an unprecedented Rocky Mountain elk dataset that will provide a fertile arena to investigate relevant management and research questions.

Presenter: PETE ZAGER, Idaho Department of Fish and Game

Abstracts, Status Reports

STATUS OF DEER AND ELK POPULATIONS IN ALBERTA

ROB CORRIGAN, Alberta Environment and Sustainable Resource Development, Wildlife Management Branch, 2nd Floor GWL 9920-108 St., Edmonton, AB, T5K 2M4. (780) 644-8011, rob.corrigan@gov.ab.ca

JIM ALLEN, Alberta Environment and Sustainable Resource Development, Wildlife Management Branch, 2nd Floor GWL 9920-108 St., Edmonton, AB, T5K 2M4. (780) 427-4194, james.allen@gov.ab.ca

Abstract: Provincial populations of white-tailed deer (235,000), mule deer (142,000) and elk (33,000) have been increasing over the past 20 years. Despite increasing provincial populations, some areas of Alberta have experienced significant declines in elk number, including core population of elk in the mountains and east slopes of west central Alberta. Population declines of elk in the west central part of Alberta are largely attributed to increasing predation by grizzly bears and cougars. Elk range has recently expanded into the prairies and central parkland eco-regions of Alberta. Increased distribution has led to new hunting opportunities but also is causing significant issues with agricultural producers. White-tailed deer and mule deer suffered significant regional winter mortality during the winter of 2010-11. High winter mortality has reduced populations below desired goals in many areas of the province. In response to below goal population levels, recreational hunting opportunities were reduced in many areas of the province. Mule deer hunting in Alberta has also undergone significant changes in response to increasing harvest of antlered mule deer by bow hunters. In order to equitably distribute harvest amongst user groups, archery hunting for antlered mule deer will now require a special licence throughout much of Alberta. Historically bow hunters have been able to hunt antlered mule deer with a general licence. Chronic Wasting Disease (CWD) in mule deer continues to increase in prevalence along the eastern border of Alberta and is moving west along major drainage systems.

Presenter: ROB CORRIGAN, Provincial Big Game Specialist

STATUS OF DEER AND ELK IN ARIZONA, 2013

BRIAN F. WAKELING, Arizona Game and Fish Department, Game Branch, 5000 West Carefree Highway, Phoenix, AZ, 85086. (623) 236-7385, bwakeling@azgfd.gov

AMBER A. MUNIG, Arizona Game and Fish Department, Game Branch, 5000 West Carefree Highway, Phoenix, AZ 85086. (623) 236-7355, amunig@azgfd.gov

Abstract: Deer and elk population levels exhibited independent patterns over the past 20 years. Elk numbers probably peaked in the early 1990s, but harvest was used to reduce their numbers. Their population levels have remained stable since about 2000. Mule and white-tailed deer populations reached the most recent peak in the early 1980s. Mule deer declined through about 2000 and since then have probably increased by about 10%. White-tailed deer followed a similar trend, although the decline was not as pronounced. Most deer populations within the state are surveyed annually using fixed-wing aircraft or helicopter, and an increasing proportion of elk populations as well. Supplemental ground surveys are used as well. All cervids are surveyed during the breeding season to estimate male to female and young to female ratios. Hunter harvest is estimated using a voluntary post card questionnaire that may be returned with postage prepaid or responses may be entered online. Currently, we receive about 35–55% response rate, with about 15–20% of all responses online. General deer harvest was about 19,000 animals in 1989, but last year harvest was estimated at just over 9,000. General elk harvest was about 5,000 animals in 1989, whereas harvest estimates for last year were about 6,200. Buck to doe ratios for both mule and white-tailed deer are managed at 20–30:100, whereas elk bull to cow ratios are managed at 25–35:100. For deer and elk, alternative management units are managed at higher male to female ratios with added guidelines regarding the age structure of the harvest or hunter density. These units approximate about 5% of the opportunity offered annually. Recent wildfires have created situations that are favorable to improved growth of deer and elk populations, yet limited land management actions (e.g., prescribed fire, thinning) benefiting forage production are implemented annually.

Presenter: BRIAN F. WAKELING, Arizona Game and Fish Department

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CHALLENGES TO INCREASING MULE DEER ABUNDANCE IN BRITISH COLUMBIA

GERALD KUZYK, Ministry of Forests, Lands and Natural Resource Operations, 2975 Jutland Road, Victoria, BC, V8W 9M8, Canada. Gerald.Kuzyk@gov.bc.ca

TARA SZKORUPA, Ministry of Forests, Lands and Natural Resource Operations, 205 Industrial Road, Cranbrook, BC, V1C 7G5, Canada. Tara.Szkorupa@gov.bc.ca

ALICIA GODDARD, Ministry of Forests, Lands and Natural Resource Operations, #400-10003-110th Avenue, Fort St. John, BC, V1J 6M7, Canada. Alicia.Goddard@gov.bc.ca

CHRIS PROCTER, Ministry of Forests, Lands and Natural Resource Operations, 1259 Dalhousie Drive, Kamloops, BC, V2C 5Z5, Canada. Chris.Procter@gov.bc.ca

AARON REID, Ministry of Forests, Lands and Natural Resource Operations, Suite 401-333 Victoria Street, Nelson, BC, V1L 4K3, Canada. Aaron.Reid@gov.bc.ca

Abstract: Hunters are central to the North American Model of Wildlife Conservation so maintaining or increasing hunter opportunity is a key focus of wildlife managers. In British Columbia, mule deer live in a diversity of habitats and are a widely sought after species by hunters for both meat and trophy opportunities. Mule deer abundance varies from increasing to decreasing throughout the province and these differences can result in divergent harvest management strategies. Additional complexities arise with varied stakeholder interests with some requesting maximized hunter opportunities throughout the species range. Determining mechanisms which may limit mule deer population growth in both stable and suppressed populations is expensive, time consuming and mechanisms can vary among landscapes, leaving wildlife managers relying on limited quantitative data combined with scientific literature to base management recommendations. Wildlife managers are often further hampered from implementing management actions that may enhance mule deer abundance due to a lack of consistent management objectives, government policy or legal management levers. In BC there is increased social pressure to enhance mule deer abundance in many parts of the province but limited research exists on mule deer population dynamics. The purpose of this paper is to provide a concise review of potential limiting factors of population abundance of mule deer relevant to BC and discuss these factors in relation to enhancing mule deer abundance relative to available policies and management levers.

Presenter: GERALD KUZYK, Ministry of Forests, Lands and Natural Resource BC, Canada

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STATUS OF DEER AND ELK POPULATIONS IN CALIFORNIA, 2000-2012

CRAIG STOWERS, California Department of Fish & Wildlife. 1812 9th Street Sacramento, CA 95758. (916) 445-3553, Craig.stowers@wildlife.ca.gov.

Abstract: California's deer population has varied between stable to moderately declining over the last 20 years. Migratory deer populations in the northern and eastern parts of the state have shown the biggest decline. Data collection methods include aerial and ground counts to determine population composition. The KILLVARY model is used to estimate populations using harvest and herd composition data. Regulations do not require reporting by non-successful hunters. We have a new on-line reporting system and are working on regulations to require mandatory reporting by all deer hunters for the 2014 hunting season. The vast majority of our tags are issued on an "over-the-counter" basis to provide maximum hunter opportunity. Premium hunt zones and late season hunts are issued through a public drawing based on a modified preference point system. CDFW has 88 separate deer herd plans. These individual herd plans and the state wide management plan are outdated and are currently being revised and updated. CDFW switched to an electronic application system which allows us to identify our entire population of deer hunters. We have recently provided an on-line harvest reporting option which will lead to large savings in staff time. We are developing a new state-wide deer conservation plan which will lead to development of individual conservation area plans. Our recent experience with OR7 has ignited a new interest in our ungulate populations but the impact on future management has yet to be determined. A strong anti-hunting segment of CA's population remains very active and is increasingly impacting management decisions.

Presenter: TERRI WEIST, California Department of Fish & Wildlife

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COLORADO DEER AND ELK POPULATION AND INVENTORY SUMMARY

ANDY HOLLAND, Colorado Parks and Wildlife, 415 Turner Drive, Durango, CO 81303. (970) 375-6722, andy.holland@state.co.us

ERIC BERGMAN, Colorado Parks and Wildlife, 317 West Prospect, Fort Collins CO 80526. (970) 472-4415, eric.bergman@state.co.us

Abstract: The statewide post-hunt 2011 deer population estimate is 418,000, compared to 430,000 in 2010, which is far below the current statewide population objective range of 528,000 - 578,000 for the state's 55 deer Data Analysis Units (DAUs) or herds. Populations have declined in the western portions of the state. Multiple factors are leading to declines in mule deer. Habitat loss to development and fragmentation, declining habitat quality from invasive weeds and fire suppression, the harsh winter of 2007-2008, reduced survival from the winter of 2010-2011 in the extreme NW part of the state, and lasting effects from the drought all contribute in varying degrees to population declines. Some deer herds in the central and northern mountains also are performing well, and population sizes are increasing. Most plains deer populations in the Northeast and Southeast Regions remained relatively stable. Colorado Parks and Wildlife (CPW) conducts post-hunt herd inventories with helicopters to estimate the sex ratios of males/100 females and the age ratios of young/100 females. In addition to survival rates and harvest survey estimates, these ratios are used to estimate population size using population models. The current weighted average sex ratio objective for DAUs statewide is 30 bucks/100 does. During the post-hunt herd inventories in 2011, CPW employees classified 57,600 deer and observed an average sex ratio (weighted by population size) of 29.4 bucks/100 does, compared to a similar 29.5 bucks/100 does in 2010. Based on observed post-hunt sex ratios and high hunter success, overall buck hunting quality continues to be good, even in some of the declining herds. In these herds, we have lowered license numbers to achieve the sex ratio objectives and maintain quality hunting. The statewide elk population estimate is 265,000 in post-hunt 2011, compared to 282,000 in 2010. The current post-hunt population objective range for elk DAUs statewide is 220,000-260,000. Season and license setting designed to increase antlerless harvest continues to reduce many elk populations, and statewide antlerless harvest remains similar to bull harvest. A reduction in antlerless licenses is anticipated in the future as more populations reach objectives. The predicted 2012 elk harvest is 44,000, which is nearly identical to last year's harvest estimate of 43,500. Bull harvest in 2011 was also nearly identical to 2010 at 21,600. Antlerless harvest was 21,800, an intentional 16% reduction from 26,100 in 2010. The current sex ratio objective range for DAUs statewide is 22-26 bulls/100 cows. Most elk DAUs are near bull/cow ratio objectives. In 2011, during the post-hunt herd inventories, CPW employees classified 70,000 elk and observed an average sex ratio (weighted by population size) of 22.6 bulls/100 cows, down slightly from the 25 bulls/100 cows observed in 2010. This largely was due to the mild weather making it more difficult to find bulls during helicopter inventory because they are in smaller groups and often at higher elevation. The statewide sex ratio has increased over the last two decades. Colorado has a combination of units that are limited in all seasons and units that have both limited and over-the-counter hunting seasons. These options allow us to offer a very wide range of hunting opportunities on one of the nation's premier elk populations.

Presenter: ERIC J. BERGMAN, Colorado Parks and Wildlife

STATUS OF DEER AND ELK POPULATIONS IN IDAHO, 2000-2013

TOBY BOUDREAU, Idaho Department of Fish and Game, 600 South Walnut Street, Boise, ID 83707. (208) 287-2746, toby.boudreau@idfg.idaho.gov

Abstract: Deer and elk population status vary greatly based on geography throughout Idaho. Changes in predator composition and long-term habitat changes are some of the factors influencing declines, in other areas, populations have increased to the point of exceeding social carrying capacity. Harvest trends have shown a general decline in elk harvest as well as stable harvest mule deer and white-tailed deer statewide over the previous decade. The bulk of our surveys are aerial sightability and composition surveys with some added ground surveys in several locales. Harvest information is collected through an automated mandatory harvest reporting system. Maintaining hunter opportunity is the main management strategy in the state, however, we also provide a variety of trophy opportunities for deer and elk. Management programs are guided by our species management plans with a variety of metrics used to manage harvest and opportunity from aerial population and composition surveys, research data, harvest numbers, and antler point counts of harvested males.

Presenter: TOBY BOUDREAU, Idaho Department of Fish and Game

STATUS OF DEER AND ELK POPULATIONS IN KANSAS

LLOYD FOX, Kansas Department of Wildlife, Parks and Tourism, 1830 Merchant, P.O. Box 1525, Emporia, KS 66801. (620)342-0658, Lloyd.fox@ksoutdoors.com

MATT PEEK, Kansas Department of Wildlife, Parks and Tourism, 1830 Merchant, P.O. Box 1525, Emporia, KS 66801. (620)342-0658, Matt.peek@ksoutdoors.com

Abstract: Kansas has a small population elk numbering approximately 300. Elk exist on several large public lands, but have become more abundant on private lands in the state in recent years. Since 1999, more liberal hunting opportunities have been authorized on private lands to allow landowners to maintain elk at desirable numbers on their own property while at the same time allowing the public lands herds to be maintained. Deer populations in Kansas increased dramatically from the 1960 through 2000 primarily because of an increase in white-tailed deer. Large areas enrolled in CRP during the 1980s and 90s probably influenced recruitment. Since 2000 the populations have remained stable as a result of increased hunting pressure placed on antlerless white-tailed deer. Harvest followed population trends from 1,500 in 1965 to more than 100,000 in 2000. The number of mule deer taken annually since 1985 has remained stable at approximately 3,000. Management has traditionally been influenced by social factors instead of habitat or deer population objectives. Open permit access is allowed for all residents. Seasons and permit numbers have been adjusted to maintain hunter satisfaction. Memorable class deer are adequately available to stimulate non-resident hunters to make the state a destination.

Presenters: LLOYD FOX and MATT PEEK, Kansas Department of Wildlife

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ABUNDANCE OF MULE DEER IN NORTHERN SONORA AND CHIHUAHUA, MÉXICO

CARLOS A. LÓPEZ-GONZÁLEZ, Laboratorio de Zoología. Universidad Autónoma de Querétaro. Cerro de las Campanas s/n Col. Las Campanas. Querétaro, Querétaro. México. 76010. cats4mex@gmail.com

NALLELI E. LARA-DÍAZ, Laboratorio de Zoología. Universidad Autónoma de Querétaro. Cerro de las Campanas s/n Col. Las Campanas. Querétaro, Querétaro. Méx2ico. 76010. nalleli.lara@yahoo.com.mx

DANIEL ÁVILA-AGUILAR, Laboratorio de Zoología. Universidad Autónoma de Querétaro. Cerro de las Campanas s/n Col. Las Campanas. Querétaro, Querétaro. México. 76010. biodaniel.a.a@gmail.com

FERNANDA CRUZ-TORRES, Laboratorio de Zoología. Universidad Autónoma de Querétaro. Cerro de las Campanas s/n Col. Las Campanas. Querétaro, Querétaro. México. 76010. mafercruzt@gmail.com

VICTORIA SAENZ, Universidad de Sonora. Blvd. Luis Encinas y Rosales S/N, Col. Centro, Hermosillo, Sonora. anna_vk_00@hotmail.com

Abstract: (See full paper, page 94)

Presenter: CARLOS LÓPEZ-GONZÁLEZ

STATUS OF DEER AND ELK POPULATIONS IN MONTANA, 1960-2012

JAY NEWELL, Montana Fish, Wildlife and Parks, 1425 2nd St. W., Roundup, MT 59072. (406) 323-3170, jaynewell@mt.gov

QUENTIN KUJALA, Montana Fish, Wildlife and Parks, 1420 East 6th Avenue, P.O. Box 200701, Helena, MT 59620. (406) 444-5672, qkujala@mt.gov

Abstract: State-wide, elk numbers and harvest have shown an increasing trend since 1970, however we may have reached a peak in elk numbers, in the early 1990s when harvest exceeded 30,000 animals. Since 2007, in some hunting districts in the western part of the state, elk numbers are declining while in the eastern part of the state relatively "new" populations of elk continue to increase rapidly. Mule deer harvest and populations have shown a long-term decline since 1960. Peak harvests of male mule deer (>60,000) were achieved in the latter part of the 1960s, 1970s and 1980s. Between 1995 and 2007 harvest fell to around 40,000 males and in 2010 and 2011, near record low numbers of males were killed. Numbers and distribution of white-tailed deer has increased since 1960. In the 1960s less than 16,000 males were harvested annually and that number increased to nearly 30,000 for most of the 1990s, and the first 8 years of this century. Harvest indicates that the western part of the state has seen the largest increases in white-tailed deer since 1960 while the eastern part of the state has had a relatively stable population. Even though the long-term harvest trend indicates increases in populations, white-tailed deer harvest has declined on a state-wide basis since 2008. Sixteen of 162 hunting districts are managed for older aged mule deer bucks. Thirty-eight of 162 hunting districts allow

elk hunting of males by special permit only and older aged males can be harvested on public and private lands in these areas.

Presenter: QUENTIN KUJALA, Montana Fish, Wildlife and Parks

STATUS OF DEER AND ELK POPULATIONS IN NEBRASKA

KIT HAMS, Nebraska Game and Parks Commission, Wildlife Division, 2200 N 33, PO 30370, Lincoln, NE 68503. (402) 471-5442, kit.hams@nebraska.gov

Abstract: Nebraska's whitetail population peaked in July 2012 and was over objective in most units. Aggressive antlerless harvest (500,000 "free antlerless tags") was not successful in reducing herds in many areas as hunters tired of harvesting antlerless whitetails. The EHD event of 2012 likely killed 1/3 of the WT herd and reduced the population to about 200,000. Herds in several units will be allowed to increase in 2013. Mule deer populations are the lowest in 10 years (70,000), having peaked in 2008 at a record high (100,000). Mortality due to CWD, meningeal worm, drought, coyote predation, habitat loss and whitetail competition has reduced MD herds despite the lowest antlerless harvest in 30 years. Aggressive WT doe harvest and restricted MD doe harvest will continue in most mule deer units. Elk populations should exceed 3,000 in 2013. Herds occupy the western ½ of the state, with 80% in the panhandle. Seasons have been held since 1995. Annual herd growth exceeds 15%. Average age of harvested bulls exceeds 5 years and success on bull tags was above 79% the past 5 years. Landowner acceptance of elk remains high and herds continue to grow. Nonresident access to deer permits is restricted on about 5% of our deer permits. In all other units residents and nonresidents have equal access. Unlimited $5 USD youth whitetail permits for residents and nonresidents under 16 are used to encourage youth hunting.

Presenter: KIT HAMS, Big Game Program Manager

CURRENT STATUS OF DEER AND ELK POPULATIONS IN NEVADA

TONY WASLEY, Nevada Department of Wildlife, 1100 Valley Road, Reno, NV 89512. (775) 688-1659, twasley@ndow.org

MIKE COX, Nevada Department of Wildlife, 1100 Valley Road, Reno, NV 89512. (775) 688-1556, mcox@ndow.org

Abstract: Nevada currently has about 110,000 deer and 15,000 elk. Deer are slightly above the 10-year average and slightly below the 20 year average. Elk populations are relatively new in Nevada and have gone from 2,000 in 1990 to 15,000 in 2012. Helicopter surveys are used to assess population trend and size in Nevada. Deer surveys are done twice annually; fall and spring while elk surveys are done once in midwinter. Although no check stations are used in Nevada, a mandatory hunter questionnaire is utilized to determine harvest for both species. The two main factors affecting opportunity are herd population performance and politics. Deer rifle deer hunters have maintained a success of ~40% and statewide, hunters harvest about 45% 4 points or better. Elk harvest has experienced sharp increases, especially cow harvest. Rifle bull hunters enjoy a hunter success of around 65% with a statewide 6 point or better

of 72%. Deer and elk harvest is measured as a percent of successful hunters by weapon class and total number of animals of each point class. Reporting is mandatory. For both deer and elk there is greater emphasis placed on trophy harvest than opportunity. However, for deer, Nevada has many areas using a split season strategy with short, hot, dry, relatively crowded hunts followed by long, cool, un-crowded hunts. Elk hunting is exclusively a trophy harvest management strategy. Deer quotas are primarily determined by post-hunt buck ratio objectives. Elk quotas are more flexible and are used to keep populations near objectives while still maintaining quality.

Presenter: TONY WASLEY, Nevada Department of Wildlife

STATUS OF DEER AND ELK IN NEW MEXICO, 1995-2011.

RYAN WALKER, New Mexico Department of Game and Fish, 215 York Canyon Rd, P.O. Box 1145, Raton, NM 87740. (575) 445-2311, ryan.walker@state.nm.us

KEVIN RODDEN, New Mexico Department of Game and Fish, 2715 Northrise Dr, Las Cruces, NM 88011. (575) 532-2100, kevin.rodden@state.nm.us

STEWART LILEY, New Mexico Department of Game and Fish, 1 Wildlife Way, P.O. Box 25112, Santa Fe, NM 87507. (505) 476-8039, stewart.liley@state.nm.us

Abstract: In New Mexico, mule deer population estimates decreased precipitously 1995–2003, increased slightly 2004–2009, and decreased slightly 2010–2011. Declines in mule deer population estimates followed changes to habitat conditions and protection of top predators. Conversely, white-tailed deer population estimates increased 1995–2011. Expansions of white-tailed deer populations followed brush encroachment and expansion of agriculture. Rocky Mountain elk population estimates increased to stabilization 1995–2011. Expanding elk populations resulted from changes in habitat conditions and conservative harvest management. Population estimation and monitoring techniques evolved from trend surveys to sightability models to population reconstruction. Mule deer harvest decreased following the population decline while public hunts transitioned from over-the-counter to draw-only. White-tailed deer harvest increased as populations expanded and additional opportunity was provided through white-tailed-deer-only hunts. Elk harvest increased slightly and then stabilized from 1995–2011 as statewide elk populations also stabilized. Harvest information became mandatory for deer and elk in 2006, greatly increasing the number of reports and reducing the amount of positive bias from voluntary reports. Deer harvest management shifted over the years from primarily unlimited opportunity through over-the-counter hunts to limited draw hunts of which approximately 25% were managed for quality based on male age structure and hunter numbers. Elk harvest management changed as social carrying capacity shifted from lesser to greater tolerance, while quality management encompassed approximately 40% of elk herds based on male age structure and hunter numbers. Managers continue to struggle with determining and trying to reverse the ultimate causes of the mule deer decline, and providing as much hunter opportunity as possible while maintaining some trophy quality.

Presenter: STEWART LILEY, New Mexico Department of Game and Fish

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STATUS OF DEER AND ELK POPULATIONS IN OREGON

DONALD WHITTAKER, Oregon Department of Fish and Wildlife, 3406 Cherry Avenue NE, Salem, OR 97303. (503) 947-6325, don.whittaker@state.or.us

THOMAS THORNTON, Oregon Department of Fish and Wildlife, 3406 Cherry Avenue NE, Salem, OR 97303. (503) 947-6310, Thomas.l.thornton@state.or.us

Abstract: In total Rocky Mountain elk populations are basically stable below objective levels. However, some regional populations are higher than desired. Roosevelt elk are stable in the Coast range areas but depressed in the Cascade Range, and are well below management objectives. Mule deer also are basically stable with a few areas showing some increases. Black-tailed deer continue to be depressed throughout most of their range in Oregon. Columbian white-tailed deer are doing well in southwestern Oregon but remain endangered in northwestern Oregon. Oregon employs a combination of aerial trend count, aerial survey sampling, ground trend count, ground classification, and spotlight counts to monitor deer and elk populations. Hunting and harvest are down the last few years in Oregon compared to about 10 years ago. Through 2012 harvest has been measured with random telephone harvest surveys. In 2010, a mandatory survey reporting system was implemented. However, response rates were too low to be usable until a penalty was assessed beginning for the 2012-2013 hunting seasons. Oregon's primary management is to provide hunter opportunity. Roosevelt elk, Rocky Mountain elk, and mule deer are guided by specific management objectives for populations and buck:doe ratios. Black-tailed deer management is guided by benchmark measures for harvest success, buck ratios, and population trend indices. Management itself has not necessarily changed dramatically; no changes to season frameworks, timing, etc. The number of controlled tags offered has declined slightly in recent years, primarily in response to declines in Roosevelt and black-tailed deer populations. The biggest issues Oregon faces are related to lack of timber harvest in western Oregon, and associated changes to habitat capabilities.

Presenter: DON WHITTAKER, Oregon Department of Fish and Wildlife

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STATUS OF DEER AND ELK POPULATIONS IN SOUTH DAKOTA, 2002-2011

ANDY LINDBLOOM, South Dakota Department of Game, Fish, and Parks, 20641 SD HWY 1806, Fort Pierre, SD 57532. (605) 223-7652, andy.lindbloom@state.sd.us

JOHN KANTA, South Dakota Department of Game, Fish, and Parks, 4130 Adventure Trail, Rapid City, SD 57702. (605) 394-1755, john.kanta@state.sd.us

Abstract: Over the last 10 years deer and elk populations in South Dakota have reached record highs followed by precipitous declines. South Dakota is approximately 80% private land, thus landowner tolerances of wildlife influence population objectives. In the mid-2000s populations of both deer and elk exceeded landowner tolerances, and harvest regulations were liberalized to reduce populations. Beginning in the winter 2008/09, South Dakota experienced 3 consecutive severe winters, each followed by increased observations of winter mortality and decreased recruitment of deer. Deer mortalities from hemorrhagic disease were also documented at record levels in the summer/fall of 2011 and 2012. Further, in the mid-2000s the mountain lion population in the Black Hills expanded to relatively high densities and preliminary research on elk suggests unsustainable levels of calf predation in some

management units. Record harvest levels, severe winters, disease, and predation all contributed to deer and elk population declines. Accustomed to high densities of big game populations and abundant harvest opportunities, publics were dissatisfied with reduced deer and elk abundance and successfully applied political pressure that resulted in a formal outside review of big game management by the Division of Wildlife. Big game populations are beginning to recover in some areas of South Dakota, although future weather conditions, predation, the unknowns of future energy development, and habitat loss in the form of native prairie conversion rates not seen since the Great Depression, loss of wetlands and shelterbelts, and loss of Conservation Reserve Program lands (~450,000 acres lost from 2006-11) will likely complicate recovery and impact social tolerances.

Presenter: ANDY LINDBLOOM, South Dakota Department of Game, Fish, and Parks

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STATUS OF DEER AND ELK POPULATIONS IN TEXAS, 2005-2011

SHAWN S. GRAY, Texas Parks and Wildlife Department, 109 South Cockrell, Alpine, TX 79830. (432) 837-0666, shawn.gray@tpwd.state.tx.us

ALAN CAIN, Texas Parks and Wildlife Department, P. O. Box 261, Pleasanton, TX 78064. (830) 569-1119, alan.cain@tpwd.state.tx.us

Abstract: In 2004, Texas Parks and Wildlife Department (TPWD) went through a comprehensive science review of the Department's survey methodologies by the Wildlife Management Institute (WMI). This critical review recommended TPWD to improve survey techniques for deer. Therefore, TPWD revamped survey methodologies for both mule and white-tailed deer based upon recommendations from WMI. These changes were implemented during the 2005 survey season. In addition, TPWD recently conducted research to develop a mule deer sightability model to improve population estimates. The mule deer sightability model was initiated in 2011. Currently, TPWD conducts post-season helicopter surveys for mule deer utilizing a stratified random sampling design within monitoring units. TPWD also uses a non-linear line-transect spotlight survey method (Distance Sampling) to survey and estimate white-tailed deer populations. The data are used to determine population trends, estimate population densities, and document herd composition to evaluate the impacts of regulations and management actions on deer at an ecoregion and management unit scale. Since 2005, mule deer numbers have been stable to increasing in the Panhandle ecoregion with approximately 82,000 mule deer estimated in 2011. In contrast, mule deer estimates are trending downward for the Trans-Pecos ecoregion and in 2011 mule deer numbers were estimated at about 140,000. Texas' white-tailed deer herd has been stable over the last 7 years and was estimated at 3.3 million in 2011. Statewide deer harvest data is obtained by a questionnaire mailed to a random sample of 25,000 hunting license purchasers annually. In general, deer harvest mirrors population trends through time. Mule deer harvest was about 8,000 and white-tailed deer harvest was estimated at approximately 575,000 during the 2011 hunting season. The Texas Legislature designated elk as an exotic species in 1997. Since the 1997 reclassification as an exotic by the state legislature, the Texas Animal Health Commission has been responsible for managing elk, primarily for disease monitoring. Elk reside throughout most of Texas with large populations within game farms and high-fence ranches. Most free-ranging elk exist in west Texas. TPWD does not conduct annual elk surveys to determine population trends or harvest. There are no seasons or bag limits on elk

in Texas; therefore, elk can be hunted/harvested 365 days a year with no annual or possession bag limits.

Presenter: SHAWN GRAY, Texas Parks and Wildlife Department

STATUS OF DEER AND ELK IN UTAH, 2000-2013

ANIS AOUDE**,** Utah Division of Wildlife Resources, 1594 West North Temple, Suite 2110 PO Box 146301 Salt Lake City, UT 84114. (801) 538-4777

Abstact: Utah's statewide deer population is stable, but lower than historical highs. We estimate the statewide population to be about 318,000. The population has been around 300,000 since the late 1990's with weather driven fluctuations. Utah's elk population has steadily grown from about 62,500 in 2000 to a current estimate of about 79,700. Deer populations are estimated using computer models. Natural mortality inputs to the model are estimated using survival rates of collared does and fawns on 7 representative units. Ground classification and harvest data are also used as input to the model. Elk populations are estimated using hybrid approach that includes helicopter survey flights every 3 years and modeling in the non-flight years. Harvest trends follow population trend with a stable trend for deer and an increasing trend for elk over the past 10 years. Harvest is estimated using a combination of phone and internet based surveys. We use a combination of random sample and mandatory reply surveys, depending on the hunt type. Utah tries to strike a balance between the demand for hunting opportunity and antler quality. For deer, we provide general season opportunity on the majority of the units and set aside a few units where we manage for large antlered animals. For elk we create opportunity by harvesting spike bulls on units that we also manage for large antlered animals on a limited entry basis. We also provide any bull elk hunting opportunity on units that have large areas of private land or wilderness. We base our buck deer permits on post season buck to doe ratios and our bull elk permits on average age of harvested bulls. Habitat quality and quantity continues to be the limiting factors for mule deer. Our elk populations are not limited by habitat since most of our population objectives are socially driven. Competition with livestock and aspen regeneration are the main issues that limit elk population objective increases.

Presenter: ANIS AOUDE, Utah Division of Wildlife Resources

MULE DEER MANAGEMENT IN WYOMING: THE PARADIGM OF A PUBLIC OWNED RESOURCE

WILL SCHULTZ, Wyoming Game and Fish Department, PO Box 1432, Saratoga, WY 82331. (307) 326-3020, will.schultz@wyo.gov

DARYL W. LUTZ, Wyoming Game and Fish Department, 260 Buena Vista, Lander, WY 82520. (307) 332-2688, daryl.lutz@wyo.gov

Abstract: Mule deer management in Wyoming is a changing landscape as mule deer populations continue to decline. Balancing society's expectations and desires with declining mule deer populations requires increased and meaningful public involvement. The Wyoming Game and Fish Department (WGFD) has undertaken a "Collaborative Learning" process to engage the public in two of Wyoming's premier mule deer herd units under the direction of the Wyoming Mule Deer Initiative. This process has

resulted in increased public understanding and sustained involvement, increased agency understanding of the public's issues and concerns, the development of herd unit management plans, and in the Platte Valley the creation of a Habitat Partnership. The paradigm of increased public involvement involves agency risk and therefore was not initially widely accepted by field personnel. This process has created improved public relations and support through an environment that facilitated scientific delivery, increased social capacity and trust.

Presenter: DARYL W. LUTZ, Wyoming Game and Fish Department

STATUS OF DEER AND ELK POPULATIONS IN WYOMING, 1990-2013

WILL SCHULTZ, Wyoming Game and Fish Department, PO Box 1432, Saratoga, WY 82331, (307) 326-3020, will.schultz@wyo.gov

DARYL W. LUTZ, Wyoming Game and Fish Department, 260 Buena Vista, Lander, WY 82520, (307) 332-2688, daryl.lutz@wyo.gov

Abstract: Mule deer populations in Wyoming declined the last two decades from ~540,000 in 1990 to ~375,000 deer in 2011. Elk populations continue to increase (~82,000 in 1990 to ~110,000 in 2011). Some mule deer populations, in more mesic portions of Wyoming, have been buffered. Elk in the northwest where low pregnancy rates in combination with predation and other variables are measurably impacting elk calf production/survival are the exception. Harvest data (collected voluntarily via a paper/internet survey), post-season sex and age composition data, and limited survival data are used in spreadsheet models to estimate population size/trend. In some elk herds mid-winter trend data is used rather than model estimates. Data are collected primarily from helicopter after the hunting season or mid-winter. Mule deer harvest has declined sharply. Elk harvest is relatively stable. Deer and elk management is directed using a "management by objective" strategy and a designation of "recreational", "special" or private land herd unit. The "special" designation is akin to "trophy" management to maintain high male/female ratios. Wyoming has undertaken a massive public involvement process under the Wyoming Mule Deer Initiative to engage everyone interested in mule deer in a MEANINGFUL way. Primary issues: Mule Deer – 1) Declining populations driven by poor fawn production/survival and 2) Related socio/political aspects of reduced deer hunting opportunity and declining hunt quality. Elk – 1) Increasing populations exceeding landowner tolerance leading to more and larger damage claims and calls for political solutions, and 2) Inability to manage towards population objectives utilizing hunter harvest in some herds.

Presenter: Will Schultz, Wyoming Game and Fish Department

Abstracts, Poster Session

THE ENVIRONMENTAL-DATA AUTOMATED TRACK ANNOTATION (*ENV-DATA*) SYSTEM: LINKING ANIMAL TRACKS WITH ENVIRONMENTAL DATA

GIL BOHRER, The Ohio State University, Department of Civil and Environmental Engineering, Columbus, OH. bohrer.17@osu.edu

SOMAYEH DODGE, The Ohio State University, Department of Civil and Environmental Engineering, Columbus, OH. dodge.66@osu.edu

SARAH DAVIDSON, The Ohio State University, Department of Civil and Environmental Engineering, Columbus, OH. sdavidson@orn.mpg.de

ROLF WEINZIERL, Max Planck institute for ornithology, Radolfzell, Germany. rolf@strd.de

ROLAND KAYS, North Carolina State Museum of Natural Science, Raleigh, NC. rwkays@ncsu.edu

DAVID DOUGLAS, USGS Alaska Science Center, Juneau, AK. ddouglas@usgs.gov

DAVID BRANDES, Lafayette College, Dept of Civil & Environmental Engineering, Easton, PA, brandesd@lafayette.edu

JIAWEI HAN, Univ. of Illinois at Urbana-Champaign, Department of Computer Science, Urbana, IL. hanj@cs.uiuc.edu

MARTIN WIKELSKI, Max Planck institute for ornithology, Radolfzell, Germany. wikelski@orn.mpg.de

Abstract: The movement of animals is strongly influenced by external factors in their surrounding environment such as weather, habitat types, and human land use. With advances in positioning and sensor technologies, it is now possible to capture animal locations at high spatial and temporal granularities. Likewise, modern technology provides us with an increasing access to large volumes of environmental data, some of which changes on an hourly basis. Environmental data are heterogeneous in source and format, and are usually obtained at different scales and granularities than movement data. Indeed, there remain scientific and technical challenges in developing linkages between the growing collections of animal movement data and the large repositories of heterogeneous remote sensing observations, as well as in the developments of new statistical and computational methods for the analysis of movement in its environmental context. These challenges include retrieval, indexing, efficient storage, data integration, and analytical techniques. We have developed a new system – the Environmental-Data Automated Track Annotation (Env-DATA) – that automates annotation of movement trajectories with environmental information, including high resolution topography, weather from global and regional reanalysis datasets, climatology, human geography, ocean currents and productivity, land use, vegetation and land surface variables, precipitation, fire, and other global remote sensing datasets. The system automates the acquisition of data from open web resources of remote sensing and weather data and provides several interpolation methods from the native grid resolution and structure to a global regular grid linked with the movement tracks in space and time. We also develop research tools that facilitate interpretation of these combined ecological-environment datasets. Env-DATA provides an easy-to-use platform for end users that eliminates technical difficulties of the

annotation processes, including data acquisition, data transformation and integration, resampling, and interpolation. The new *Env-DATA* system enhances Movebank (www.movebank.org), an open portal of animal tracking data. The system is open and free to any user with movement data. The aim is to facilitate new understanding and predictive capabilities of spatiotemporal patterns of animal movement in response to dynamic and changing environments from local to global scales.

IMPACT OF RECOLONIZING GRAY WOLVES ON MULE AND WHITE-TAILED DEER IN WASHINGTON

JUSTIN DELLINGER, School of Environmental and Forest Resources, University of Washington, Box 352100 Seattle, WA 98195. (704692-8142, jad1nel2@gmail.com

AARON WIRSING, School of Environmental and Forest Resources, University of Washington, Box 352100 Seattle, WA 98195. (206)-543-1585, wirsinga@uw.edu

ERIC KRAUSZ, Colville Confederated Tribes Fish and Wildlife. (509) 722-7681, eric.krasz@colvilletribes.com

MATT MARSH, Okanogan-Wenatchee National Forest Tonasket Ranger District, 1 W Winesap Rd. Tonasket, WA 98855. (509 486-5116, mdmarsh@fs.fed.us

WOODROW MYERS, Washington Department of Fish and Wildlife, 2315 North Discovery Place Spokane Valley, WA 99216. (509) 892-1001 Ext 325, Woodrow.Myers@dfw.wa.gov

BRIAN KERTSON, Washington Department of Fish and Wildlife, 1775 12th Ave NW Issaquah, WA 98027. (425) 478-7501, Brian.Kertson@dfw.wa.gov

Abstract: Gray wolves are rapidly recolonizing Washington State. Our study seeks to understand the impacts that the return of a large carnivore can have on mule and white-tailed deer in north-central Washington. The study is examining both consumptive (e.g., fawn and adult survival) and non-consumptive (e.g., shifts in behavior and habitat use) effects of wolves on both deer species using wolf and non-wolf study areas within a multi-use landscape. Long and short-term data is being collected in the form of remote camera grids, GPS collars, and GPS camera collars.

MULE DEER POPULATION IN THE MAPIMI BIOSFERE RESERVE, CHIHUAHUAN DESERT, MEXICO.

SONIA GALLINA, Red de Biología y conservación de Vertebrados, Instituto de Ecología, A.C., Carretera Antigua a Coatepec # 351, El Haya, Xalapa, CP 91070, Veracruz, México, sonia.gallina@inecol.edu.mx

ADRIANA COSSÍO, Posgrado del Instituto de Ecología, A.C., Carretera Antigua a Coatepec # 351, El Haya, Xalapa, CP 91070, Veracruz, México, adriana.cossio@posgrado.inecol.edu.mx

Abstract: Mule deer (*Odocoileus hemionus*) has been studied in the Mapimí Biosphere Reserve (MBR), Durango, Mexico, in the Chihuahuan Desert, because of its importance as an herbivore and hunting resource, sharing this habitat with cattle under extensive management. During 1996-1997 using an indirect method as counting fecal groups in 8 transects of 800 m, the estimation density was considered very low (between 2 and 3 deer / km^2). In 2006-2007 the same sites were sampled estimating a density

between 4 and 6, although during the 2010-2011 average was 3 deer / km^2. During 2010 and 2011 to know if there is spatial competition between deer and cattle, fecal groups were obtained in the same transects for both species. The average was 86.58 deer fecal groups / ha (3.33 $\pm$ 0.97; range 1.54-4.09 deer / km^2) and 32.21 cattle fecal groups/ ha (2.39 $\pm$ 0.98; range 1.24 - 3.65 cows / km^2). Measures of habitat variables such as visibility, slope, elevation and vegetation were also taken. Correlations of habitat variables with density ratios and principal component analysis (PCA) were used to identify the most important: the volume of vegetation and visibility for one component, the density and the slope for the component two. There were found differences in habitat use between deer and cattle related to the slope, altitude and vegetation cover.

MAPPING INTERACTIONS OF ELK, MULE DEER HUNTERS, AND ATVS DURING HUNTING SEASONS IN NORTHEAST OREGON.

JENNIFER HAFER, U.S. Forest Service, Pacific Northwest Research Station, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6527, jmhafer@fs.fed.us

SCOTT FINDHOLT, Oregon Department of Fish and Wildlife, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6538, scott.l.findholt@state.or.us

BRUCE JOHNSON, Oregon Department of Fish and Wildlife, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6556, bruce.k.johnson@state.or.us

MARY ROWLAND, U.S. Forest Service, Pacific Northwest Research Station, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6582, mrowland@fs.fed.us

MICHAEL WISDOM, U.S. Forest Service, Pacific Northwest Research Station, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6532, mwisdom@fs.fed.us

Abstract: Hunting has been a traditional form of recreation in North America, but developing technologies and changing land use have led to discussions among land and resource managers and various public groups on how to adapt to these developments. At the same time, elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*) populations are declining in many areas, while demand for recreational opportunities remains high. Growing use of all terrain vehicles (ATV) by hunters and recreationists has led to debates over how to best manage this activity for public lands and wildlife. Since 2008, researchers at the Starkey Experimental Forest and Range in northeast Oregon have manipulated ATV access by creating a gradient of open and closed roads and ATV trails and have used GPS units with high frequency relocations to record elk, mule deer, hunter, and ATV movements during three fall hunts: archery elk (late August-early September), rifle deer (late September-early October), and rifle elk (late October-early November). Having location data for these components will help answer key questions. Do elk and mule deer avoid areas heavily used by ATVs? Do hunters have greater success when they use ATVs? Not only is animal behavior captured with GPS data, but now hunter behavior is also being recorded. How much time do hunters spend away from their ATVs? How far from roads and access points do hunters travel? Characterizing and quantifying interactions between hunters, ATVs, mule deer, and elk may provide managers with information to better manage public lands, ATVs, and hunters.

LINKING SURVIVAL AND RESOURCE SELECTION BY FEMALE WHITE-TAILED DEER WITH DIFFERENT MIGRATION STRATEGIES

CHARLES HENDERSON, Wildlife Biology Program, Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, Montana 59812. (406) 214-7154, charles1.henderson@umontana.edu

MICHAEL MITCHELL, United States Geological Survey, Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, Montana 59812. (406) 243-4390, mike.mitchell@umontana.edu

WOODROW MYERS, Research Biologist, Eastside Deer Investigations, Wildlife Science Division, Washington Department of Fish and Wildlife, Spokane Valley, Washington 99216. (509) 892-1001, Woodrow.Myers@dfw.wa.gov

JERRY NELSON, Deer and Elk Section Manager, Washington Department of Fish and Wildlife, Olympia, Washington 98501. (360) 902-2519, Jerry.Nelson@dfw.wa.gov

Abstract: After two harsh winters that reduced the white-tailed deer (*Odocoileus virginianus*) population in eastern Washington and a public initiative to change harvest regulations, the Washington Department of Fish and Wildlife implemented a study to improve understanding of the population. Our study focuses on how seasonal movements and survival rates affect estimates of seasonal resource selection by female whitetails. We are also examining the broader questions of what factors contribute to the distribution of white-tailed deer at the western edge of their geographic distribution and the effects of different migratory strategies on survival. We are using locations from global positioning system (GPS) and very high frequency (VHF) radio collars and ear tags to create seasonal resource selection functions (RSFs). We are linking survival estimates generated from collar data to the RSFs to evaluate what parts of the study area contribute most to high survival of whitetails during different seasons (Adult S= 0.698 SD = 0.082, Yearling S = 0.712 SD = 0.104, Fawn (6 month+) S = 0.932 SD = 0.119). We are also examining how land cover type and land use by humans affect the spatial dynamics of this widely distributed species. Wildlife managers will be able to use the information we generate in setting land use and harvest regulations to effectively manage whitetail populations at targeted levels.

SEASONAL HOME RANGES OF DESERT MULE DEER IN THE APACHE MOUNTAINS OF THE TRANS-PECOS REGION OF TEXAS

ANDY S. JAMES, Borderlands Research Institute, Natural Resource s Management, Sul Ross State University, P.O. Box C-16, Alpine, TX 79831. (432)-837-8488, Andy.James10@gmail.com

LOUIS A. HARVESON, Borderlands Research Institute, Natural Resource s Management, Sul Ross State University, P.O. Box C-16, Alpine, TX 79831. (432)-837-8488, Harveson@sulross.edu

Abstract: Desert mule deer *(Odocoileus hemionus)* are a prominent animal in Texas, but limited research has been conducted on them in the Trans Pecos region of the state. From 2006-2010 approximately 40 mature bucks (≥4.5 yrs. old) were captured using a helicopter and net gun from two study areas. One area had supplemental feeders while the other was a non-fed site. Once the deer were captured the age and antler measurements were recorded, and a global positioning system (GPS) radio collar was placed around the neck before being released. The radio collars were programmed to record each deer's location as well as a date and time every 5 hours. Deer were then recaptured annually to

retrieve the GPS collars, and measure antler development. The data suggests that home ranges are much larger than previously estimated. Using the fixed kernel home range analysis tool with a 95% confidence level, home ranges for mature mule deer averaged 35.3 km^2 on the supplemental fed site and 45.0 km^2 on the non-fed site with a range from 20.5 km^2 to 96.2 km^2. Home ranges during the winter (includes the rut) was more than double the size of any other season (spring, summer, fall). Data also shows that deer move less during the fall than any other season. With the completion of this project, understanding mule deer annual and seasonal home ranges will allow biologist to make better recommendations on how to manage mule deer in the Trans Pecos.

HABITAT USE OF MULE DEER ON AGRICULTURAL LANDS: IMPLICATIONS FOR SURVIVAL AND REPRODUCTION

SABRINA MORANO, Ecology Evolution and Conservations Biology Program, Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV 89557.

KELLEY M. STEWART, Ecology Evolution and Conservations Biology Program, Department of Natural Resources and Environmental Science, University of Nevada, Reno, NV 89557.

PEREGRINE WOLFF, Nevada Division of Wildlife, 1000 Valley Road, Reno, NV 89512.

TONY WASLEY, Nevada Division of Wildlife, 1000 Valley Road, Reno, NV 89512.

Abstract: Extensive use of agricultural lands by deer is common throughout the west, especially in desert environments where native forage and water is limited. Artificially high densities of deer on fields can lead to increased disease risk due to close association with livestock and conspecifics. Also trace mineral or nutritional imbalances may result from inability to digest a diet comprised primarily of alfalfa, a high energy, high protein forage, resulting in sickness or decreased body condition. For these reasons agricultural fields have the potential to act as a population sink. We have monitored habitat use, survival and occurrence of disease symptoms (diarrhea and emaciation) for deer associated with agricultural fields. We have identified 3 strategies for use where animals either; remain in the uplands throughout the spring and summer, remain in the uplands through the spring and early summer than transition to the fields during late summer, or remain on the fields throughout the spring and summer. We have identified variation in seasonal use of agricultural lands with greater numbers of individuals using the fields as the summer progresses and increasing numbers of symptomatic individuals during late summer and fall. We have also identified higher iron and molybdenum levels in the livers of sick individuals, which can cause secondary copper deficiencies and result in disease symptoms. Using this information we can identify how habitat relationships influence health and subsequent survival.

EFFECTS OF NATURAL GAS DEVELOPMENT ON NEONATAL MULE DEER MORTALITY

MARK PETERSON, Colorado State University, Department of Fish, Wildlife, and Conservation Biology, 1474 Campus Delivery, Fort Collins, CO 80523. (970) 491-2370, Mark.Peterson@colostate.edu

CHUCK ANDERSON, JR., Colorado Parks and Wildlife, 711 Independent Blvd., Grand Junction, CO 81505. (970) 255-6189, Chuck.Anderson@state.co.us

PAUL DOHERTY, JR., Colorado State University, Department of Fish, Wildlife, and Conservation Biology, 240 Wagar Hall, Fort Collins, CO 80523. (970) 491-6597, Paul.Doherty@colostate.edu

Abstract: Extensive natural gas development on public lands has elevated concern among public stakeholders, wildlife managers, and researchers about the impacts on wildlife. Impacts on mule deer (*Odocoileus hemionus*) populations and their habitat are of particular interest due to the deer's recreational, social, and economic importance as a game species. Understanding neonatal mule deer fawn survival and cause-specific mortality is critical to properly managing mule deer populations, especially where natural gas development disturbances are occurring. The intensity of disturbance from development may be directly negatively correlated with neonate survival, or indirectly correlated through changes to habitat. However, no published studies have quantified the effects of natural gas development disturbances and consequent habitat conversion on neonatal fawn survival. In fact, only with recent technological innovations, is the ecology of the neonate life stage being illuminated and much general biology still needs to be described. We propose to provide neonatal mule deer fawn survival estimates related to energy development, neonate, dam, and temporal characteristics, and assess cause-specific mortality. Estimates of survival and cause-specific mortality will be derived from a sample of neonates captured from 2012-2014 using vaginal implant transmitters inserted in dams (n = 360) and subsequent attachment of radio telemeters on neonates. In addition, we will assess habitat characteristics of neonate birth and mortality sites. We will compare characteristics of these sites to random sites to assess habitat selection and patterns in mortality occurrence. Overall, our goal will be to provide results promoting improved energy development mitigation and wildlife management practices.

TOP-DOWN VERSUS BOTTOM-UP FORCING: EVIDENCE FROM MOUNTAIN LIONS AND MULE DEER

BECKY M. PIERCE, California Department of Fish and Game, 407 West Line Street, Bishop, CA 93514. (760) 873-7452, bmpierce@dfg.ca.gov

VERNON C. BLEICH, California Department of Fish and Game, 407 West Line Street, Bishop, CA 93514. retired. (760) 937-5020, vcbleich@gmail.com

KEVIN L. MONTEITH, Department of Biological Sciences, 921 South 8th Avenue, Stop 8007, Idaho State University, Pocatello, ID 83209, Present Address: Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Dept. 3166, 1000 East University Avenue, Laramie, WY 82071. (307) 766-2322, kmonteith@uwyo.edu

R. TERRY BOWYER, Department of Biological Sciences, 921 South 8th Avenue, Stop 8007, Idaho State University, Pocatello, ID 83209. (208) 282-4082, bowyterr@isu.edu

Abstract: We studied mountain lions (*Puma concolor*) and mule deer (*Odocoileus hemionus*) inhabiting a Great Basin ecosystem in Round Valley, California, USA, to make inferences concerning predator-prey dynamics in that system. Our purpose was to evaluate whether the mule deer population was affected more by top-down or bottom-up processes, and thereby assess the applicability of the "world is green" or the Hairston, Smith, and Slobodkin (HSS) hypothesis. We identified a period of decline for mule deer (1984-1990), and then a period of slow but steady increase (1991-1998). For mule deer, bitterbrush (*Purshia tridentata*) in diets, per capita availability of bitterbrush, kidney fat indices, fetal rates, fetal weights, and survivorship of adults and young indicated that the period of decline was typical of a deer population near the carrying capacity (*K*) of its environment. The period of increase was typified by deer displaying characteristics of a population below *K*, but the finite rate of growth (λ = 1.10) did not reach what would be expected for a population rapidly rebounding toward *K* (λ = 1.15-1.21). These outcomes indicated that top-down and bottom-up forcing is a poor dichotomy—we observed both processes in the same population of deer. Moreover, we conclude that the HSS hypothesis is too broad and sweeping to encompass complex predator-prey dynamics, and may not be as useful as once thought for characterizing trophic dynamics for ecosystems in which large mammals are important components of food webs.

THE WESTERN ASPEN ALLIANCE: PROMOTING SUSTAINABLE ASPEN ECOSYSTEMS IN WESTERN NORTH AMERICA

PAUL C. ROGERS, Western Aspen Alliance, Ecology Center, and Wildland Resources Department, 5230 Old Main Hill, Utah State University, Logan, Utah, 84322. (435)797-0194, p.rogers@usu.edu

Abstract: The Western Aspen Alliance (WAA) is a consortium of managers, researchers, conservationists, and the public interested in science-based sustainable management. Recent events have spurred interest in aspen ecology. For example, reports of sudden aspen mortality, large-scale seedling establishment following wildfires, and documentation of trophic interactions between wolves, elk, and aspen, have significantly modified our understanding of aspen ecosystems. An aging aspen regional cohort must successfully regenerate to maintain sustainable populations. Wildlife pressure on aspen regeneration is an issue of concern for managers throughout the western United States. The WAA will incorporate current science into an ongoing resource bank for managers throughout the region. From a research perspective, we wish to engender a cross-disciplinary network of researchers willing to take on pertinent aspen topics. For example, there is a current need to assess the extent of Sudden Aspen Decline (SAD), seral/stable aspen coverage, water conservation, and historic aspen extent and change. Basic research on aspen physiology, disturbance ecology, water yield, genetics, herbivory, and biodiversity/trophic interactions issues are also desired. The social/aesthetic value of aspen is an emerging research area. We will form working groups for these issues and pursue additional aspen topics that arise. A central role of the WAA is to sponsor field visits, workshops, conferences, and collaboration between researchers. We have compiled a bibliographic database (+7,000 records) of aspen research and management topics for use by WAA members. We are currently working with numerous state and federal agencies, NGO's, and universities. We welcome your input and participation!

NEXT GENERATION MODELS FOR ELK ON BLUE MOUNTAINS SUMMER RANGE

MARY ROWLAND, U.S. Forest Service, Pacific Northwest Research Station, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6582, mrowland@fs.fed.us

MICHAEL WISDOM, U.S. Forest Service, Pacific Northwest Research Station, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6532, mwisdom@fs.fed.us

JENNIFER HAFER, U.S. Forest Service, Pacific Northwest Research Station, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6527, jmhafer@fs.fed.us

BRIDGETT NAYLOR, U.S. Forest Service, Pacific Northwest Research Station, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6564, bnaylor@fs.fed.us

MARTIN VAVRA, U.S. Forest Service, Pacific Northwest Research Station, La Grande Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6561, martinvavra@fs.fed.us

JOHN COOK, National Council for Air and Stream Improvement, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6536, cookjg.ncasi@gmail.com

RACHEL COOK, National Council for Air and Stream Improvement, 1401 Gekeler Lane, La Grande, OR 97850. (541) 963-9275, rachierae@gmail.com

RYAN NIELSON, Western EcoSystems Technology (WEST), Inc., 415 West 17th St., Suite 100, Cheyenne, WY 82001. (970) 484-3353, rnielson@west-inc.com

PRISCILLA COE, Oregon Department of Fish and Wildlife, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6550, priscilla.k.coe@state.or.us

BRUCE JOHNSON, Oregon Department of Fish and Wildlife, 1401 Gekeler Lane, La Grande, OR 97850. (541) 962-6556, bruce.k.johnson@state.or.us

Abstract: Elk (*Cervus elaphus*) are widely distributed in Oregon and Washington, where they are a valued resource providing hunting and viewing opportunities and contributing substantially to rural economies. Elk also function as a keystone species that influences plant community development and other ecosystem processes. Current habitat management for elk across much of Oregon and Washington relies heavily on guidelines developed decades earlier, when scant empirical data were available to inform the models on which the guidelines relied. Spatially explicit models that predict nutritional resources and relative use of elk on multiple land ownerships can help inform cohesive and strategic management of elk populations and their habitats. We developed new regional nutrition and habitat use models for elk for application on elk summer range in the Blue Mountains of eastern Oregon and Washington. We developed a unique meta-analysis approach for modeling that leverages existing telemetry and environmental covariate data from a variety of sources. The stand-alone nutrition model predicted elk dietary digestible energy based on potential vegetation type, percent canopy cover, precipitation, and date. The nutrition model output served as one input covariate to the habitat use model. Other covariates of the habitat use model included slope, distance to roads, and percent area in forested vegetation. The nutrition and habitat use models incorporate readily available spatial data layers and can be used to evaluate current conditions for elk or to predict future conditions under an array of management alternatives.

COMPARISON OF GENDER AND ITS EFFECTS ON TOOTH WEAR ACCURACY ON ELK IN MICHIGAN

TIM C. SWEARINGEN, College of Forestry and Conservation, University of Montana, Missoula, MT 59812. (734) 755-5194, Tcsdef@yahoo.com

DEAN E. BEYER JR. Michigan Department of Natural Resources, Wildlife Division, 3001 New Science Facility, Northern Michigan University, Marquette, MI 49855. (906) 227-1627, dbeyer@nmu.edu

JERRY L. BELANT Carnivore Ecology Laboratory, Forest and Wildlife Research Center, Mississippi State University, Box 9690, Mississippi State, MS 39762. (662) 325-2996, jbelant@cfr.msstate.edu

PAT W. BROWN, Biology Program, Northern Michigan University, Professor and Dept. Head Biology Program 2001A New Science Facility, Marquette, MI 49855. (906) 227-2130, pbrown@nmu.edu

Abstract: Accurate determination of age in harvested species is critical for estimating population trends and modeling abundance to achieve management objectives. We used the tooth wear aging method to accurately age 1,212 of 3,005 (40.3%) harvested elk (*Cervus elaphus*) in Michigan, 1964 - 2007. In contrast, Hamlin et al. 2000 had about 50% agreement. Our accuracy although lower could potentially be associated to our large sample size and the presence of older age classes within our sample. Accuracy in the tooth wear aging method in adult elk in Michigan differs with respect to gender. Male accuracy (44.69%) for the tooth wear aging method was higher than females (36.99%). This is opposite of our original hypothesis and conflicts with Van Deelen et al. 2000 findings in white-tailed deer. We do not recommend using the tooth wear method if precise age estimates are necessary for population models.

Papers - Alphabetical by Senior Author

STATUS OF DEER AND ELK IN BRITISH COLUMBIA (1981-2013)

GERALD KUZYK, Ministry of Forests, Lands and Natural Resource Operations, PO Box 9391 Victoria, British Columbia, V8W 9M8, Canada. Gerald.Kuzyk@gov.bc.ca

AARON REID, Ministry of Forests, Lands and Natural Resource Operations, Suite 401-333 Victoria Street, Nelson, BC, V1L 4K3, Canada. Aaron.Reid@gov.bc.ca

TARA SZKORUPA, Ministry of Forests, Lands and Natural Resource Operations, 205 Industrial Road, Cranbrook, BC, V1C 7G5, Canada. Tara.Szkorupa@gov.bc.ca

ALICIA GODDARD, Ministry of Forests, Lands and Natural Resource Operations, #400-10003-110th Avenue, Fort St. John, BC, V1J 6M7, Canada. Alicia.Goddard@gov.bc.ca

CHRIS PROCTER, Ministry of Forests, Lands and Natural Resource Operations, 1259 Dalhousie Drive, Kamloops, BC, V2C 5Z5, Canada. Chris.Procter@gov.bc.ca

DARRYL REYNOLDS, Ministry of Forests, Lands and Natural Resource Operations, 6451 Sechelt Inlet Road, Box 950, Sechelt, BC, V0N 3A0, Canada. Darryl.Reynolds@gov.bc.ca

SEAN PENDERGAST, Ministry of Forests, Lands and Natural Resource Operations, 2080a Labieux Road, Nanaimo, BC, V9T 6J9, Canada. Sean.Pendergast@gov.bc.ca

Abstract: We present population and harvest trends of deer and elk in British Columbia from 1981-2013. Populations were estimated in each wildlife management region and compiled for provincial totals. Mule deer (*Odocoileus hemionus*) numbers were relatively stable ($\bar{x}$ = 153,200; SD = 14,500) during this time but showed a slight decline after the severe winter of 1996/1997. Black-tailed deer (*O. h. columbianus*) numbers ($\bar{x}$ = 163,400; SD = 33,400) also declined in the late 1990s and their numbers have not yet returned to former abundance, possibly due to predation and habitat alterations. White-tailed deer (*O. virginianus*) abundance increased from about 40,000 in 1987 to over 100,000 in 2011. Rocky Mountain elk (*Cervus elaphus nelsoni*) numbers ($\bar{x}$ = 43,400; SD = 9,500) have generally increased since 1987 whereas Roosevelt elk (*C. e. roosevelti*) numbers ($\bar{x}$ = 3,850; SD = 1,400) tripled from 1987 to 2011, mostly due the long-term re-introduction program on the lower mainland. Deer and elk are valued by hunters in British Columbia with 2012 hunting license sales at approximately 80,000 for mule/black-tailed deer, 50,000 for white-tailed deer and 25,000 for elk. From 1987 to 2011, resident harvest averaged 17,623 for mule deer, 6,705 for black-tailed deer and 8,038 for white-tailed deer. From 1981-2011, combined resident and non-resident harvest averaged 3,741 for Rocky Mountain elk and 130 for Roosevelt elk. Management of deer and elk populations in British Columbia would benefit from more accurate harvest data and estimates of population size and trend across the province.

INTRODUCTION

In British Columbia there are two species of deer, mule deer and white-tailed deer. Some authors identify 3 subspecies of mule deer, including those found across the interior of the province, and two subspecies of black-tailed deer (*O. h. columbianus* and *O. h. sitkensis*; Cowan 1956, Anderson and Wallmo 1984, Latch et al. 2009). There is 1 species of elk, with 2 subspecies, Rocky Mountain Elk and Roosevelt Elk (Shackleton 1999; British Columbia Conservation Data Centre 2013). British Columbia establishes hunting regulations for mule deer, black-tailed deer (without subspecies), white-tailed deer, Rocky Mountain elk and Roosevelt elk.

Deer are distributed throughout most of the province with the exception of portions of the northwest. The height of the Coast Mountains generally divides mule deer to the east and black-tailed deer to the west and is also a hybridization zone for these subspecies (Figure 1). In British Columbia there are both migratory and resident mule deer (Armleder et al. 1994) and black-tailed deer (McNay and Voller 1995). Mule deer occupy a diversity of habitats in British Columbia including wet temperate forests (D'Eon and Serrouya 2005), dry interior sagebrush ranges (Willms et al. 1979) and northern boreal forests that typically have cold winters with deep snow (Baccante and Woods 2010, Jex 2011). Black-tailed deer occupy mainly wet coastal habitats (Cowan 1945, Harestad 1985) and have a broad distribution on the mainland coast and islands including the large island archipelago of Haida Gwaii (Figure 1) where they were introduced (Shackleton 1999). White-tailed deer have expanded their distribution in recent decades (Shackleton 1999) and now occur throughout much of the province (Figure 2).

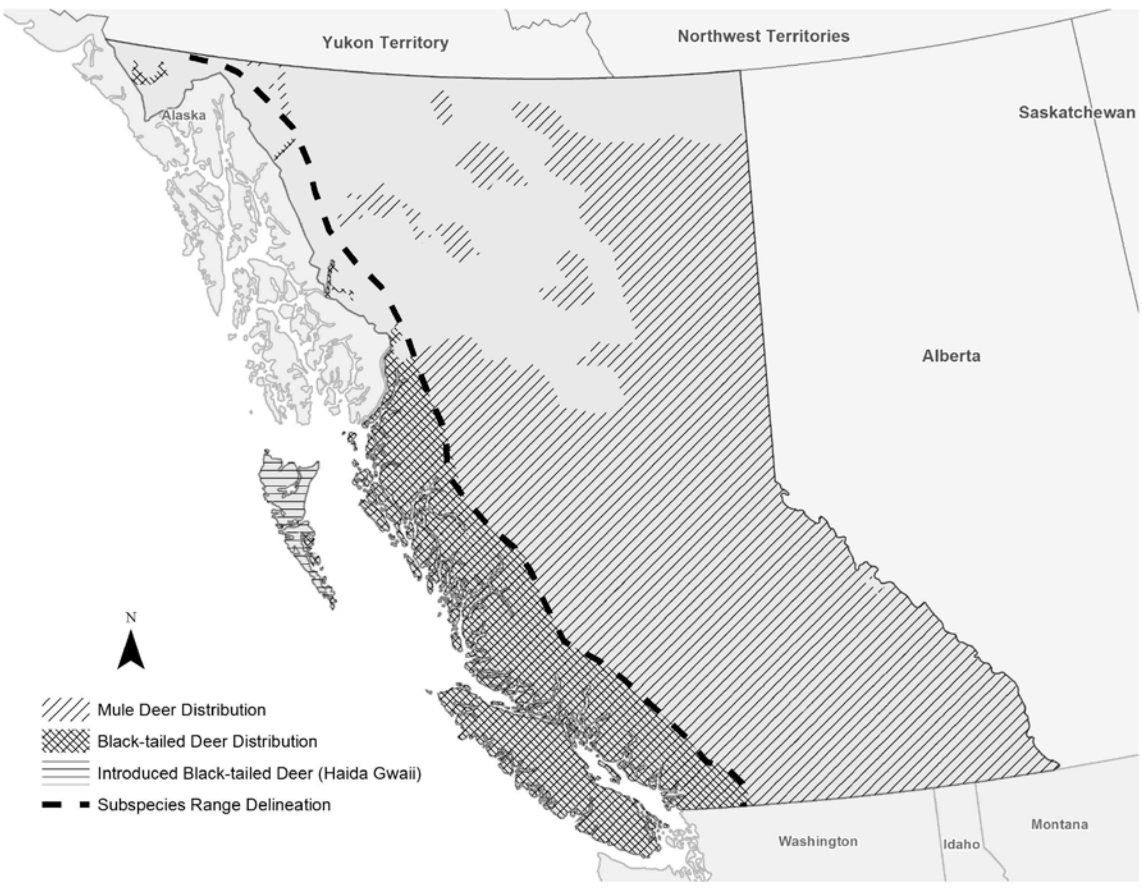

Figure 1. Current distribution of mule deer and black-tailed deer in British Columbia.

Figure 2. Current distribution of white-tailed deer in British Columbia.

Rocky Mountain elk occur in varied habitats from wet temperate forests (Poole and Mowat 2005), dry interior forests and grasslands (Hudson et al. 1976) and remote northern mountain ranges (Bergerud and Elliot 1998, Gillingham and Parker 2008). They are most abundant in southeastern and northeastern portions of the province, with smaller populations in the interior (Figure 3). Roosevelt elk are geographically separated from Rocky Mountain elk and are limited to the southwest coastal portions of the province (Figure 3). They normally live in coastal forests and use habitat with abundant forage adjacent to security cover (Brunt 1990, Quayle and Brunt 2003). Re-introductions of approximately 500 elk to the mainland began in the 1980s with a goal to restore Roosevelt elk to suitable historic ranges wherever possible. The resulting population increases have resulted in new hunting seasons (Wilson 2012).

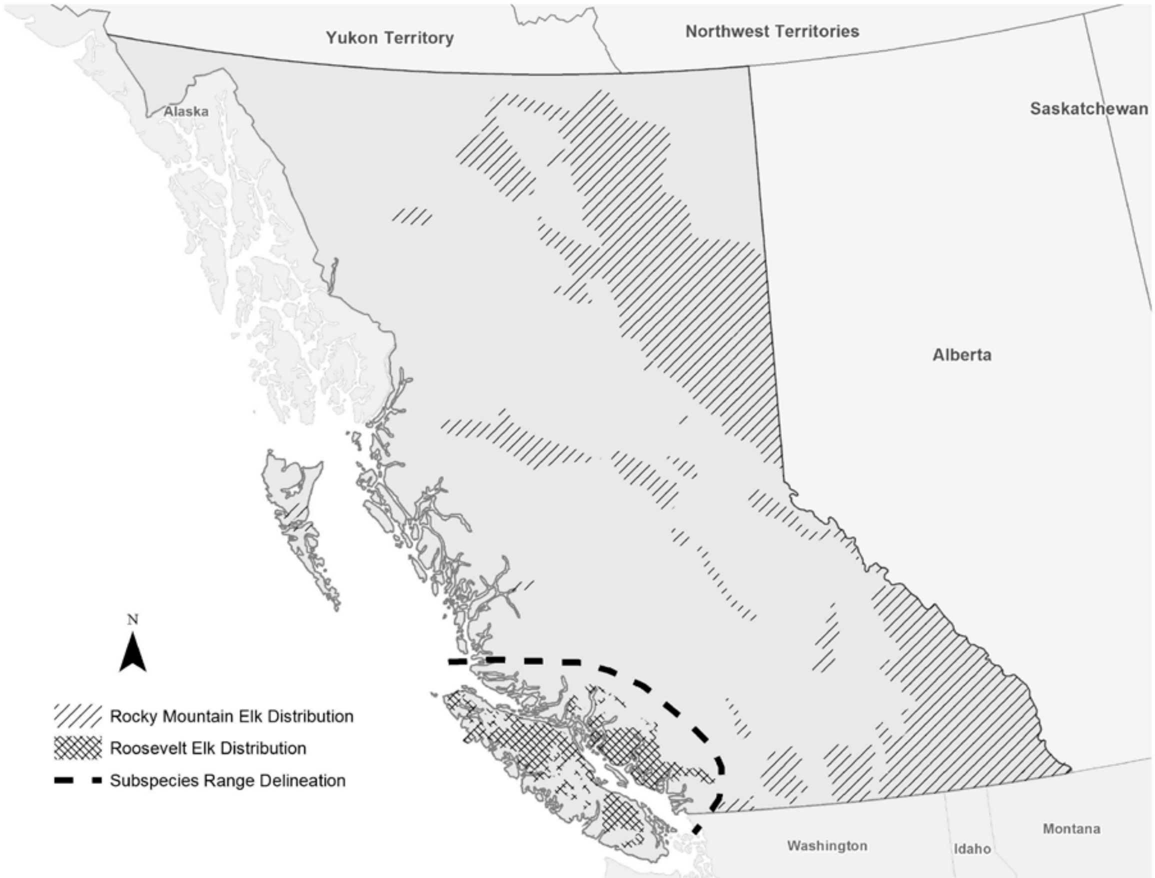

Figure 3. Current distribution of Rocky Mountain elk and Roosevelt elk in British Columbia.

Most research on deer and elk in British Columbia has focused on improving habitat management including delineation of winter ranges and developing integrated forest harvesting practices (Willms et al. 1979, Armleder and Dawson 1992, Armleder et al. 1994, D'Eon and Serrouya 2005, Poole and Mowat 2005). In British Columbia, legally protected winter ranges have been established for deer and elk in some areas of the province. A variety of infectious diseases and parasites of deer and elk occur in British Columbia including papilloma virus, infrequent localized hemorrhagic viral epizootics, giant liver fluke (*Fascioloides magna*), lungworm (*Dictyocaulus viviparus*), tick and localized exotic louse infestations, however none of these appear to affect the species at the population level (Helen Schwantje, Wildlife Veterinarian, British Columbia Ministry of Forests, Lands and Natural Resource Operations, personal communication). A monitoring and proactive prevention program is in place for Chronic Wasting Disease (CWD) which to date has not been detected in British Columbia.

Deer and elk are important species in British Columbia for recreational and commercial hunting, cultural values and wildlife viewing. Hunting opportunities are managed through 9 administrative units known as Regions (Figure 4). Understanding population size and harvest of deer and elk over time is integral to their management (Hatter 1988, Hatter 2001, DeVos et al. 2003, Forrester and Wittmer 2013, Mule Deer Working Group 2013). The purpose of this paper is to provide a long term assessment of population and harvest trends of deer and elk in British Columbia.

Figure 4. Nine wildlife management regions in British Columbia.

Study Area

Deer and elk occupy a variety of diverse landscapes and habitats in British Columbia ranging from wet coastal forests, dry interior deserts and northern boreal forests (Meidinger and Pojar 1991). The vegetation composition important to these species is highly variable and region-specific. The diversity of landscapes across the province is further reflected in the variety of other ungulates in British Columbia including moose (*Alces americanus*), caribou (*Rangifer tarandus*), Stone's sheep (*Ovis dalli stonei*), Dall's sheep (*O. d. dalli*), California bighorn sheep (*O. canadensis californiana*), Rocky Mountain bighorn sheep (*O. c. canadensis*), mountain goats (*Oreamnos americanus*), plains bison (*Bos bison bison*) and wood bison (*B. b. athabascae*) (Shackleton 1999). There are 8 medium to large carnivores: wolves (*Canis lupus*), coyotes (*C. latrans*), grizzly bears (*Ursus arctos*), black bears (*U. americanus*), cougars (*Puma concolor*), lynx (*Lynx canadensis),* bobcats (*L. rufus*), and wolverines (*Gulo gulo*; Nagorsen 1990).

METHODS

Estimates of relative and absolute abundance of deer and elk were determined using aerial and ground surveys which conformed to provincial standards and were based on repeatable and defensible scientific standards (RISC 1998, RISC 2002, RISC 2013). The majority of aerial surveys were required to maintain a 90% CI with error of ± 15% to ± 25%. The standards for aerial-based surveys were developed for elk and deer (RISC 2002) following several published methods (Caughley 1977, Gasaway et al. 1986, Samuel et al. 1992, Unsworth et al. 1994, and White 1996). Specific protocols were developed for mule deer composition surveys (Resources Information Standards Committee [RISC] 2013) which largely followed Keegan et al. (2011). Mule deer, black-tailed deer and white-tailed deer which occur in forested habitats were surveyed using ground-based techniques (RISC 1998). Abundance estimates were determined using repeat surveys over time to attain trend information and sex/age composition of the population. Black-tailed deer were surveyed using spotlight counts in spring to develop a kilometric index (RISC 1998). The resulting deer per km index was found to be related to absolute abundance over a 2,400 km^2 study area on northern Vancouver Island (Hatter and Janz 1994). White-tailed deer population estimates were based on indices of population size available for some areas of the province and determined using spotlight counts (Gwilliam and Krebs 2006), pellet counts (Boulanger et al. 2000) and spring composition surveys (Baccante and Woods 2010). Population estimates for elk were generated using aerial (stratified random block) and ground (transect classification counts) surveys conducted primarily during winter or spring (RISC 1998, RISC 2002, Thiessen 2009, Szkorupa and Mowat 2010). Data obtained from both aerial and ground-based inventories were used in developing regional and provincial population estimates.

Provincial deer and elk populations were estimated every 3 to 5 years by regional biologists and compiled for provincial totals from 1987 to 2011. One exception was for mule deer and black-tailed deer, which were pooled prior to 1994. From 2000 to 2011, minimum and maximum estimates were provided to quantify uncertainty; all values within this minimum to maximum range were considered to be equally likely. There is a high level of uncertainty in provincial estimates despite the rigor associated with aerial surveys and ground based inventories (RISC 1998, RISC 2002). This was largely due to extrapolating deer and elk population estimates from small survey areas to regional abundance estimates. To help refine the levels of uncertainty, different approaches were used depending on available information. The first was to extrapolate area-based estimates and account for varied habitat suitability. Second was to use population models that fit available survey and harvest data (White and Lubow 2002). Lastly, when the first 2 methods could not be used and only hunter harvest data were available, then estimates were further refined using expert opinion from regional biologists. This opinion included observations and information from knowledgeable individuals including resident hunters, guide-outfitters, First Nations and other resource professionals.

Hunting seasons for deer and elk were available throughout most of their range with the exception of National Parks which comprised <1% of the province. We present 31 years (1981 to 2011) of hunter harvest data for elk and 25 years (1987 to 2011) for deer. Resident and non-resident hunting license sales from 1989 to 2012 are provided for mule deer and black-tailed deer (combined) white-tailed deer, and Rocky Mountain and Roosevelt elk (combined). Due to the structure of the provincial hunter survey, harvest of deer was reported for residents only whereas elk harvest combined information from resident and non-resident hunters. A mail-out questionnaire was used to estimate resident harvest (with 95% confidence intervals; CIs) and sex-age composition (male, female, juvenile) for each region. The sample size of questionnaires and response rates from hunters remained relatively stable over the 31 years. For example, in 2011 the questionnaire was sent to 20,177 mule deer/black-tailed deer hunters, 13,859 white-tailed deer hunters and 19,290 elk hunters with a response rate of

58% for both deer species and 55% for elk. Guide/outfitters reported their harvest using a mandatory guide declaration form.

RESULTS AND DISCUSSION

There were general differences in abundance and management of mule deer and Rocky Mountain elk between the southern (i.e., Regions 3, 4, 5, 8) and northern (i.e., Regions 6, 7A, 7B) parts of the province (Figure 4). We speculate differences in abundance are due in part to varied ungulate and predator densities, weather and human-caused landscape disturbance (including variable hunter access to remote areas). Hunting seasons for mule deer bucks in southern British Columbia were one of the most liberal in North America. General open seasons ran up to 101 days in some areas, with a combination of ≥4 antler point restriction and a 31-day general open season for any buck during October. White-tailed deer expanded in distribution and abundance since the late 1990s. In response, a provincially-coordinated general open season was implemented in 2010 to liberalize hunting opportunities. Roosevelt elk numbers increased in their historic ranges on Vancouver Island (Figure 4) and were managed through limited entry hunts. On the mainland coast Roosevelt elk re-introductions increased elk abundance and hunter opportunities through limited entry hunts (Wilson 2012). Black-tailed deer occurred throughout coastal British Columbia and had fairly consistent hunting seasons among Regions (1, 2, 5, and 6) for any buck up to 92 days. In addition, there were liberal seasons in Haida Gwaii (Figure 1) where black-tailed deer were introduced and the population grew due to a lack of predation to the point of conflict with the forest industry (Hatter et al. 1989).

Hunter interest for deer and elk generally remained high in the province as reflected by resident hunting license sales. Non-resident hunting licenses for deer and elk were primarily used by the guide/outfitter industry and composed a small percentage of total sales. Resident license sales for mule and black-tailed fluctuated with population size and ranged between about 60,000 to 80,000 per year since 2000 (Figure 5). Resident license sales for white-tailed deer ranged from 30,000 to 40,000 per year from 1989-2009. There was an increase of approximately 10,000 licenses in 2010 with the inception of the liberalized season and those license sales remained at about 50,000 per year through 2012 (Figure 6). There were about 10,000 resident elk license sales sold in the late 1990s and the number gradually increased each year, reaching about 25,000 in 2012 (Figure 7).

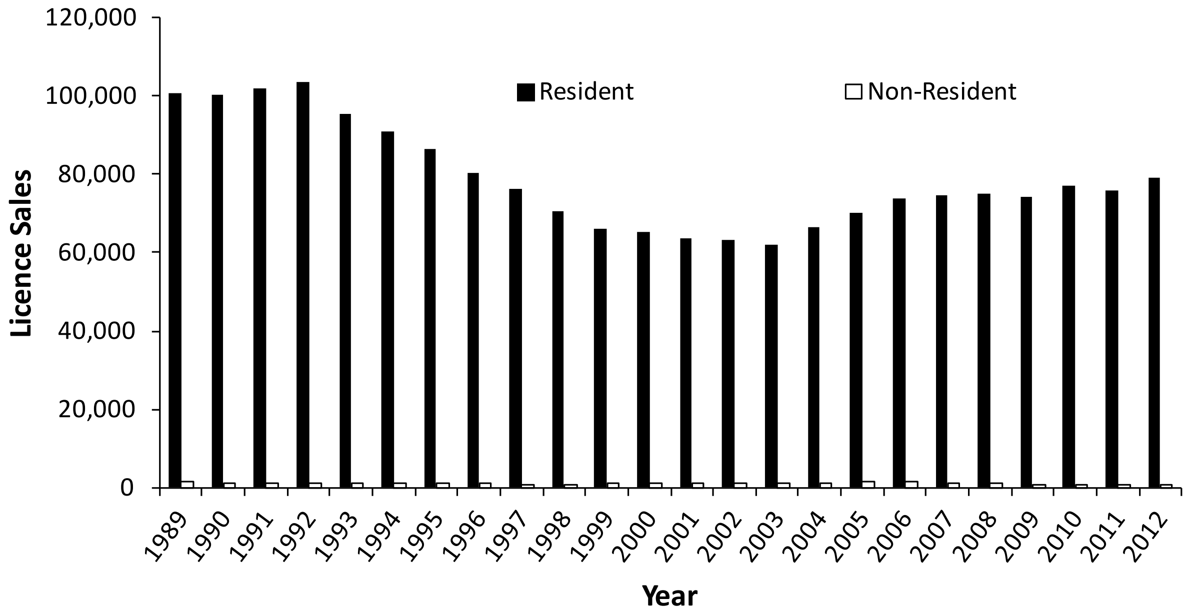

Figure 5. Resident and non-resident mule deer and black-tailed deer (combined) license sales in British Columbia from 1989 to 2012.

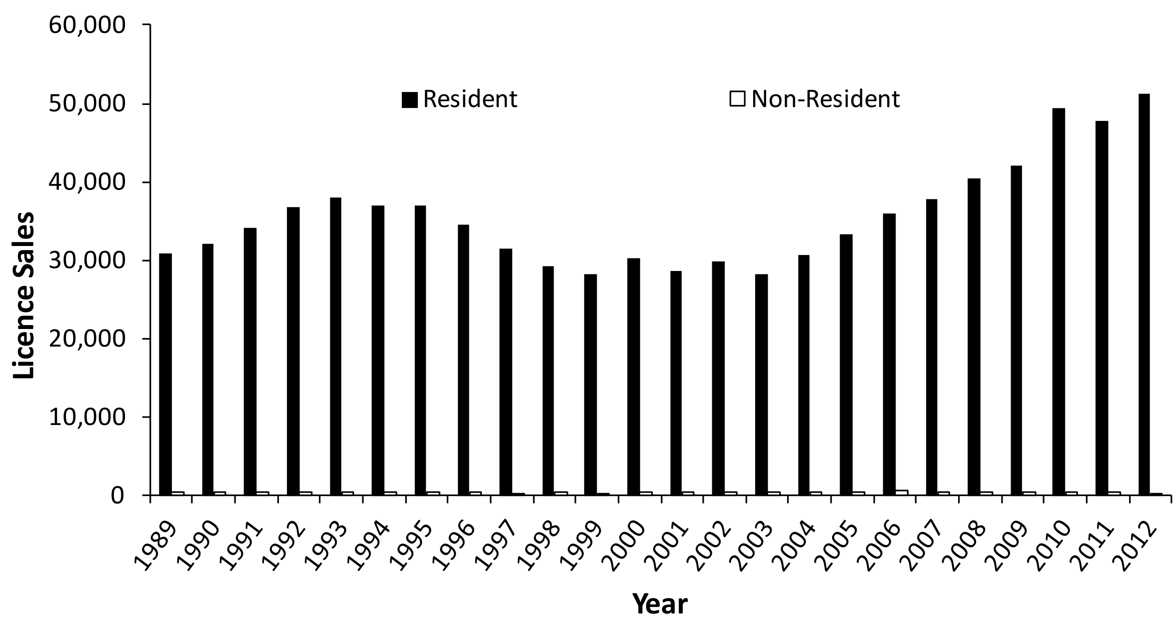

Figure 6. Resident and non-resident white-tailed deer license sales in British Columbia from 1989 to 2012.

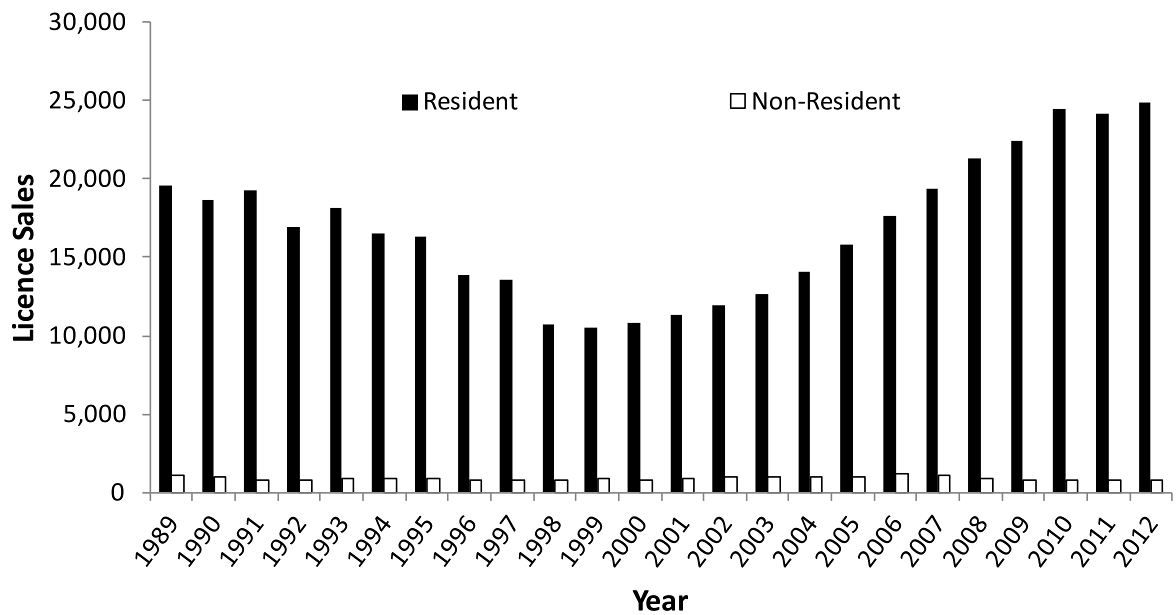

Figure 7. Resident and non-resident Rocky Mountain elk and Roosevelt elk (combined) license sales in British Columbia from 1989 to 2012.

Mule Deer

Mule deer numbers in British Columbia remained relatively stable ($\bar{x}$ = 153,200; SD = 14,500) from 1994-2011 (Figure 8). There was a decline after the severe winter of 1996/1997 but since the early to mid-2000's numbers appeared to have recovered across most of the province. Populations on the northern edge of the range probably fluctuated with winter severity (Baccante and Woods 2010, Jex 2011). Since 2008, most of the province had stable to increasing mule deer numbers while some localized areas in south-central, southeast, and northeast experienced declines. These declines may have been attributed to declining quality and quantity of shrub forage on mule deer winter ranges largely due to lack of forest fire, severe winter conditions and increased predation by wolves, cougars and bears. One example from southeast British Columbia found white-tailed deer population growth allowed for cougar populations to increase, resulting in higher predation rates on mule deer because mule deer are particularly vulnerable to cougar predation. This may have resulted in increases in white-tailed deer numbers while mule deer numbers declined (Robinson et al. 2002). Exploratory analysis using harvest data from 1987 to 2011 found this pattern to exist in areas throughout the province but concentrated in the southeast (Aldous 2013). Increasing mule deer populations in parts of the province may have been related to several mild winters and increased forage availability resulting from large wildfires and other disturbances, such as forest removal.

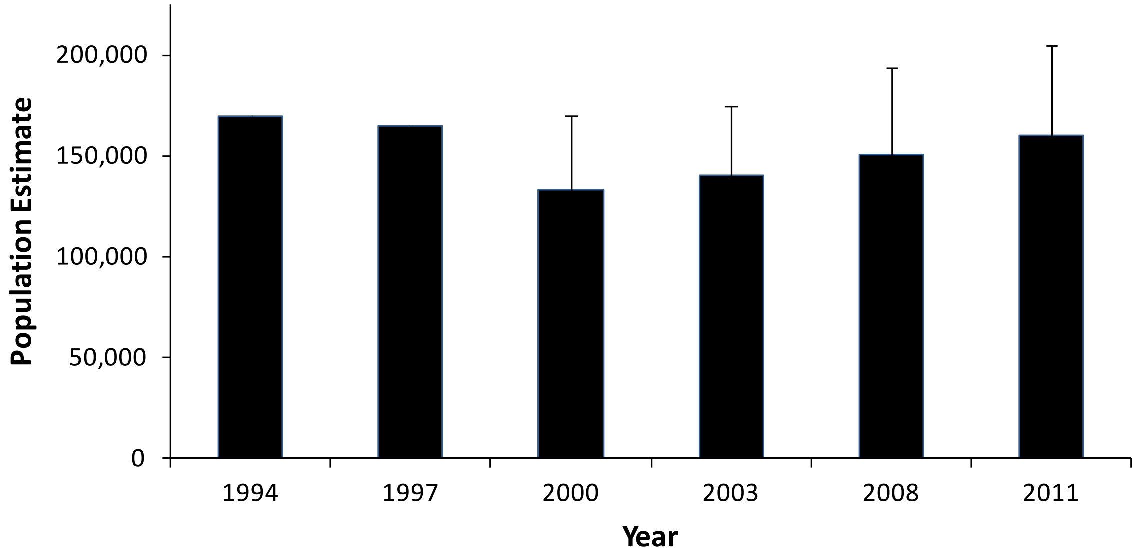

Figure 8. Mule deer population estimates in British Columbia from 1994 to 2011. Estimates were derived from inventories, population modeling and expert opinion. Error bars represent minimum and maximum population estimates expected.

Mule deer buck harvest by resident hunters ranged from about 10,000 to 19,000 bucks per year ($\bar{x}$ = 17,623; SD = 2,400) from 1987 to 2011. Buck harvest decreased slightly from 2008 to 2011 (Figure 9). Mule deer harvest was managed with a general open season for bucks and limited opportunity for antlerless harvest through limited entry hunts. Buck seasons were structured using a combination of any-buck and ≥3 or ≥4 antler point restriction with seasons running for up to 101 days. In the south, there were generally ≥4 antler point restrictions for September and parts of November, with any-buck seasons in October. This combination was used successfully to maintain sustainable harvest of bucks with season lengths up to 92 days (Kuzyk et al. 2011). However, the recent mountain pine beetle (*Dendroctonus ponderosae*) attack and associated salvage logging in central and southern portions of the province resulted in increased density of roads and thus increased hunter access to deer habitat, some of which was previously remote. In the future, this increased hunter access may result in elevated harvest levels and could challenge achievement of management objectives (e.g., sex ratio) under a general open season. In some northern regions, where open habitat allows for greater visibility of mule deer, harvest was managed through a 30-day general open season in November.

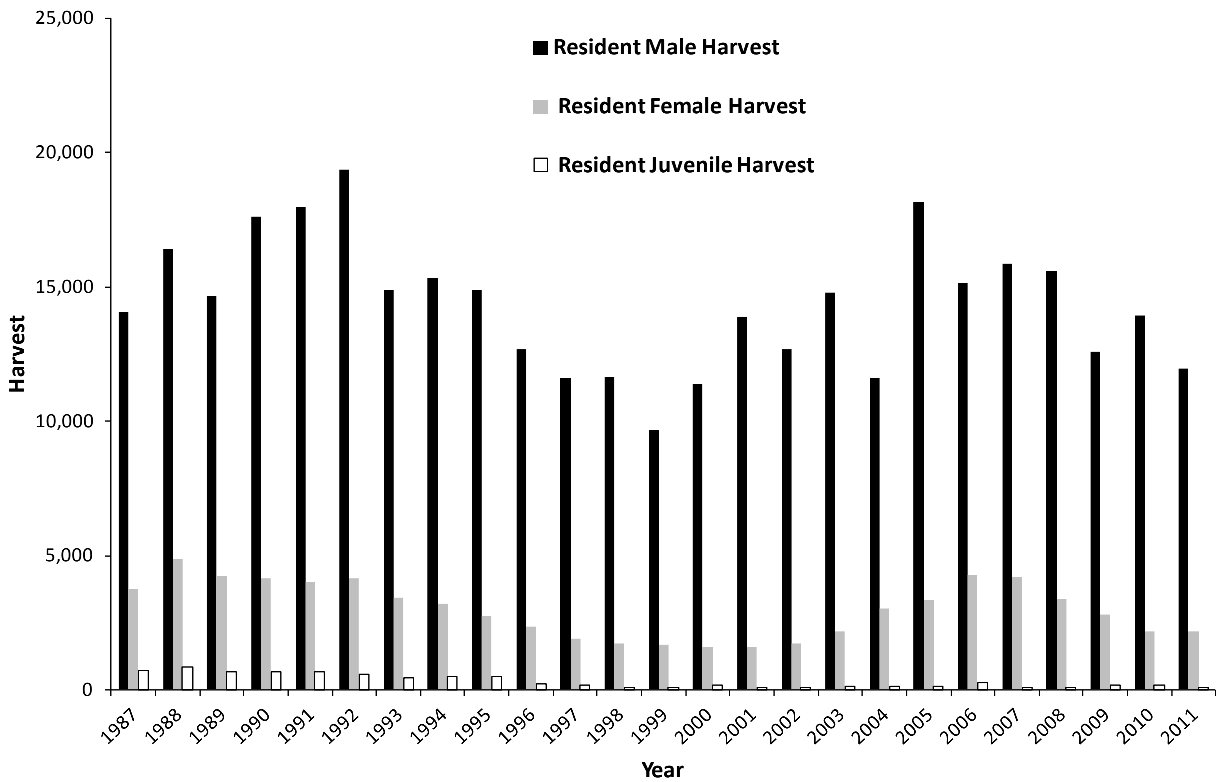

Figure 9. Estimated resident hunter harvest of mule deer in British Columbia from 1987 to 2011.

Black-tailed Deer

Black-tailed deer numbers ($\bar{x}$ = 163,400; SD = 33,400) declined in the 1990s, which is believed to correspond with increasing cougar numbers and changing forest structure. During this time high elevation old growth, as well as large tracts of second growth forests were harvested and road densities increased which reduced available winter habitat and refuge areas from predators (Sean Pendergast, Wildlife Biologist, British Columbia Ministry of Forests, Lands and Natural Resource Operations, personal observation). In the early to mid-2000s, black-tailed deer numbers increased in some areas (Figure 10) due to localized wolf trapping (Hatter and Janz 2004) and a presumed decrease in cougar abundance as determined by hunter harvest and reporting data. In the late 2000s it is believed black-tailed deer numbers fluctuated in response to increased predation from wolves and cougars, and associated low elevation (<500m) second growth forest harvesting. Both cougar and wolf population levels were thought to have stabilized in the late 2000s albeit at a lower level than the early 2000's. This resulted in an apparent overall moderate increase in black-tailed deer along the south coast. There were concerns over low black-tailed deer numbers in parts of the mainland coast and coastal islands, particularly in areas of intensive industrial forestry operations, where a large percentage of the land base is privately owned. In these areas effective measures to conserve deer winter range and high quality habitat are considered below what is needed to maintain optimal populations.

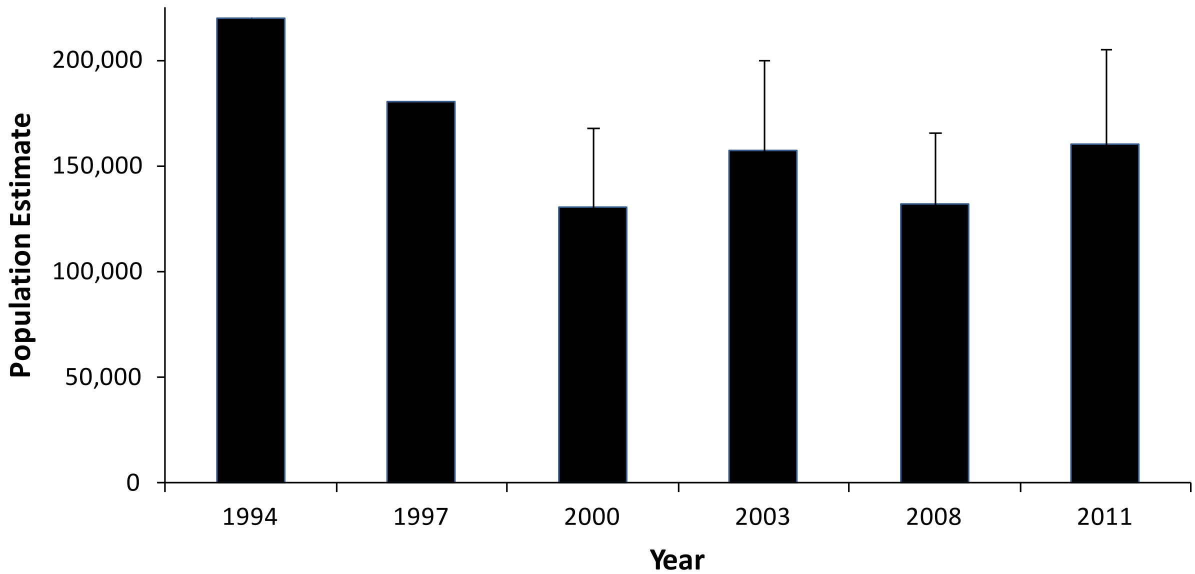

Figure 10. Black-tailed deer population estimates in British Columbia from 1994-2011. Estimates were derived from inventories, population modeling and expert opinion. Error bars represent the minimum and maximum population estimates expected.

Estimated annual black-tailed deer buck harvest was about 10,000 in the early 1990s and dropped to 4,000 to 6,000 from 1996-2011 (Figure 11). Most management units had a 92 day any-buck season, which was one of the most liberal black-tailed deer seasons in North America. There were limited but increased opportunities for antlerless harvest, most of which occurred in agricultural areas adjacent to forests. Increased hunter access to remote areas and extensive second growth logging activities in much of the black-tailed deer range may negatively impact deer numbers and pose challenges for the current harvest management especially if adequate winter ranges are not present. In areas of intensive forestry activity, increased road density (and associated animal sightability) was assumed to result in increased hunter success and predation rates with reduced amount of available winter range and refuge habitat.

Black-tailed deer were introduced to Haida Gwaii (Figure 1) prior to 1901, remained abundant since 1935 (Hatter et al. 1989) and were thought to number approximately 20,000 to 30,000 in 2011 (Mark Williams, Wildlife Biologist, British Columbia Ministry of Forests, Lands and Natural Resource Operations, personal communication). There were liberal seasons for black-tailed deer on Haida Gwaii (i.e., bucks June 1 - Feb. 28; bag limit of 15) as they had only one predator (black bear) and had strongly affected both ecological communities and commercial forestry operations through overbrowsing (Hatter et al. 1989).

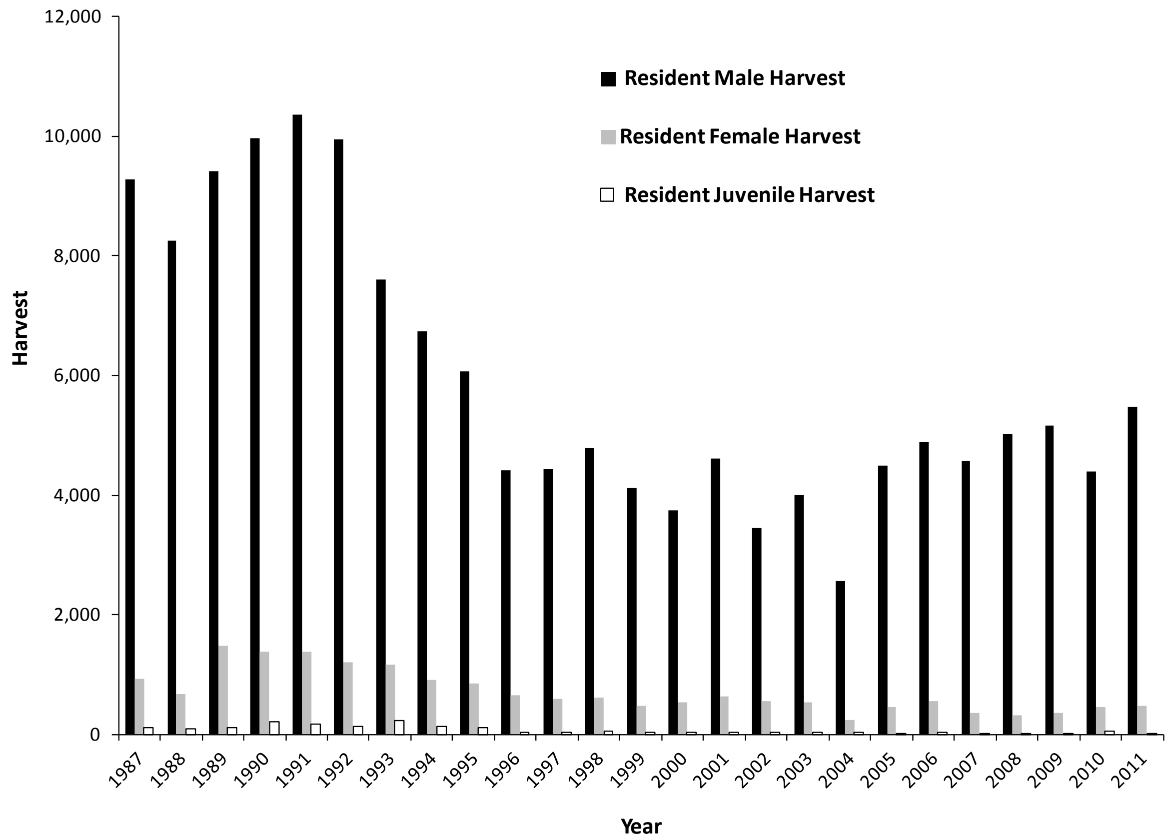

Figure 11. Estimated resident hunter harvest of black-tailed deer in British Columbia from 1987-2011.

White-tailed Deer

Estimated abundance of white-tailed deer in British Columbia increased from about 40,000 in 1987 to over 100,000 in 2011 (Figure 12). Populations declined following the severe winter of 1996/97 but steadily increased in size and distribution since then (Mowat and Kuzyk 2009). The southeast and northeast parts of the province had the highest abundance of white-tailed deer, although in the late 2000s they were found throughout the south-central interior and continued to expand to new areas. Those increased numbers and distribution of white-tailed deer may have been a reflection of their ability to co-exist with human development and use landscapes altered by agriculture, forestry and forest fires. White-tailed deer populations may have also responded favorably to relatively low winter severity from about 2000 to 2011. Both cougars (Robinson et al. 2002) and wolves (Kunkel and Pletscher 2000) are known to prey on white-tailed deer in British Columbia. White-tailed deer may be more resilient than mule deer to predation pressure, possibly due to cougars selecting mule deer at higher rates than white-tailed deer (Robinson et al. 2002) and to wolves preferring larger bodied prey as moose (Kunkel and Pletscher 2000).

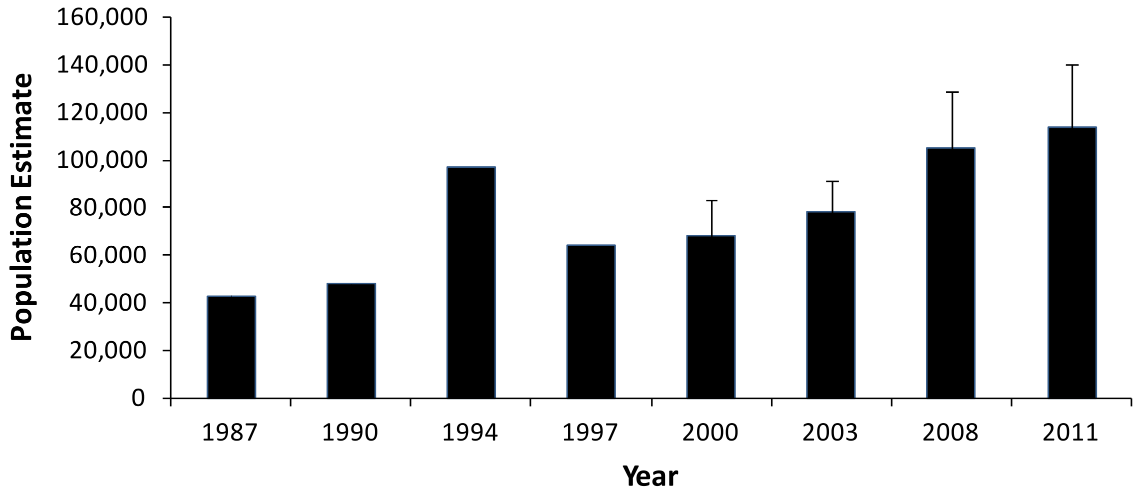

Figure 12. White-tailed deer population estimates in British Columbia from 1987-2011. Estimates were derived from inventories, population modeling and expert opinion. Error bars represent the minimum and maximum population estimates expected.

White-tailed deer were managed under a combination of general open season and limited entry hunt seasons from 1987-2009. In 2010, provincially-coordinated seasons were introduced to liberalize hunting opportunity for white-tailed deer in response to their increasing abundance and expanding distribution. All limited entry hunt seasons were eliminated and general open seasons were implemented for bucks (no antler point restriction) for 82 days between September and November and for antlerless white-tailed deer where populations were deemed abundant. Harvest generally tracked population size from 1987-2011 ($\bar{x}$ = 8,038; SD = 2,800) (Figure 13). There was a noticeable drop in harvest for one year following the severe winter of 1996/97 but harvest continued to rise since then. The liberalized seasons in 2010 appeared to have increased antlerless harvest but the buck harvest remained at or below 1990 levels. This may have been due in part to the elusive nature of white-tailed bucks especially during hunting seasons where for example, Van Etten et al. (1965) found it took hunters about 18 hours to locate white-tailed bucks during controlled hunts in a one-mile square fenced enclosure. In southern portions of the province where white-tailed deer were expanding in distribution buck harvest continued to increase annually which contributed to hunter satisfaction. Westward expansion of white-tailed deer populations in British Columbia have been determined using an analysis of hunter harvest trend data from 1987-2011 (Aldous 2013).

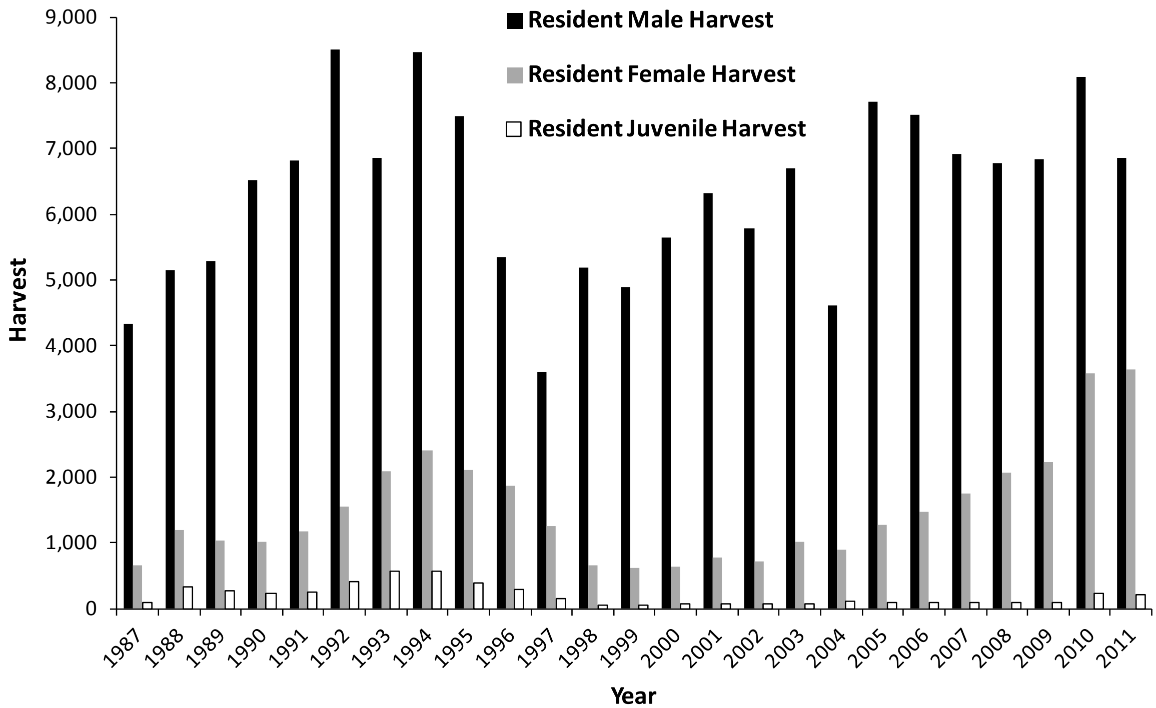

Figure 13. Estimated resident hunter harvest of white-tailed deer in British Columbia from 1987-2011.

Rocky Mountain Elk

Rocky Mountain elk populations generally increased across the province from an estimate of about 35,000 in the late 1980s to 55,000 in 2011 (Figure 14). Part of this increase may have been due to expanding distribution in parts of the interior, in some cases facilitated by translocations (Szkorupa and Mowat 2010) including one to Haida Gwaii. Population changes have varied among regions and habitats, with generally stable trends in remote mountainous areas and increases in and around agriculture areas, resulting in high levels of crop damage (Thiessen 2009, Szkorupa and Mowat 2010). The elk population temporarily declined in the mid-1990s (Figure 14) and was slightly down in 2011 compared to 2008. These declines may be attributed to some combination of antlerless hunting (particularly in agricultural areas where managers targeted population reductions), wolf and cougar predation and harsh winter conditions (Szkorupa and Mowat 2010, Phillips and Szkorupa 2011).

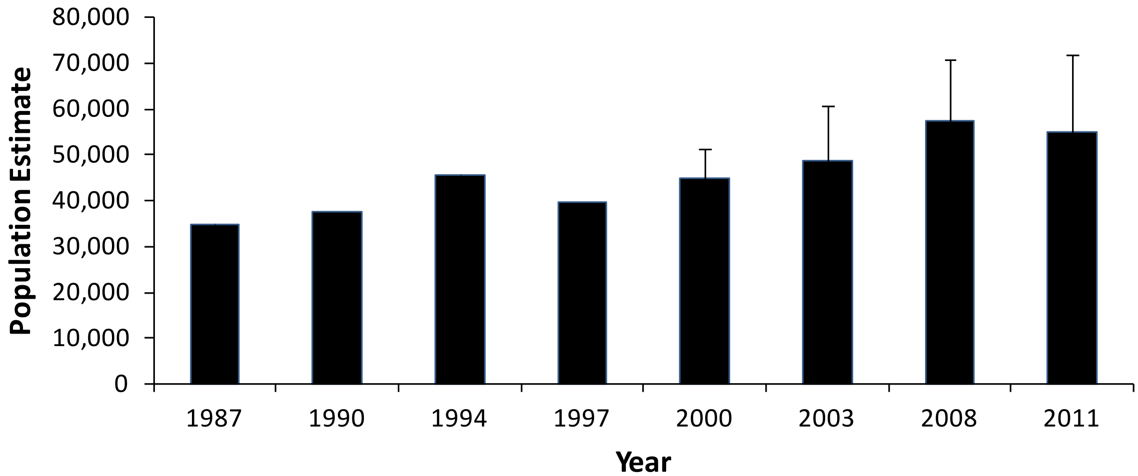

Figure 14. Rocky Mountain elk population estimates in British Columbia from 1987-2011. Estimates were derived from inventories, population modeling and expert opinion. Error bars represent the minimum and maximum population estimates expected.

Combined resident and non-resident harvest of Rocky Mountain elk increased from 1981 to 2011 ($\bar{x}$ = 3,741; SD = 1,100) (Figure 15). In the early 1980s, harvest of bulls was generally over 2,000/year and increased to over 3,000/year since 2008. In most of British Columbia, bull harvest was managed through a general open season for 6 point or better bulls in September and October. In agriculture-dominated habitats in the northeast and southeast, elk hunting seasons were more liberal with the goal of reducing populations in areas with high crop damage and over-grazing (Ministry of Environment 2010). More liberal seasons included general open seasons for spike bulls (10 days), 3-point or better bulls (61 days), and antlerless elk (11-73 days), and limited entry hunts that extended until the end of February.

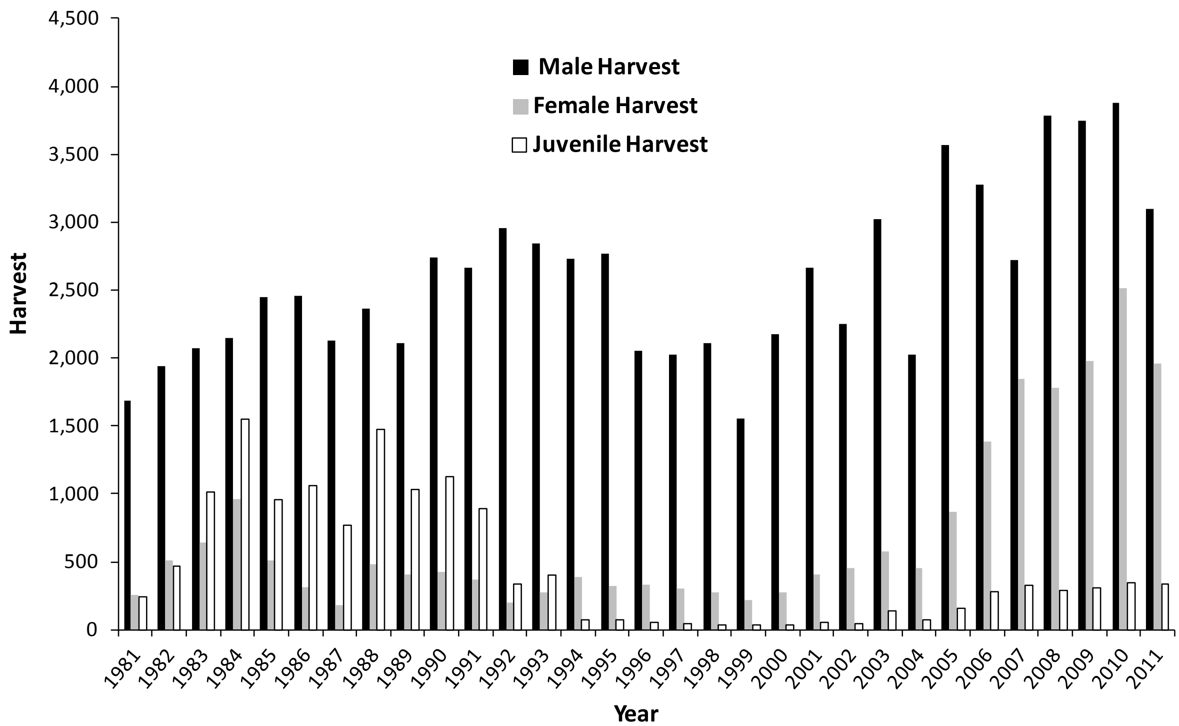

Figure 15. Estimated resident and non-resident hunter harvest of Rocky Mountain elk in British Columbia from 1987-2011.

Roosevelt Elk

Roosevelt elk numbers tripled from 1987 to 2011 ($\bar{x}$ = 3,850; SD = 1,400), with just over 2,000 in 1987 to more than 6,000 in 2011 (Figure 16). Although their distribution remained smaller and more fragmented than historic levels, the population grew particularly on the mainland in southwest British Columbia (Wilson 2012). This increase was mostly due to the re-introduction and re-distribution of more than 500 Roosevelt elk to parts of their historic range on the mainland coast, resulting in more than 24 new herds since 1987. Most new herds had increased in size at more than 20% per year for the first 4-5 years following release. Anecdotal observations indicated predator densities had increased in these same areas (Darryl Reynolds, Wildlife Biologist, British Columbia Ministry of Forests, Lands and Natural Resource Operations, personal observation). Roosevelt elk are endemic to Vancouver Island and their numbers had generally increased since 1987, partially in response to favorable habitat conditions created from forestry and to a lesser extent from translocations. Predation by cougars and wolves may have affected these elk populations, especially when predation was selective to calves (Brunt 1990, Quayle and Brunt 2003).

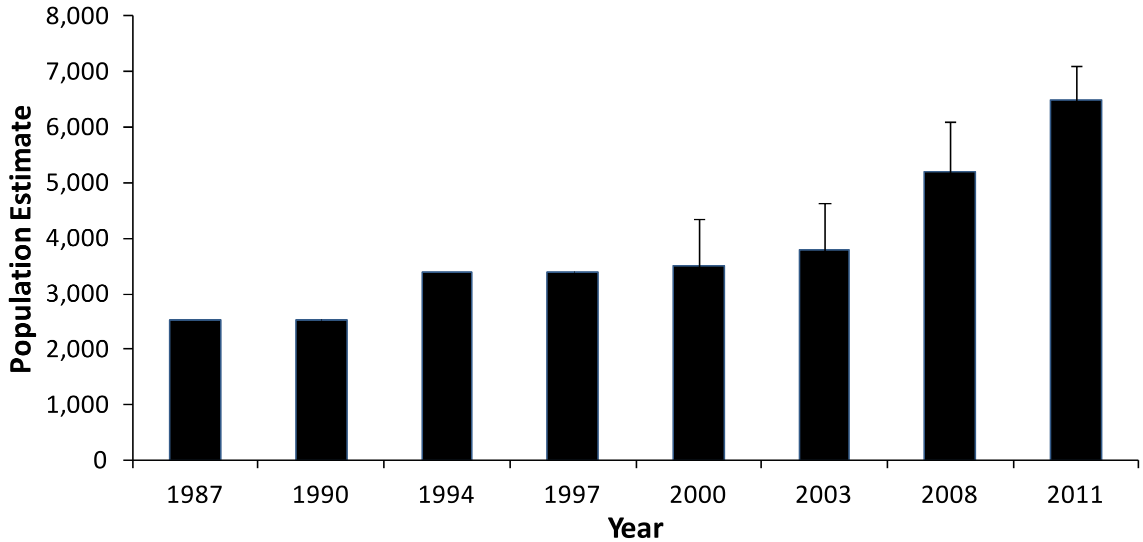

Figure 16. Roosevelt elk population estimates in British Columbia from 1987-2011. Estimates were derived from inventories, population modeling and expert opinion. Error bars represent the minimum and maximum population estimates expected.

Total resident and non-resident harvest of Roosevelt elk increased from 1981 to 2011 ($\bar{x}$ = 130; SD = 50) concurrent with increasing population size (Figure 17). Bull harvest doubled during this time from about 70 bulls per year in the early 1980s to close to 140 bulls per year from 2007-2011. There continued to be high hunter interest in Roosevelt elk with up to 15,000 applications for approximately 300 limited entry hunt authorizations in the late 2000s. First Nations were very interested in increasing their use of Roosevelt elk (Wilson 2012). There were some opportunities for antlerless harvest in both agricultural and remote areas. There were no antler point restrictions for bulls and seasons ran mainly from October 10 to November 30. Antlerless seasons were open for 14 to 97 days.

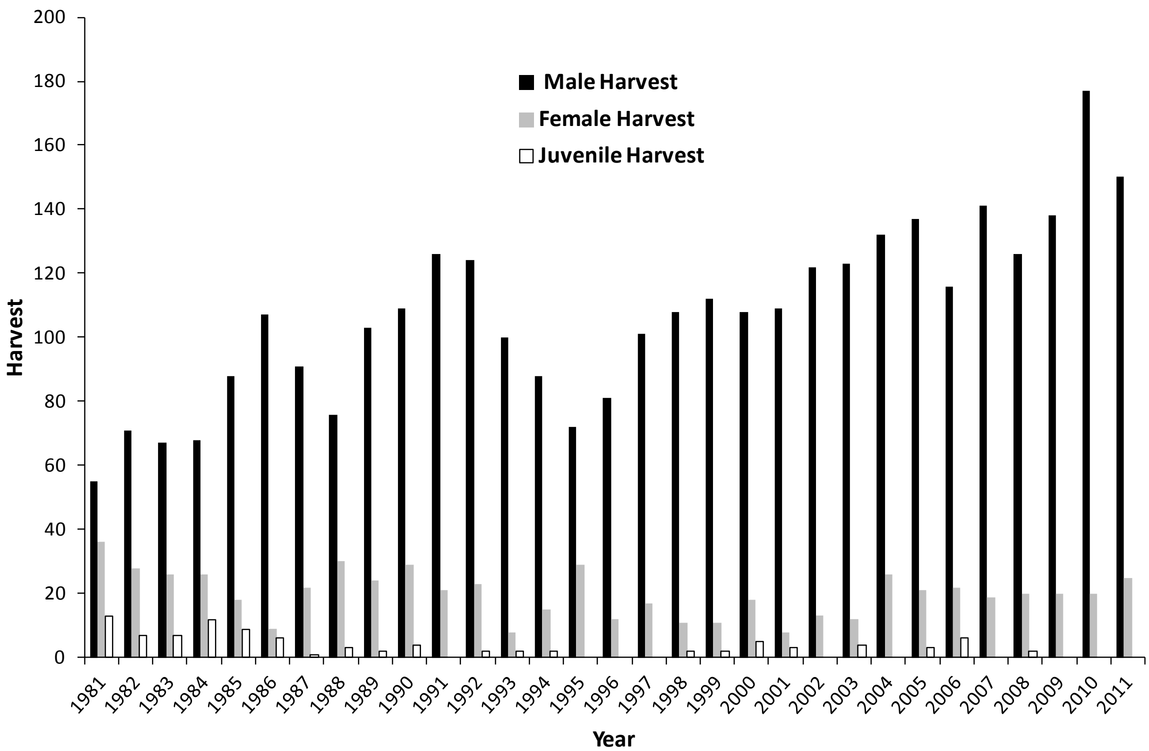

Figure 17. Estimated resident and non-resident harvest of Roosevelt elk in British Columbia from 1987-2011.

CONCLUSION

We reviewed population and harvest trends of deer and elk in British Columbia from 1981 - 2013. Mule and black-tailed deer harvest and population size were generally stable over the most recent 5 - 10 years at the provincial level but in parts of British Columbia, mule and black-tailed deer numbers were declining or remain suppressed. In contrast, white-tailed deer, Rocky Mountain elk and Roosevelt elk populations and harvest trends generally increased. Management of deer and elk in British Columbia would benefit from more timely and accurate harvest data and refined estimates of population trend and size. Provincial biologists require this information to evaluate harvest rates and hunting seasons, and recommend changes when conforming to established management objectives.

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ABUNDANCE OF MULE DEER IN NORTHERN SONORA AND CHIHUAHUA, MÉXICO

CARLOS A. LÓPEZ-GONZÁLEZ, Laboratorio de Zoología. Universidad Autónoma de Querétaro. Cerro de las Campanas s/n Col. Las Campanas. Querétaro, Querétaro. México. 76010. cats4mex@gmail.com

NALLELI E. LARA-DÍAZ, Laboratorio de Zoología. Universidad Autónoma de Querétaro. Cerro de las Campanas s/n Col. Las Campanas. Querétaro, Querétaro. México. 76010. nalleli.lara@yahoo.com.mx

HELÍ CORONEL-ARELLANO, Laboratorio de Zoología. Universidad Autónoma de Querétaro. Cerro de las Campanas s/n Col. Las Campanas. Querétaro, Querétaro. México. 76010. heli.coronelarellano@gmail.com

DANIEL ÁVILA-AGUILAR, Laboratorio de Zoología. Universidad Autónoma de Querétaro. Cerro de las Campanas s/n Col. Las Campanas. Querétaro, Querétaro. México. 76010. biodaniel.a.a@gmail.com

FERNANDA CRUZ-TORRES, Laboratorio de Zoología. Universidad Autónoma de Querétaro. Cerro de las Campanas s/n Col. Las Campanas. Querétaro, Querétaro. México. 76010. mafercruzt@gmail.com

Abstract: The mule deer is the largest of the 4 species of deer in México. Mule deer (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*) are the main prey for large carnivores, and both are highly regarded for their hunting value. There are few studies of mule deer in México; with range reduction occurring due to habitat loss, baseline data are necessary to develop management plans for the species. Our objective was to estimate the abundance of mule deer in the northern states of Sonora and Chihuahua, as they potentially have the most habitat for the species in México. We placed camera traps on 4 ranches for a 30-day period each. We identified mule deer individually, and we built a capture-recapture history for individual deer by site. We estimated abundance of mule deer using Program MARK, and estimated density by dividing abundance by effective sampling area based on published home range sizes. We found the lowest abundance and density of mule deer on the Ojos Ranch in Sonora (11 ± 3.8 individuals; 0.14 ± 0.04 individuals/km^2). We also found white-tailed deer there (2.1 ± 0.37 individuals/km^2). On the San Bernardino and Los Fresnos ranches in Sonora, we estimated abundance of mule deer as 70 ± 17.6 and 32 ± 7.45 respectively, and a density of 1.56 ± 0.39 and 0.6 ± 0.14 individuals/km^2, respectively. In the foothills of the Sierra del Nido in Chihuahua, we estimated abundance of mule deer as 42 ± 7.28 individuals and density as 0.8 ± 0.13 individuals/km^2. Our results indicate that mule deer were most abundant in low elevations and relatively flat areas with scrubland and grassland vegetation, contrary to the western United States. Continuous monitoring is necessary to assess the abundance and distribution of deer that can be harvested through regulated hunting, particularly by repeating surveys and incorporating a landscape analysis approach.

INTRODUCTION

Cervids in México are represented by 4 species: mule deer, white-tailed deer, red brocket deer (*Mazama temama*) and brown brocket deer (*M. pandora*; Hall 1981, Gallina and Mandujano 2009). Of these, mule deer are the largest with a distribution restricted to northern México. In the borderland states of Sonora and Chihuahua, mule deer are found within the Chihuahua and Sonoran deserts and are associated with creosote-mesquite, desert grasslands, arid pinyon-juniper woodlands, dense chaparral, and oak woodlands; generally they are found at elevations lower than 1500 m (Heffelfinger 2006). These populations of mule deer are not considered of conservation concern, but at a national level the species has lost approximately 60% of its original range (Weber and Gonzalez 2003).

Despite the need to better understand these dynamics, studies on range contraction in mule deer comprise less than 15% of the total deer studies in México (Mandujano 2004). Of those, few studies deal with abundance and population density (e.g., Reyes-Osorio 1981, Pérez-Gil 1984, Sánchez-Rojas and Gallina 2000). This lack of information precludes decision makers from establishing management and conservation plans for the species, a need heightened by the fact that mule deer are highly sought-after as a trophy hunting species.

Throughout México, Wildlife Management and Conservation Units (UMAs) have been established as a strategy for making the conservation of biodiversity compatible with the production and development needs of rural environments, particularly those of people living in regions with high poverty (Secretaría del Medio Ambiente y Recursos Naturales; SEMARNAT 2012). Northern México has the largest proportion of UMAs, most of them dedicated to hunting, which has resulted in elevated economic revenue to owners of privately owned and large ranches (>5000 ha). Many of the hunters and outfitters in the region come from the United States to hunt trophy bighorn sheep (*Ovis canadensis*) and mule deer. Economically, the UMAs in northern México have demonstrated profitability and feasibility, but there are no clear results in terms of conservation (Gonzalez-Marín et al. 2003, Gallina and Escobedo-Morales 2009).

The quantification of abundance and density of mule deer is necessary to support management and conservation plans that incorporate hunting. An additional benefit of understanding deer numbers is to also understand their contribution to the maintenance of the large carnivore guild, the density of which may vary as a function of prey (Heffelfinger 2006). Our objective was to estimate the abundance and density of mule deer in the northern states of Sonora and Chihuahua, México, using camera-trap surveys.

Study Area

Historically, mule deer have been distributed within the states of Sonora and Chihuahua. Within this region we surveyed 22 sites to determine white-tailed and mule deer presence between 2009 - 2013; of these sites, only 6 ranches contained mule deer (Ranch Los Ojos, San Bernardino, Los Fresnos, Sierra San José, El Muchacho and El Rincón; Figure 1). The vegetation in these areas was dominated by desert grasslands, desert scrubland, and the occasional oak (*Quercus* spp.) woodland. The ranches ranged in size from 25 - 180 km^2. The ranches typically experienced arid, dry, and temperate weather, dominated by two periods of rain (1 in the winter and a monsoon during the summer), with annual precipitation ranging from 200 - 600 mm. Across the ranches, elevation ranged from 800 - 1900 m. Average temperature ranged from 12 - 20°C.

Permanent and seasonal rivers occurred on all ranches (Instituto Nacional de Estadística y Geografía 2009). Additionally, the ranches represented different land use management. The Ranches Los Fresnos, Los Ojos and San Bernardino were dedicated to conservation with no livestock or hunting allowed, the remaining 3 had livestock production.

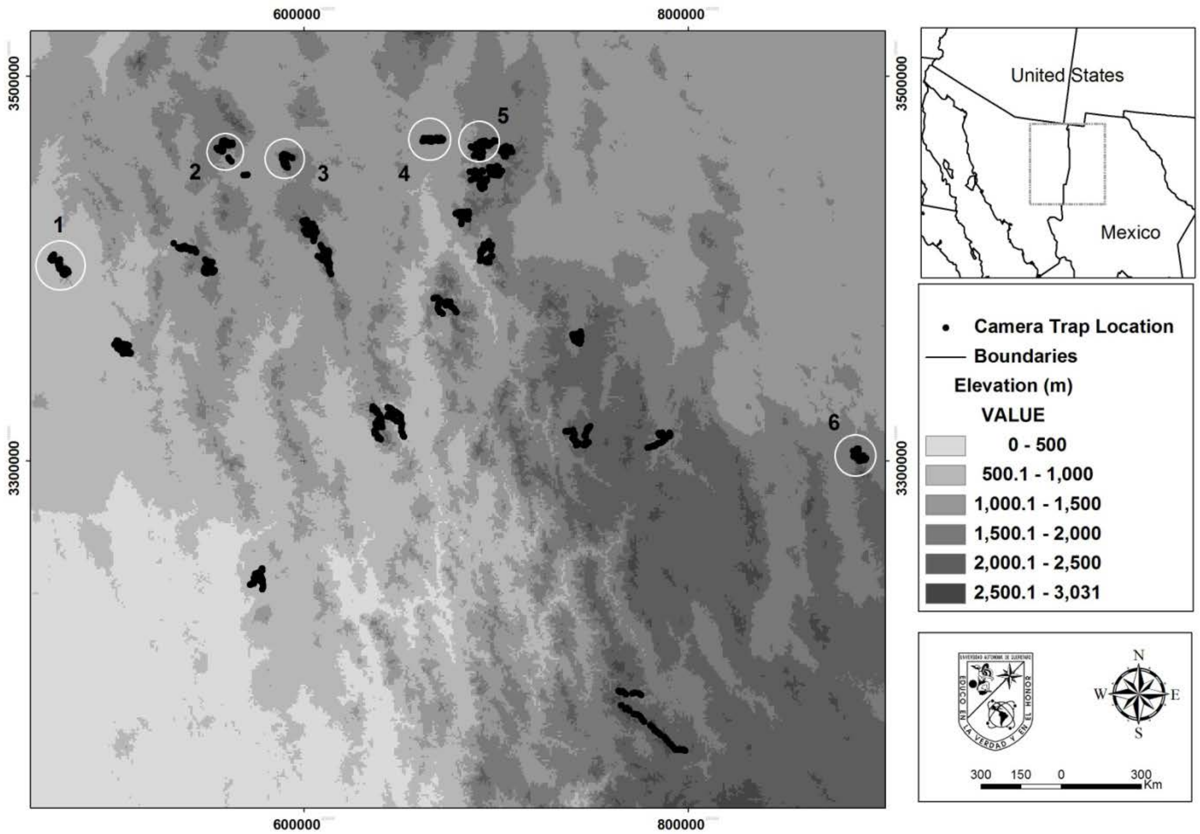

Figure 1. Geographic location of ranches surveyed for mule deer from 2009 - 2013 in northern México. Open white circles represent ranches with mule deer present (1 = Ranch El Rincón, 2 = Ranch Los Fresnos, 3 = Sierra San José, 4 = Ranch San Bernardino, 5 = Ranch Los Ojos, and 6 = Ranch El Muchacho).

METHODS

We surveyed mule deer using camera traps, with the number of cameras deployed on each ranch ranging from 21 - 31. We surveyed Ranches San Bernardino and Los Ojos in 2009 with 21 and 31 camera-traps, respectively. We surveyed the Ranch Los Fresnos in 2011 with 29 camera traps. We surveyed Ranches Sierra San Jose and el Muchacho in 2012, each with 29 cameras. Lastly, we surveyed Ranch El Rincon in 2013 with 29 cameras.

We placed cameras along wildlife trails, and on average they remained operational for 30 days during winter (January to March). Spatial separation between camera traps was 1 km, with slight differences due to terrain ruggedness and accessibility. We strapped camera traps to trees at heights ranging from 50 to 100 cm, roughly facing north. We baited camera traps using a mixture of corn, oatmeal and vanilla, placed approximately 3 m in front of each camera (Lara-Díaz 2010). We programed cameras to take 3 consecutive pictures each time they were triggered with a time lapse of 1 minute.

Photographic records of mule deer obtained during each sampling period were evaluated using a cross blind analysis (Kelly et al. 2008). Five independent observers evaluated each photograph and used physical characteristics and unique markings to identify individuals, based on methods applied successfully to white-tailed deer (Lara-Díaz et al. 2011). We considered all subsequent photographs of identified individuals separated by 24 hours as recaptures (Yasuda 2004). Photographs of animals which could not be individually identified were eliminated from analysis. We used a consensus of pooled estimates among observers of unique individual deer observed at each camera trap to develop a capture–recapture history for each.

For each ranch we sampled, we assumed closed populations and used program MARK 6.0 to estimate abundance, using CAPTURE to select the appropriate capture probability model (White 2008). We estimated effective sampling areas for each camera trap by creating a circular buffer around each camera trap (ArcGIS 9.3; ESRI 2011) equal in area to the average home range of mule deer in arid environments (5.74 km^2; Anderson and Wallmo 1984). We summed the area of all buffers within a sampling period, excluding overlap, to estimate total area sampled during the sampling period; we then calculated density (individuals per km^2) by dividing estimated abundance by total area sampled.

RESULTS

As can be expected from surveys conducted at multiple sites on a landscape, our estimates of abundance and densities among ranches varied. The lowest estimated abundance and density (mean ± SE) of mule deer among our sampled sites were found on Ranch Los Ojos (11 ± 3.8 individuals; 0.14 ± 0.04 individuals/km^2, respectively) and Ranch El Rincon (9 ± 3.01 individuals, 0.2 ± 0.06 individuals/km^2, respectively). We also found white-tailed deer on these ranches. On Ranch Los Ojos we documented a density of 2.1 ± 0.37 white-tailed deer individuals/km^2; on Ranch El Rincon, the density of white-tailed deer density was lower than 0.1/km^2 with 5 individuals identified. Ranch Sierra San Jose had the third lowest abundance and density of mule deer (11 ± 4.8 individuals, 0.24 ± 0.1 individuals/km^2, respectively) and no white-tailed deer. Ranch San Bernardino had an abundance of 70 ± 17.6 individual mule deer with a density of 1.56 ± 0.39 individuals/km^2. Ranch El Muchacho had an abundance of 42 ± 7.28 mule deer with a density of 0.8 ± 0.13 individuals/km^2. Lastly, Ranch Los Fresnos had an abundance of 32 ± 7.45 mule deer with a density of 0.6 ± 0.14 individuals/km^2; Figure 2).

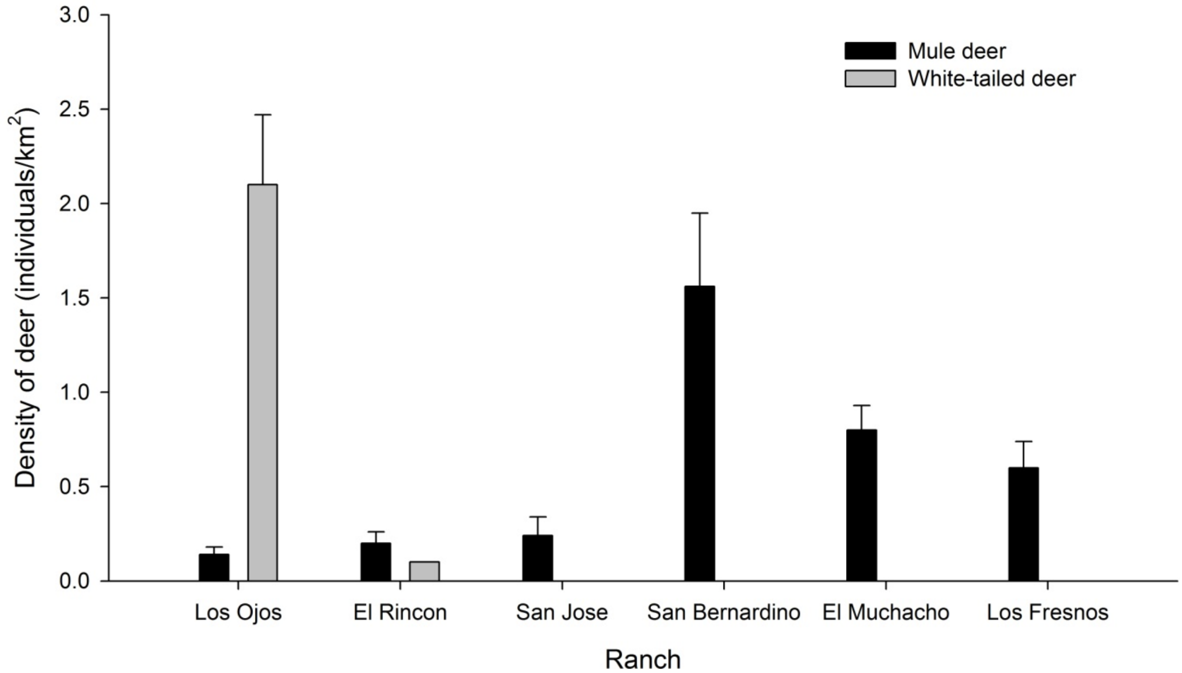

Figure 2. Average density (with standard error) for mule deer and white-tailed deer for six surveyed sites in Sonora and Chihuahua, México.

DISCUSSION

Our estimates of density of mule deer fall on the low end reported for the species (Mackie et al. 2003). Sánchez-Rojas and Gallina (2000) reported a density of 2 mule deer/km^2 in the Mapimi Biosphere Reserve in northeast Durango, which has been dedicated to the conservation of this and other species since the mid-1970s; this site is particularly relevant to our study because it is the only place in México with abundance estimates for comparison to ours. Importantly, the density estimated by Sánchez-Rojas and Gallina (2000) was based on pellet surveys, which tend to inflate population numbers up to 3 times (Lara et al. 2011).

Other mule deer populations that inhabit arid conditions tend to be relatively high in abundance and density, probably due to a variety of factors. Historical management in the United States created multiple use lands regulated by the government (e.g., areas managed by the U.S. Forest Service or the U.S. Bureau of Land Management). In México, value has been given to management of wildlife as recently as 1997. Whereas in the past only the Mexican government benefitted from hunting, now land owners now can profit from harvest of trophy animals on their land, providing incentive for land owners to care for their wildlife populations (Valdez et al. 2006).

The density estimates we present here may reflect the management strategy implemented on the ranches we surveyed. The relatively high perimeter-to-area ratio of small livestock-producing ranches like el Rincon results in a broad area of contact with neighboring lands, making the ranch readily accessible to poachers. El Muchacho Ranch, the largest ranch we surveyed, had a much lower boundary effect, providing less access to poachers, which may be why this ranch had a higher estimated density than the other livestock-producing ranches we surveyed. San Bernardino Ranch, conversely, was dedicated to conservation with no livestock or hunting. Additionally, this ranch has been subject to broad-scale habitat restoration which may be why we found the largest abundance of mule deer on this ranch. The density estimates among the ranches we sampled are relatively low, possibly related to human-related phenomena rather than the biological capacity of the habitat. The predator communities present in the surveyed ranches may be contributing to these low densities, as several of the ranches may be subsidizing the predators' numbers by providing livestock as prey or carrion. The habitat in most of the ranches in northern México is often overgrazed, with recuperating areas scattered throughout the landscape that may eventually favor an increase in mule deer abundance.

Mule deer use a gradient of open to closed habitats in the United States and Canada (Mackie et al. 2003), in México they use open habitats characterized by rolling hills with low cover. It appears that mule deer in those areas that we surveyed form groups of relatively small size (no more than 5 individuals per group) which may be the result of historical hunting pressure and relatively low habitat quality. Our surveys were carried out during the time when mule deer form large groups.

Desert mule deer in México have a relatively unknown distribution because there have been no clear and concrete efforts to assess it. This may be related to a lack of interest from academics as it is not an endangered species, and deer managers are only interested in the small segment of the population that they manage. We provide a broad-scale survey for mule deer that may help to assess the status of the species on a regional scale. The variety of conditions surveyed may help improve decisions about how many harvest permits can be issued to a ranch or group of ranches. Mule deer in México represent a large economic asset, up to $12,000 USD per trophy buck. The exploitation that accompanies this purely economic perception may be the leading cause of poor management for the species. We recommend the establishment of source populations of mule deer that remain large and unexploited. Repeated monitoring of hunted and unhunted populations will then be necessary to assess the distribution and number of deer that can be harvested through regulated hunting.

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RANGE-WIDE STATUS OF MULE DEER AND BLACK-TAILED DEER IN 2013.

Mule Deer Working Group. Western Association of Fish and Wildlife Agencies, USA.

The purpose of this paper is to provide a general overview of the current status of black-tailed and mule deer (*Odocoileus hemionus*) population abundance and harvest data (Tables 1 and 2) throughout their range in North America (Figure 1). The Mule Deer Working Group (MDWG) comprises 23 state and provincial agencies in the Western Association of Fish and Wildlife Agencies (WAFWA); its purpose is to provide a collaborative approach to finding solutions to improve mule deer and black-tailed deer (*O. h. columbianus*) conservation and management. The most common information requested of the MDWG is regarding the general population status and trajectory of mule deer and black-tailed deer populations. Stakeholders are interested in whether mule deer are still declining or in the process of recovering. To provide a quick snapshot of the status of this species, we assembled this information by having each agency MDWG representative provide a current estimated population size, status and general harvest information for mule and black-tailed deer for their respective jurisdiction. All states and provinces use very different methods to survey and estimate populations, parameters and harvest. Some have more scientifically rigorous processes than others, based on their resources and management needs. It is beyond the scope of this paper to provide a detailed accounting of the wide variation in data collection methodology and statistical treatment of the information collected. This paper will serve to inform biologists and interested public on the current status of this important species.

Table 1. Range-wide estimation of population size, harvest, and hunter numbers of mule deer provided by member agencies of WAFWA, 2013. All data presented are from the most recent year available.

	Estimated Population[1]	Total Harvest	% Males in Harvest	Hunter Numbers
Alberta	140,000	11,675	53%	22,263
Arizona	75,000 - 120,000	7,326	99%	61,118
British Columbia	115,000 - 205,000	14,205	84%	48,169
California[2]	400,000 - 500,000	32,954	98%	174,208
Colorado[3]	408,000	33,086	74%	73,705
Idaho	170,000 - 200,000	18,466	81%	71,078
Kansas	35,000	2,713	84%	19,467
Montana	Unknown	37,793	82%	165,473
Nebraska[4]	75,000	9,265	79%	15,000
Nevada	106,000	10,112	89%	24,257
New Mexico	80,000 - 90,000	9,400	99%	34,500
North Dakota[5]	13,260 (Badlands)	2,056	74%	6,122
Oklahoma	2,000	147	96%	472
Oregon	200,000 - 225,000	23,433	91%	66,719
Saskatchewan	30,000 - 60,000	6,500	NA	10,553
South Dakota[6]	73,000 - 130,000	9,300	60%	71,557

Table 1. (cont.)

	Estimated Population[1]	Total Harvest	% Males in Harvest	Hunter Numbers
Texas	150,000 – 210,000	10,261	100%	18,976
Utah	318,550	29,411	94%	79,066
Washington[7]	85,000 - 95,000	10,599	83%	120,082
Wyoming	376,000	27,720	80%	50,737
Yukon	1,000	4	100%	12

[1] Estimated populations may be presented as ranges to denote the difficulty and levels of uncertainty in gathering an estimate over a large spatial scale.
[2] Black-tailed and mule deer numbers combined.
[3] Population estimate, harvest, and hunters include white-tailed deer (*O. virginianus*) which cannot be easily removed and make up less than 5%.
[4] Number of mule deer hunters is difficult to estimate because many mule deer permits allow take of either species.
[5] Population estimate only for the Badlands, which was the primary range.
[6] Hunter number includes whitetail hunters.
[7] Total deer hunters.

Table 2. Range-wide estimation of population size, harvest and hunter numbers of black-tailed deer provided by WAFWA member agencies, 2013. All data presented are from the most recent year available.

	Estimated Population[1]	Total Harvest	% Males in Harvest	Hunter Numbers
Alaska		17,230	80%	11,744
British Columbia	99,000 - 155,000	5,949	92%	9,497
Hawaii[2]	1,000-1,200	30	100%	
Oregon	300,000 - 320,000	19,703	86%	98,290
Washington	90,000 - 110,000	12,551	83%	120,082

[1] Estimated populations may be presented as ranges to denote the difficulty and levels of uncertainty in gathering an estimate over a large spatial scale.
[2] Population estimate includes only public hunting areas, not private land. Harvest from 2011 because 2012 had fire closure declarations.

Figure 1. Range and current sub-specific designations for black-tailed and mule deer in North America.

Alaska

Sitka black-tailed deer are native to the wet coastal rainforests of Southeast Alaska (ADFG's Region 1) and due to historic translocation efforts, have now established populations in parts of South Central Alaska (ADFG's Region 2), including Prince William Sound and on Kodiak and Afognak islands. Populations fluctuate predominately with the severity of winters - increasing during a series of mild winters and sometimes declining dramatically after 1 or more severe winters. Predation can slow recovery of deer after these events. Harvest by deer hunters is believed to be compensatory in Alaska as a whole, due to the remoteness of most areas. However, early and heavy snowfall can occasionally concentrate deer on beaches in areas relatively close to population centers, leading to substantially higher harvests in these areas. In contrast, where logging road systems exist adjacent to communities, low snowfall in the fall or early winter may allow hunters prolonged use of these secondary roads, leading to higher than normal harvests in these areas.

In Southeast Alaska, Sitka black-tailed deer are fairly ubiquitous, and the most frequently pursued big game species. Deer density on the mainland has historically appeared to be much lower than on the islands, presumably due to lower habitat quality. Because of the island geography, varying weather patterns, different predator guilds, and differences in the extent and pattern of forest logging, deer densities can vary greatly from 1 game management unit (GMU) to another and even within GMU's. Population size or density has never been formally calculated in Southeast Alaska due to the difficulty of employing various techniques in remote and densely forested areas. Historically, we have attempted to index changes in deer abundance using deer pellet count surveys and hunter surveys. Currently we are conducting research to evaluate the implementation of a regional monitoring protocol using deer fecal DNA for mark-recapture estimation.

Southeast Alaska experienced 2 severe and 1 above average winter between 2006 and 2009, which led to substantial declines in the deer population and management actions such as doe harvest closures were taken in parts of the region. After these years, we documented a decline in deer harvest, deer hunters, and hunter effort, suggesting a population decline. Since then we have experienced winters of average to below average severity across most of the region, and believe our deer populations are recovering in most areas, with hunter harvest and effort appearing to rebound as well. However, deer densities remain of particular concern in GMUs 1A and 3Z. The reduced number of deer in these areas from historical highs is thought to involve the effects of periodic severe winters, reduced habitat quality, and predation slowing deer population recovery. Intensive management (predator control) proposals for wolves were reviewed and approved by the Board of Game in 2013. Currently research is underway to better evaluate the potential causes of the decline of deer in these areas. Predator control will not be implemented until preliminary research indicates it is warranted.

In South Central Alaska, the weather patterns can differ substantially from those in Region 1. Effects of winter in 2011 to 2012 in GMU 6 were the worst in probably 30 years. Winter mortality was estimated at >50% overall, and was probably 70% in western Prince William Sound. Deer numbers are believed to have remained low; to relieve pressure the deer hunting season was closed by emergency order in early December of 2012 for the remainder of the deer hunting season. In GMU 8, the deer population of the Kodiak archipelago declined due to a severe winter with near-record snowfall in 2011 to 2012. Deer mortality was greatest on the northern portion of Kodiak and the western side of Afognak Island. Deer populations are likely still rebounding, but the winter of 2012 to 2013 was much milder and over-winter survival in all areas was very good.

-Karin McCoy, Alaska Department of Fish and Game

Alberta

The southern parts of the province are still recovering from die-offs associated with the severe winter of 2010 to 2011. The last 2 winters have been mild in the south, but central and northern Alberta saw deep snow conditions this past winter which affected all ungulates, including mule deer populations. In the south, lack of snow cover continued to limit the number of wildlife management units (WMU's) where winter aerial surveys could be conducted, so it has been difficult to determine whether populations have recovered. Because of this, wildlife managers applied conservative estimates for mule deer populations when establishing permit numbers for the 2013 hunting season. Overall, antlered mule deer permits were adjusted up by only 20% from last year. Even with effects of winter weather on ungulates over the last couple years, Alberta continues to provide great hunting experiences for mule deer for residents and non-residents alike.

The current provincial population estimate is approximately 140,000 mule deer. This will provide approximately 11,400 hunting opportunities this fall for residents for antlered mule deer (64,800 hunters applied last year) and approximately 17,000 hunting opportunities for residents for antlerless mule deer (25,500 hunters applied last year). Approximately 1,500 opportunities are also available for non-residents through outfitter-guide allocations.

-Kim Morton, Alberta Fish and Wildlife Division

Arizona

Mule deer populations reached the most recent peak in the early 1980s. Mule deer declined through about 2000 and since then have probably increased by about 10%. Most deer populations within the state were surveyed annually using fixed-wing aircraft or helicopter with supplemental ground surveys used as well. Mule deer were surveyed during the breeding season to estimate buck:doe and fawn:doe ratios. Hunter harvest was estimated using a voluntary post card questionnaire that may be returned with postage prepaid or responses may be entered online. Currently, we receive about 35 – 55% response rate, with about 15 – 20% of all responses online. Buck:doe ratios for mule deer were managed at 20 – 30:100. Alternative management units were managed at higher buck:doe ratios with added guidelines regarding the age structure of the harvest or hunter density. These units approximate about 5% of the opportunity offered annually. Recent wildfires created situations that were favorable to improved growth of deer populations, yet limited land management actions (e.g., prescribed fire, thinning) benefitting forage production are implemented annually.

-Brian Wakeling, Arizona Game and Fish Department

British Columbia

Mule deer numbers declined in the late 1990's largely due to severe winter conditions but since then have recovered to a 2011 provincial estimate of 115,000 to 205,000 (Figure 2). Populations on the northern edge of the range vary with winter severity. Currently, most of the province has stable to increasing mule deer numbers while some areas in southeast BC have recently experienced declining mule deer populations. Mule deer surveys are generally focused to obtain post-hunt buck:doe ratios and overwinter fawn survival.

Black-tailed deer numbers declined during the early- to mid-2000's (Figure 3). We suspect this was mainly due to increased predation from cougars (*Puma concolor*) combined with factors related to anthropogenic disturbance. Both cougar and wolf (*Canis lupus*) population levels seem to have stabilized at lower densities resulting in a subsequent general increase in deer numbers in parts of the province. There is still some concern for low black-tailed deer numbers on parts of the mainland coast. Black-tailed deer surveys were conducted to obtain pre-hunt buck:doe ratios and overwinter fawn survival. The 2011 provincial estimate for black-tailed deer was 99,000 to 155,000.

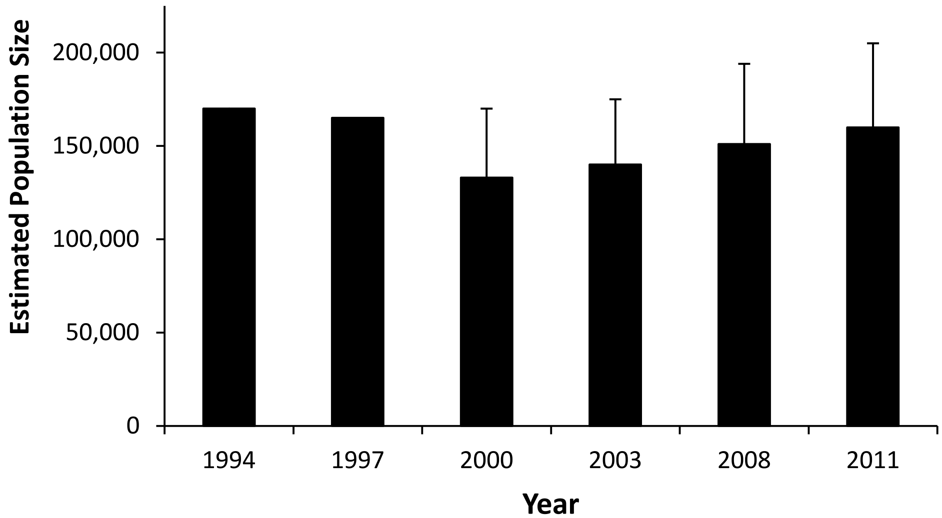

Figure 2. Mule deer population trends in British Columbia

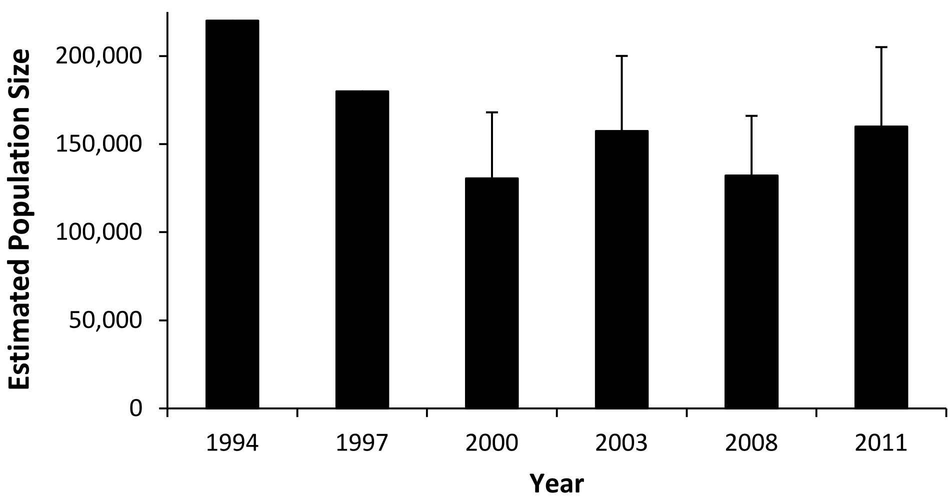

Figure 3. Black-tailed deer population trends in British Columbia.

-Gerry Kuzyk, British Columbia Ministry of Forestry, Lands and Nat. Res.

California

California's deer population has been stable to slightly declining for at least the last 20 years. Most apparent is the reduction in migratory deer populations in the northern and eastern parts of the state. Some areas in the state with resident deer populations are actually experiencing increases in deer populations with resultant deer depredation-vehicle collision issues. The overall harvest trend has been decreasing. This trend may be as much a result of changes in hunter numbers as changes in deer populations. The statewide average hunter success rate was 18.9% in 2012. Last year's experience with a radio collared gray wolf from Oregon moving into California (the last confirmed wolf in California was in 1924) has ignited a new interest in deer populations from hunters, but the impact on future deer management remains to be determined. A fairly strong anti-hunting or anti-management segment of California's population remains very active and is increasingly affecting management decisions.

-Mary Sommer, California Department of Fish and Wildlife

Colorado

The statewide post-hunt population estimate for deer in 2012 was 408,000, compared to 418,000 in 2011. Mule deer populations in the far western portions of the state have declined. These declines are in some of the largest populations we have. Sportsmen and women, landowners, and Colorado Parks and Wildlife (CPW) are concerned about declining mule deer populations in western Colorado. CPW is in the process of developing a stakeholder process focusing on deer management.

Whereas there is reason for concern in many western herds, other herds in the state are performing well. The diversity of deer habitat types and environmental conditions around the state create considerable geographic variability in population performance. Most deer herds in the central and northern mountains are performing well, and population sizes as well as license numbers are increasing. We are encouraged by increasing buck:doe ratios post-hunt 2012 in several herds. In 2013, we are starting to restore quotas that we reduced in response to declines from the winter of 2007 - 2008 in herds that are recovering and/or are above population and buck:doe ratio objectives. Most plains deer populations are relatively stable. The average of buck:doe ratio objectives for deer herds statewide is 30 bucks:100 does. CPW conducts post-hunt herd inventories with helicopters to estimate the ratios of bucks:100 does and fawns:100 does. During the post-hunt herd inventories in 2012, biologists classified 69,400 deer and observed an average buck:doe ratio of 30.7:100, compared to 29.3:100 in 2011. Based on these observed post-hunt buck:doe ratios and high hunter success, which was 50% for all rifle seasons in 2012, overall buck hunting continues to be good for those that are able to draw a tag. This good hunting even applies to some of the declining herds where we lowered license numbers to achieve the buck:doe ratio objectives and maintain the opportunity to harvest mature males.

-Andy Holland, Colorado Division of Parks and Wildlife

Hawaii (Kauai Island: Introduced Black-tailed Deer)

Since the introduction of the Oregon black-tailed deer to west Kauai in 1961, its range has expanded to southern and eastern sections of the island. The deer population on Kauai's public hunting areas is estimated to be between 1,000 to 1,200 animals. Population estimates on private lands are not known at this time. Kauai uses the Aldous 1944 browse survey method which was modified to better fit Hawaiian environments. Dry conditions brought on by periodic El Nino oscillations have persisted throughout much of deer hunting range during the past decade. There were 2 major wildland fires last year which severely affected much of the deer hunting range. Hunting seasons have been scaled back due to the ongoing fire closure declaration.

Table 4. Trends in harvest of black-tailed deer from 2003 to 2012 on Kauai public hunting areas, Hawaii.

	Buck	Doe	Total
2003	45	19	64
2004	39	12	51
2005	32	8	40
2006	32	2	34
2007	32	4	36
2008	51	2	53
2009	29	-	29
2010	26	-	26
2011	30	-	30
2012[1]	4	-	4

[1] Fire closure limited deer hunting season

-Thomas Kaiakapu, Hawaii Division of Forestry and Wildlife

Idaho

Idaho's mule deer population appears to have been relatively stable over the last decade. The state is in the process of converting population monitoring to allow total population estimates through a combination of sightability, survival estimates, composition surveys and modeling. Although not all areas have yet been assessed, recent winter population levels have likely been between 170,000 and 200,000. Short- and long-term objectives are to increase mule deer numbers. Post-season buck ratios have mostly exceeded the statewide minimum objective of 15:100 does (Table 5). However, December fawn:doe ratios are typically low (mid-1950s to mid-1960s), and fawn survival varies dramatically among years, from 30% to 76%.

Mule deer harvest in Idaho has been approximately stable since the mid-1990s ($\bar{x}$ = 19,310 bucks) following a steep decline in harvest in the early 1990s. Recent years' license and tag sales data indicate a decline in nonresident hunters in Idaho. Percent bucks with 4-point or better antlers in the harvest has remained stable in the upper 30% range.

Table 5. Population estimates from Idaho mule deer surveys, 2002-2012.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Fawn:Doe[1]	61	60	56	63	61	56	60	61	61	55	63
Buck:Doe[2]	17	16	19	21	22	16	15	17	21	15	21
Fawn Survival[3]	0.40	0.69	0.54	0.76	0.31	0.69	0.30	0.52	0.68	0.32	0.61
Adult Doe Survival[4]	ND	ND	ND	ND	0.87	0.89	0.90	0.90	0.95	0.82	0.95

[1] Fawn:Doe = fawns per 100 does
[2] Buck:Doe = bucks per 100 does
[3] Fawn Survival = overwinter fawn survival (December - May),
[4] Adult Doe Surival = annual survival (June - May)

-Toby Boudreau, Idaho Department of Fish and Game

Kansas

Mule deer comprise a small portion of the deer population in Kansas; however, they receive enthusiastic support from deer hunters. Limited survey efforts are currently used to monitor mule deer populations. We do not have estimates of survival rates. Distance sample surveys in 2011 estimated the density to be 1.8 mule deer/mile^2 in the western portion of the range and approximately 0.2/mile^2 in the eastern portion of their distribution. Estimates from spotlight surveys indicate a pre-firearm season population of approximately 35,000 animals. No discernible trends have been seen in the herd composition with 6 year average ratios of 42.5 bucks:100 does and 76.5 fawns:100 does. Field biologists indicate a declining population of mule deer, especially in the eastern part of their range; however, daily diaries from bowhunters suggest an increasing trend in mule deer observations (Figure 4).

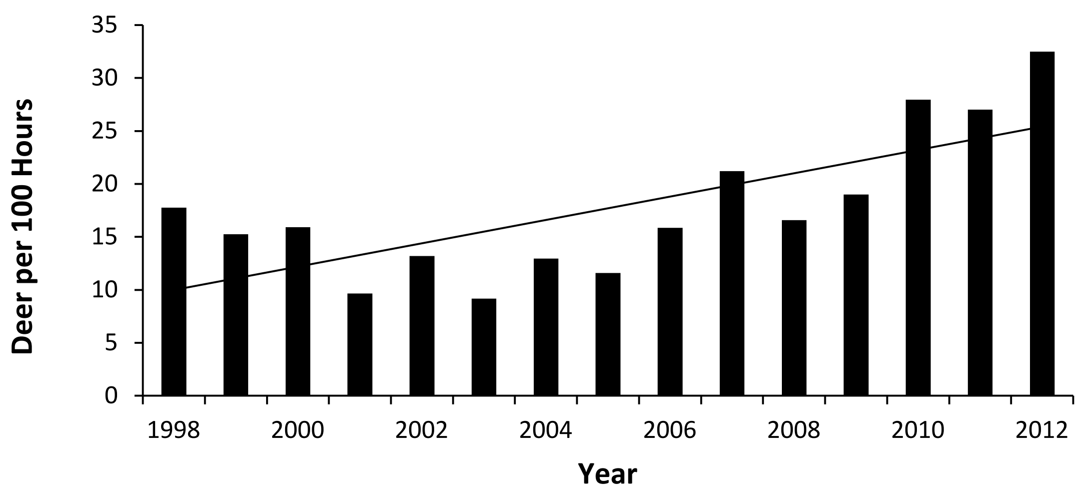

Figure 4. Trends in mule deer observations from Kansas bowhunter diaries, 1998 to 2012.

Our hunting regulations have been liberal for white-tailed deer while being restrictive for mule deer. In recent years mule deer could be taken on about 10% of the deer permits issued in Kansas and more than half of those have been issued to landowners. Each permit allows only 1 deer to be taken and all permits that allow the hunter to take a mule deer were valid for a white-tailed deer if the hunter decided to take a white-tailed deer instead of a mule deer. This practice generally takes hunters out of the field earlier in the season and takes pressure off mule deer while allowing approximately 19,000 people to have the potential to pursue mule deer. Hunters have taken an average of 2,669 mule deer/year during the last 11 years (Figure 5).

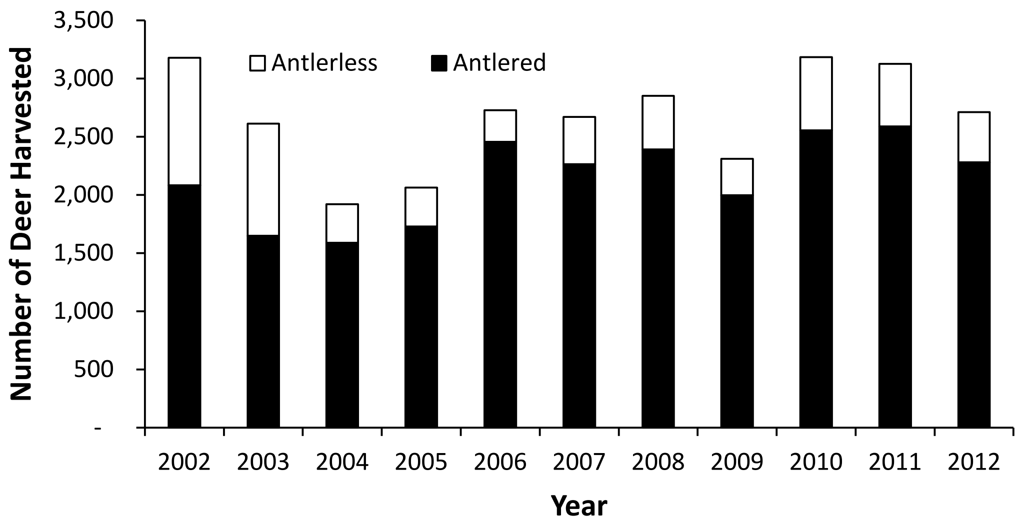

Figure 5. Trends in the number of mule deer harvested in Kansas, 2002 to 2012.

-Lloyd Fox, Kansas Department of Wildlife and Parks

Montana

Montana Fish, Wildlife and Parks does not collect data to estimate mule deer abundance in Montana. Population growth is indexed with data from trend areas that represent populations in the state. Management is guided by a population model with harvest, population trend, recruitment, and buck abundance as inputs. Recent trend estimates have been as much as 30% below long term average.

Mule deer over much of Montana experienced significant declines in recruitment and observed numbers of mule deer during 2007 - 2011. Surveys during 2012 - 2013 revealed improved recruitment and stable numbers in central and eastern Montana. Mule deer populations in western Montana continue to perform poorly. Recent, significant declines of mule deer populations in eastern Montana were associated with inclement winter/spring weather and drought. Harvest management responses have included conservative adjustments to general license harvest opportunity and dramatic reductions in antlerless licenses. Harvest of antlerless mule deer declined from 20,000 - 24,000 annually in 2007 - 2009, to 6,832 in 2012.

-George Pauley, Montana Fish, Wildlife and Parks

Nebraska

Harvest of mule deer bucks was 7,325 in 2012, down 3% since 2011 and down 20% from the record high of 9,115 in 2008. Mortality from a combination of factors that included meningeal worm, chronic wasting disease, and interspecific competition with white-tailed deer were the suspected causes. Antlerless harvest of mule deer in 2012 was 1,940, the lowest in 31 years. Harvest of does and fawns was restricted to allow for population recovery. We hope that the record-breaking drought and epizootic hemorrhagic disease event of 2012 which killed about 30% of our herd of white-tailed deer may ease suspected competition and allow mule deer to recover.

-Kit Hams, Nebraska Game and Parks Department

Nevada

Population estimates for mule deer in Nevada based on computer modeling suggested a decline of approximately 18% from just over 130,000 deer between 1998 - 2001, to a more recently estimated population level closer to 110,000 deer (Figure 6). A major decline (about 20,000) was reported in 2002 and since then, estimates have remained relatively stable, between 106,000 and 112,000 deer. The 2013 estimate decreased to 106,000 deer from 112,000 in 2012. Deer tags were increased nearly 50% for the 2012 season and statewide hunter success for all hunters was 42%, up from 39% for the previous 2 years. Percent bucks with 4-point antlers or better in the harvest has averaged 40% over the past 10 years and even with the substantial increase in tags was 37% in 2012. With 34,000 mule deer classified during post-hunt helicopter surveys in Nevada, the statewide post-hunt buck:doe ratio remained the same as that observed the previous year (a record 32:100). The fawn:adult ratio of that sample was only 41:100. Spring surveys classified over 33,000 mule deer and a statewide spring recruitment rate of only 31 fawns:100 adults was measured. Drought conditions will likely continue to negatively affect mule deer again this year.

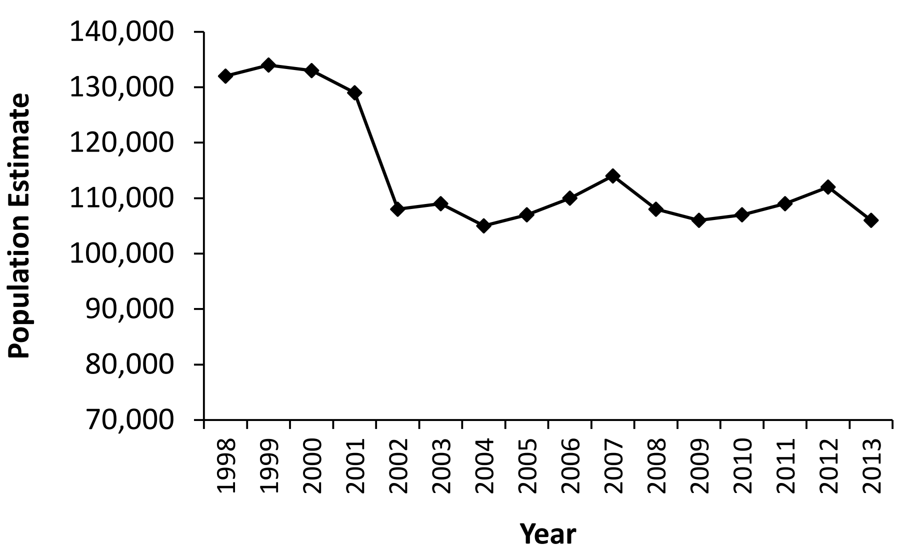

Figure 6. Nevada mule deer population estimate trends, 1998 to 2013.

-Larry Gilbertson, Nevada Department of Wildlife

New Mexico

The latest drought hitting New Mexico that began in the winter of 2010 - 2011 has continued throughout the state. Mule deer populations have declined statewide because of low recruitment. Some moisture occurred statewide during the monsoon season followed by the 2011 - 2012 winter with more precipitation than in 2010 - 2011. 2012 - 2013 has been 1 of the driest periods in recorded history. Overall, fawn ratios were too low to maintain or increase population levels. Most of New Mexico's wildlife populations are stressed from this sustained drought and mule deer will likely continue poor production under these conditions. In response to the drought conditions and low recruitment rates, license numbers for mule deer in some GMUs have been reduced for the 2013 - 2014 hunting season.

On a positive note, during the past 2 years, wildfires in New Mexico have burned several hundred thousand acres. Specifically in the Gila National Forest, 3 fires have burned close to 500,000 acres. The Silver Fire in the southeastern portion of the Gila National Forest approached 100,000 acres. This will translate into better habitat conditions for mule deer in those areas. Beginning in 2014, the New Mexico Department of Game and Fish will initiate a process to evaluate, make recommendations, and implement changes to the deer rule for the 4-year cycle. These changes will be implemented in 2015.

New Mexico has begun a trap and translocation project for mule deer in the southern part of the state. Approximately 170 mule deer have been trapped and moved to 3 different locations. The deer are being monitored to determine movement patterns, survival rates, and specific cause mortality. These projects will continue in the future.

Habitat work is continuing; funded both through our Habitat Stamp Program that funds improvements on Bureau of Land Management and U.S. Forest Service property, as well as funds originating from our Enhancement Tags (statewide licenses). These monies are used in selected priority areas. We have identified 3 focus areas for this work: GMU 2C in northwest New Mexico, GMU 18 in central New Mexico, and GMU 16 in west-central New Mexico. Other areas are also being considered. Prescriptions include thinning and burning as well as planting and seeding with native browse. The Mule Deer Working Group (MDWG) Habitat Guidelines (Heffelfinger et al. 2006, Watkins et al. 2007, Fox et al. 2009) are used as a reference in implementing these prescriptions.

Our Private Land Deer Conservation Incentive Program has expanded over the past 7 years to include >50 ranches. This program is being reviewed to determine changes that need to be made and implemented with landowners. Approximately 40% of New Mexico is private land, therefore it is critical to work with landowners to improve conditions for mule deer. This program works with private landowners to improve the habitat on their property. Again, we try to use the MDWG Habitat Guidelines (Heffelfinger et al. 2006, Watkins et al. 2007, Fox et al. 2009) in cooperating with the landowners. In return for their work, participating landowners are issued specific sport hunting incentives which they can market with the goal of using generated funds to further pay for their habitat work. Additional funds are sought through Federal Farm Bill Programs. Consultation among agency staff, landowners, Natural Resources Conservation Service, etc., has resulted in an expansion of the acreage in the program as well as increased variety of prescriptions employed.

-Kevin Rodden, New Mexico Department of Game and Fish

North Dakota

The badlands mule deer population estimate increased from 1998 - 2007 because of a decade of very mild winters and a conservative harvest strategy (Figure 7). Since 2008, numbers of mule deer have declined due to 3 consecutive severe winters (2008 to 2010). Fawn production following the winters of 2008 - 2010 resulted in the 4 lowest fawn:doe ratios since the late 1950s. In response to the declining trend in numbers of mule deer, no antlerless licenses were issued for the badlands deer units in 2012. The combination of no antlerless harvest and a relatively mild winter in 2012-2013 over much of the badlands led to a small increase in numbers of mule deer. The 2013 spring index was 15% higher than in 2012, but 22% lower than the long-term average.

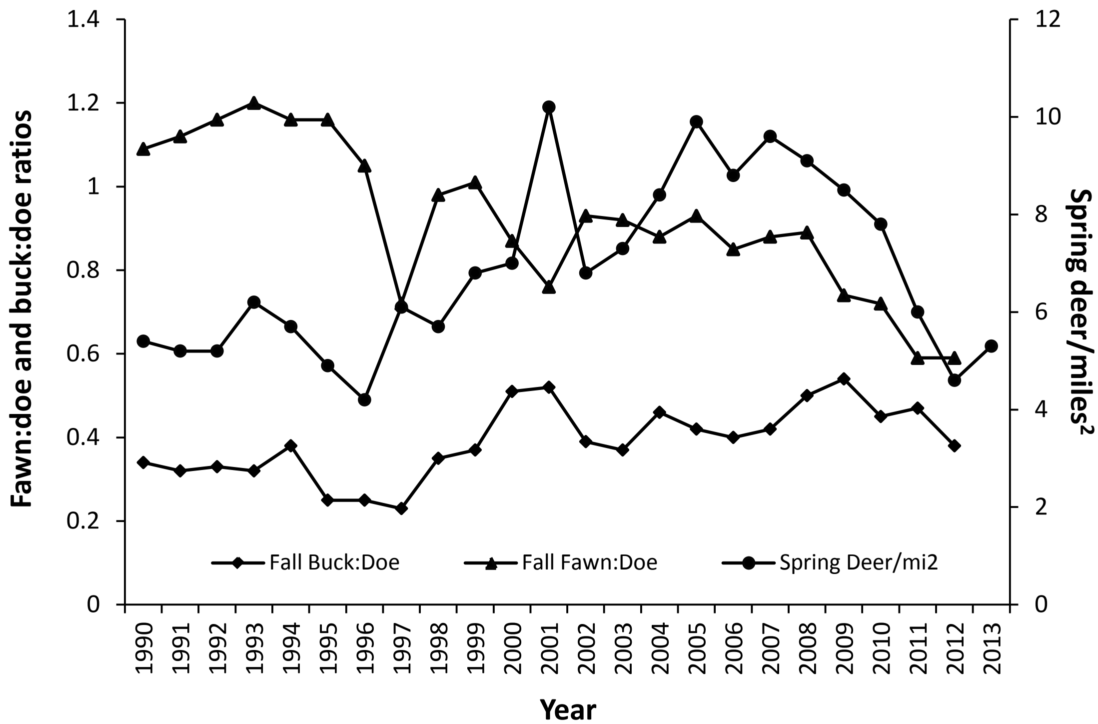

Figure 7. Mule deer population trends in North Dakota, 1991 to 2013.

- Bruce Stillings, North Dakota Game and Fish Department

Oklahoma

Mule deer in Oklahoma inhabit a very small portion of the state. The result is that very little opportunity exists to hunt mule deer in Oklahoma and those opportunities are mostly on private land. Hunters take an average of 200 mule deer/year in Oklahoma. In 2012, 147 mule deer were harvested. Oklahoma does not have a separate mule deer license, they are part of the general hunting license for deer. However, we do provide some protection for mule deer by not allowing does to be harvested during any firearms season and as a result, have a very low doe harvest rate.

-Erik Bartholomew, Oklahoma Department of Wildlife Conservation

Oregon

Both mule deer and black-tailed deer are substantially below the long-term statewide management objectives and benchmarks. Oregon's estimated mule deer population continues to hover around 222,000. Because of the difficulties with surveying black-tailed deer we have been unable to develop annual population estimates. However, in 1998 the black-tailed deer population was estimated at 387,000, declining to 320,000 in 2004; the population seems to have been relatively stable since that time.

Efforts to more rigorously estimate deer populations in Oregon continue. The Oregon Department of Fish and Wildlife is attempting to implement the mark-resight estimator developed by Brinkman et al. (2010) to estimate black-tailed deer populations at a unit-wide scale. Further, quadrat surveys have been flown in 13 eastern Oregon mule deer management units.

Oregon's Mule Deer Initiative and Black-tailed Deer Management Plan Implementation process continue to move forward as well. Over 405,000 hectares of habitat have been treated, primarily juniper (*Juniperus spp.*) control, specifically to improve mule deer habitats. A strategy to more aggressively improve black-tailed deer populations and habitats has been developed by local public working groups and is now in final review by Wildlife Division.

-Don Whittaker, Oregon Department of Fish and Wildlife

Saskatchewan

Mule deer populations continue to fall below long term averages in several core areas across Saskatchewan. The winter of 2012 - 2013 was difficult for deer populations due to extended periods of above-average snowfall. License availability will remain similar to the previous years for both antlerless and either-sex components of the population. Surveys completed this fall will be used to further assess the population status.

- Travis Williams, Saskatchewan Department of Environmental and Resource Management

South Dakota

Mule deer populations in South Dakota have decreased in recent years following multiple years of high harvest rates and severe winters. Pre-season recruitment estimates have shown declining trends over the past 4 years, but the estimate of 65 fawns:100 does in 2012 was not substantially different from the previous year. Eighty percent of deer management units on the prairie are currently below population objective, and license quotas have been reduced. Mule deer populations in the Black Hills region are below objective but remain stable despite restricted harvest regulations promulgated several years ago. Record drought conditions experienced in 2012 could affect some herds, but the winter of 2012 - 2013 was mild to normal in the mule deer range of the state; recent precipitation has removed most areas out of the severe drought status thus far in 2013. Loss of land enrolled in the Conservation Range Program, native grassland, pasture, and rangeland-to-agriculture conversion continues to be a concern for mule deer management.

-Andy Lindbloom, South Dakota Department Game and Fish

Texas

Trans-Pecos.—In general, the Trans-Pecos population is trending downward primarily from extended and expansive drought conditions during most survey years after 2005 (Figure 8). Estimates from a sightability model show an approximately 20% decline from 2011 (138,703) to 2012 (108,739). Raw, uncorrected survey data indicate a decline of about 40% in mule deer numbers from 2009 - 2012. We did not survey in 2007 and 2010. The estimated 2012 fawn crop of 32 fawns:100 does was better than the 2011 estimate of 13, but slightly below the long-term average (40 to 45). Improved range conditions in parts of the region helped increase fawn production in 2012. The sex ratio was similar for both 2011 and 2012, and has been fairly stable since post-season surveys began in 2005, although the buck:doe ratio has slightly decreased since 2009. This could be because extended drought conditions increased post-rut mortality among bucks.

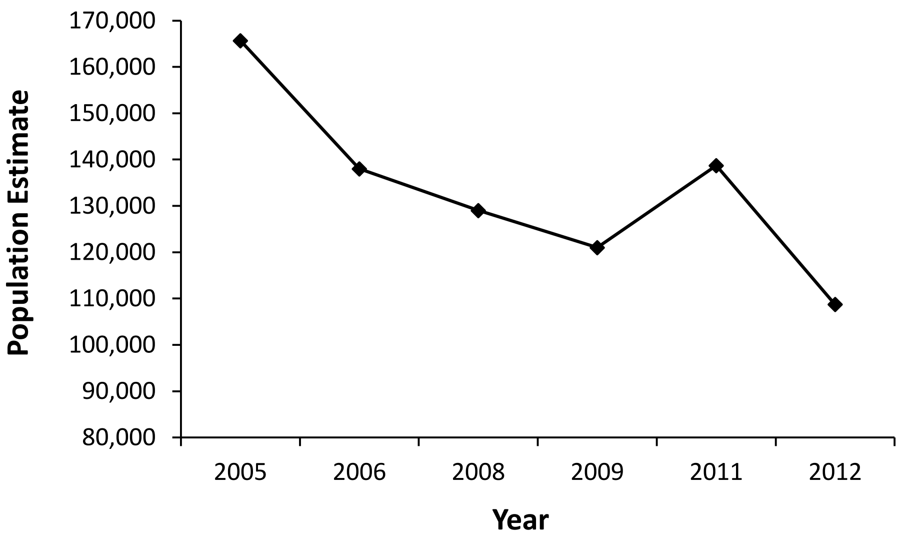

Figure 8. Trends in mule deer population estimates in the Texas Trans-Pecos, 2005 - 2012.

Panhandle.—Similar to the Trans-Pecos, the Panhandle population decreased from 2011 (81,705) to 2012 (70,544; Figure 9). Raw count data suggest the Panhandle population has declined approximately 50% since 2010. However, sightability model data from 2005 - 2012 suggest a stable to increasing trend in Panhandle mule deer numbers. Even with access to supplemental food from agricultural production, the mule deer population has been significantly affected by historic drought conditions. In fact, fawn crops have been severely affected by poor range conditions over the last 2.5 years, with estimates of only 6 fawns:100 does in 2011 and 16 fawns:100 does in 2012 (Figure 10). This is much lower than the long-term average of about 35:100 does. Fawn production is usually more stable than that in the Trans-Pecos, but over the last 3 years it has experienced extreme fluctuations. The sex ratio for 2012 was 33 buck:100 does, like 2008 and 2009 (Figure 11). Sex ratios have varied from 21 to 32 buck:100 does since post-season surveys have been initiated in 2005. Sex ratio data indicate a higher harvest rate on mule deer bucks than that in the Trans-Pecos and in most years the post-season sex ratio has been below 25 buck:100 does.

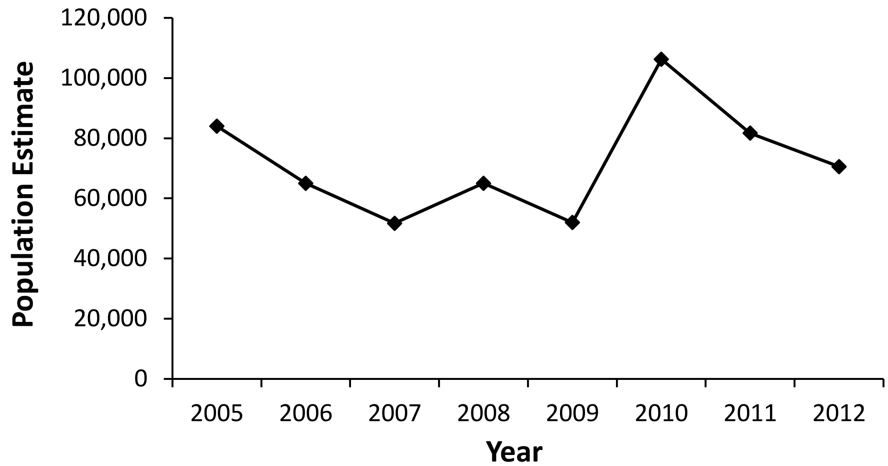

Figure 9. Trends in mule deer population estimates in the Texas Panhandle, 2005 - 2012.

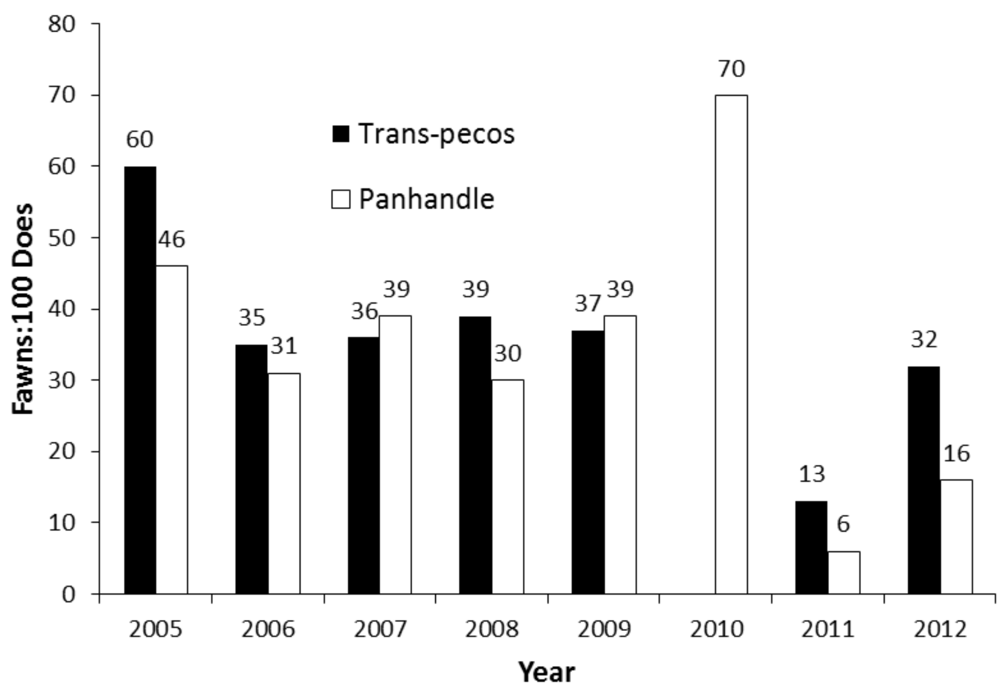

Figure 10. Trends in the number of mule deer fawns per doe in the Texas Panhandle and Trans-Pecos area, 2005 - 2012.

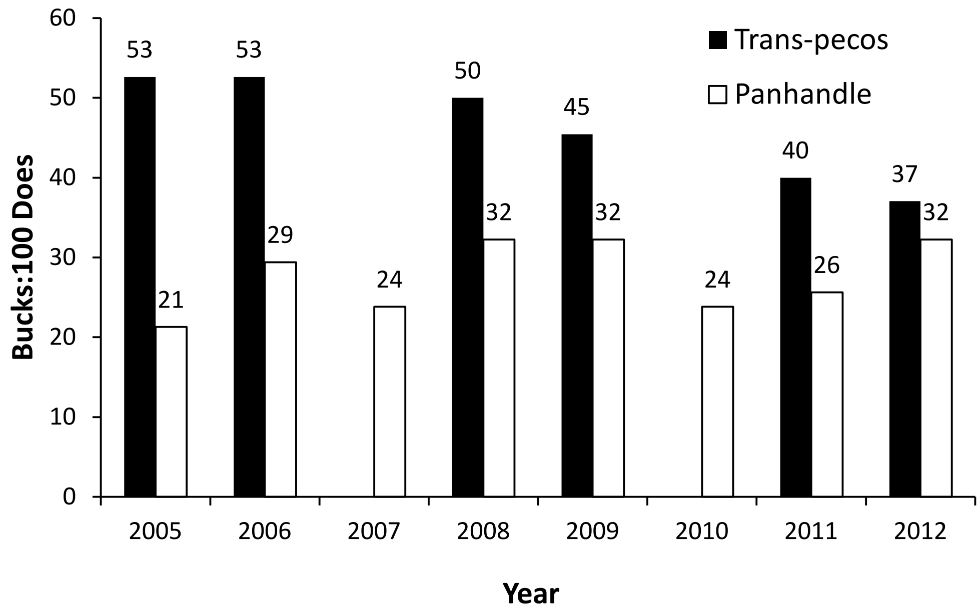

Figure 11. Trends in the number of mule deer bucks per 100 does in the Texas Panhandle and Trans-Pecos area, 2005 - 2012.

-Shawn Gray, Texas Parks and Wildlife Department

Utah

Mule deer populations in Utah had the same trends as surrounding states (Figure 12). Two pronounced peaks in populations occurred in the mid-1950's and mid-1980's. Although no reliable population

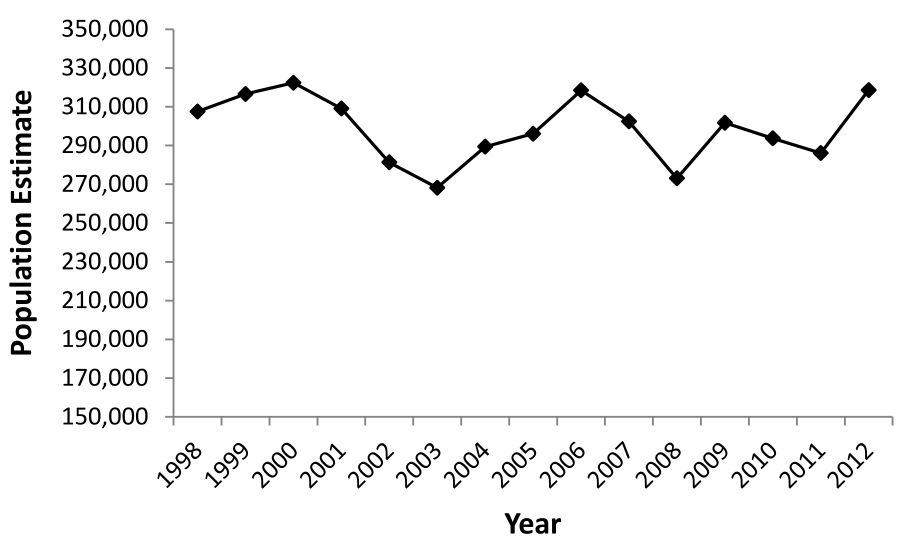

Figure 12. Estimates mule deer population in Utah, 1998 - 2012.

estimates exist there were likely close to 600,000 mule deer in Utah during those peak years. Above average winter conditions in 1992 caused a marked decline in mule deer populations in Utah. Populations fell to about 250,000. Since that time they have recovered slightly and have maintained at a level around 300,000 animals, with some weather-related declines and rebounds. Since 2002 population estimates have been derived using population models. Prior to 2002 population estimates were a best guess based on harvest data. Harvest estimates are derived from a randomized phone survey. We have a 2013 objective of 350,000 deer and a long term objective of 423,000 deer.

-Anis Aoude, Utah Division of Wildlife Resources

Washington

Washington state mule deer and black-tailed deer populations have rebounded and are doing well, with some exceptions. In north-central Washington (Okanogan, Chelan, and Douglas counties) mule deer seem to be at the capacity that the habitat will support and continue to respond positively to habitat improvements when they occur. Mild to average winters the last 3 years allowed for better over-winter survival and strong young of the year recruitment. In the northeast, mule deer numbers have climbed slightly. More habitat enhancement (e.g., prescribed burns, thinning) is being focused on public lands that would benefit mule deer in the Northeast. The Palouse, southeastern Blue Mountains, and the Columbia Basin mule deer populations were all stable. Summers are a critical time of year for deer in these portions of the state. The last summer in these 3 areas have been dry and hot. Wildfires have affected habitat slightly to benefit mule deer by setting back succession and promoting early successional species. South-central mule deer populations (Yakima and Kittitas counties) experienced a slight resurgence after recent declines attributed to hair loss caused by exotic lice. Deer numbers were still below what they were prior to the occurrence of the hair loss. The mule deer/black-tailed deer transitional populations along the Columbia River gorge on the state's southern border were stable, with harvest and post-hunt buck numbers responding to more restrictive hunting season structures that were implemented recently. Black-tailed deer in western Washington were stable. Some localized segments of the population still struggle with hair loss as well as less than ideal habitat conditions. There is still potential to improve black-tailed deer numbers if private and public forests were managed for an increase in early successional habitat.

-Jerry Nelson, Washington Department of Fish and Wildlife

Wyoming

Mule deer populations throughout Wyoming have generally declined since the early 1990s (Figure 13). It was apparent, given declining production of mule deer fawns starting in the late 1980s, that some populations were responding in a density-dependent fashion to decreasing habitat availability and/or quality. Over the past 30 years, fawn productivity, on average, has decreased statewide by about 20% and has been below 65 fawns:100 does 12 times. Throughout Wyoming, mule deer populations have declined by an estimated 168,000 (31%) mule deer since 2000. After the 2011 hunting seasons, it was estimated there were 376,000 mule deer in the state. This is 24% below the statewide objective of 564,650 mule deer.

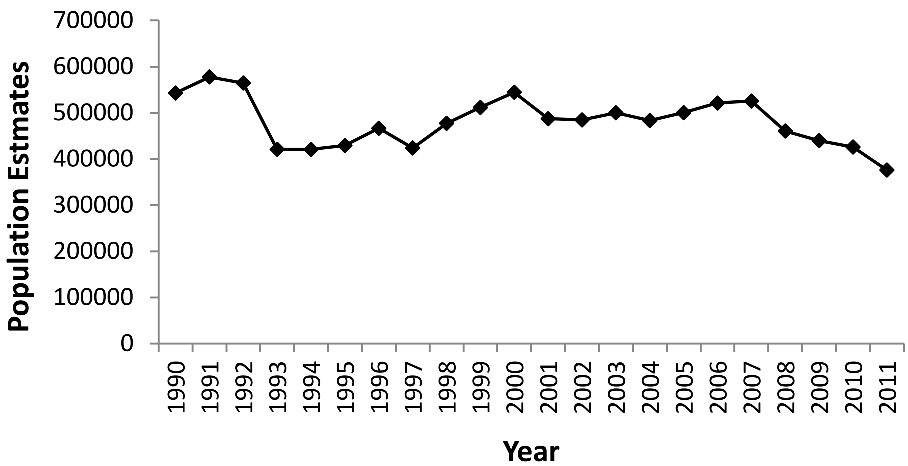

Figure 13. Trends in the Wyoming statewide mule deer population estimate, 1990 to 2011.

-Daryl Lutz, Wyoming Game and Fish Department

Yukon

There has been no formal inventory work on mule deer in Yukon. Trends in abundance and distribution are monitored primarily through sighting and motor vehicle collision reports. Numbers and distribution have generally been on the upswing since first reports in the early 1920's but there are still likely fewer than 1,000 territory-wide. Following a recent decline in 2008 - 2009, believed to be the result of harsh winter conditions, numbers have been rebounding and deer are more commonly observed in the northern part of their distribution.

The first deer hunting season was implemented in 2006. Licensed hunters in Yukon must apply for a male-only permit through a lottery system. Interest in the deer hunt continues to be high with 400 to 500 hunters applying for 10 permits issued each year. As of 2010, 2 additional permits have been available annually to young hunters. First Nation beneficiaries are entitled to harvest deer under their subsistence rights as of the effective date of their settled final agreements. The licensed harvest in 2012 was 4, relatively consistent with the annual licensed harvest ranging between 4 and 8 deer since the hunt was initiated.

-Rob Florkiewicz, Yukon Department of Environment

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