HAUB SCHOOL OF ENVIRONMENT AND NATURAL RESOURCES

EVALUATING THE ROLE OF HARVEST, DEMOGRAPHY AND CHANGING ENVIRONMENTS ON HORN SIZE OF MOUNTAIN SHEEP

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TABLE OF CONTENTS

HARVEST OF WILD POPULATIONS

Hunting of wild populations has been an important part of human existence since the beginning of our species. In North America, hunting has a long history as a fundamental component of wildlife management. Following the exploitation and near extirpation of many wildlife species in the 1800s, biologists, managers and sportsmen developed a set of principles that allowed them to not only sustainably harvest wild game, but also to return many of the nearly extinct populations back to robust numbers. This body of principles, better known as the North American Model of Wildlife Conservation, recognized hunting as the cornerstone of wildlife management, and is arguably one of the most successful sets of tools used for the conservation and management of wild species throughout the world.

Beyond its importance as a tool in wildlife management, hunting also provides one of the largest sources of funding for management and conservation of both game and non-game species in North America. Hunting generates billions of dollars each year through federal taxes that directly benefit the conservation and management of wildlife and their habitat throughout North America.

Without the efforts of early sportsmen and anglers in developing the North American Model of Wildlife Conservation, and the continued monetary contributions of both hunters and anglers today, many of our wild populations and the habitat upon which they rely likely would no longer exist.

SELECTIVE HARVEST AND HARVEST-INDUCED EVOLUTION

Although harvest remains a fundamental part of conservation and management of wild populations, there has been concern recently over unintended consequences of selective pressures that may result from current harvest strategies. The idea that selection for specific sizes, behaviors or characteristics of wild animals can cause an evolutionary change in those characteristics through time has garnered increased interest and concern among both researchers and the public over the past two decades. Indeed, there can be evolutionary changes through time when harvest pressure is both highly selective and intensive, including: reduction in the average body size of a population, changes in the size of horns and antlers, increasingly early sexual maturation, and changes in behaviors such as courtship and foraging. Yet, the degree of selectivity and intensity necessary to produce such evolutionary changes remains unclear in most instances.

In ungulates, the evolutionary effects of selective harvest pressure typically are assessed through changes in the size of horns and antlers through time. Research on this subject is still relatively limited, but there is evidence that harvest can cause changes in the size of horn-like structures. The mechanisms, however, behind these changes have not been identified in most instances. The majority of the work on this topic has been focused on a single population of bighorn sheep found on Ram Mountain in Alberta, Canada. In this particular population, harvest has resulted in a genetically based reduction in the size of horns through time. The results of this research represent an important step forward in understanding the effects that selective harvest can have on the size of horn-like structures; however, this population possesses several unique characteristics that make extrapolating the results from Ram Mountain to other populations and species potentially problematic. For the majority of the study period, harvest of bighorn sheep on Ram Mountain was regulated based solely on a size requirement, with no limit to the number of animals that could be harvested each year. During most of

the study, males had a 40% probability of being harvested during the year in which they reached legal size. The high degree of both harvest selectivity and intensity of the population on Ram Mountain almost certainly contributed to the genetic change in the size of horns through time.

Despite the limited generality of the Ram Mountain study, research results from this population are often used by both the public and researchers to suggest that management strategies throughout North America are causing irreversible evolutionary changes to the size of horns and antlers through time. In reality, harvest of most populations and species of big game throughout the rest of North America does not occur at the same level of severity as the harvest pressure that existed on Ram Mountain when a genetic change in horn size was detected, thereby calling into question the selective role of harvest practices more broadly. Public perception of harvest is constantly changing, and the idea that selective harvest is causing changes at the population level has increased in popularity. Nevertheless, if current harvest practices are causing declines in the growth of hornlike structures in ungulates, managers and biologists would want to know and adjust harvest practices accordingly. More research is necessary on a broader spatial scale (i.e., a scale that encompasses populations that are more representative of how we harvest most populations of wild game), before a true assessment can be made of how harvest selection truly influences the size of horns and antlers through time.

ADDRESSING QUESTIONS OF SELECTIVE HARVEST IN MOUNTAIN SHEEP

Mountain Sheep as a Study System

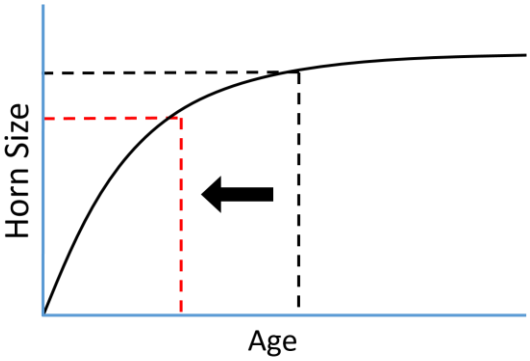
Understanding how selective harvest influences ungulates is a highly controversial issue that can be difficult to address fully, especially because changes to horn and antler sizes in response to harvest can take decades to manifest. Furthermore, other factors such as age and nutrition can override genetic contributions to horn and antler size and can potentially confound results if not properly accounted for. Age plays the most important role in size of horn-like structures, particularly in species that cumulatively grow horns throughout their lifetime. Additionally, nutritional condition during different stages of life can have lifetime consequences for horn size, and individuals that experience poor environmental conditions may have smaller horns than individuals of the same age that are not limited by poor resources.

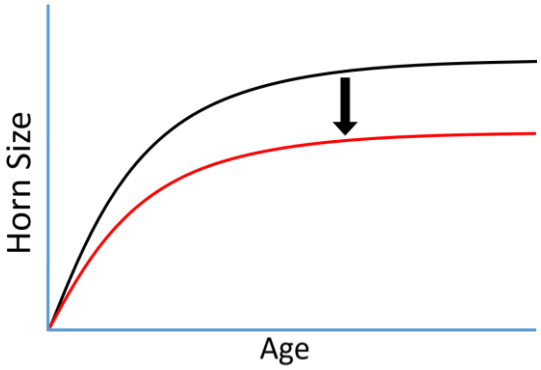
Mountain sheep represent an ideal system to test the question of how selective harvest influences horn size for two reasons. First, the presence of horn annuli allows biologists and managers to estimate the age of mountain sheep relatively accurately. These age data are critical for assessing changes in the age structure of the population, which can result in population-level changes in horn size through time that may mimic trends caused by selective harvest. Second, harvest of mountain sheep is highly regulated, and harvested individuals must be checked in to state and provincial agencies. In many areas, biologists and managers throughout North America have collected both horn measurements and age data from wild sheep for decades. These records represent one of the few sources of empirical data that are currently available for testing the question of selective harvest at the time scale on which evolutionary processes occur in a long-lived species.

Using harvest data from four subspecies of mountain sheep (Rocky Mountain bighorn sheep, desert bighorn sheep, Stone's sheep and Dall's sheep) we will evaluate the following hypotheses for explaining how harvest influences the size of mountain sheep horns through time:

Demographic Shift Hypothesis

Through intensive removal of males in a population, there will be a shift in the overall age structure through time. Young males will become more common than old males in the population, and the mean age of harvested males will decrease through time. As a result, average horn size of the population will decrease. The shift in horn size of the population will occur solely because of the young age of harvested animals, and the mean horn size of individuals within age classes will not change through time.



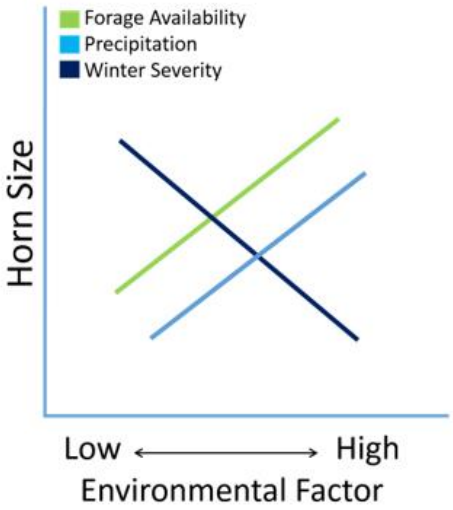


Selective Harvest Hypothesis

Selective harvest that removes fast-growing and large-horned males will favor the persistence of males with slow growing and small horns in a population. Over time, horn size relative to age class will become smaller as individuals with large horns are removed from the population.

Environmental Effects Hypothesis

Environmental conditions during different stages of life will influence horn size of males. Forage availability, precipitation and winter severity all influence the nutritional condition of an animal. Males that experience poor nutritional conditions (low precipitation, low forage availability and high winter severity) will have smaller horns than males of the same age that experience better nutritional condition.

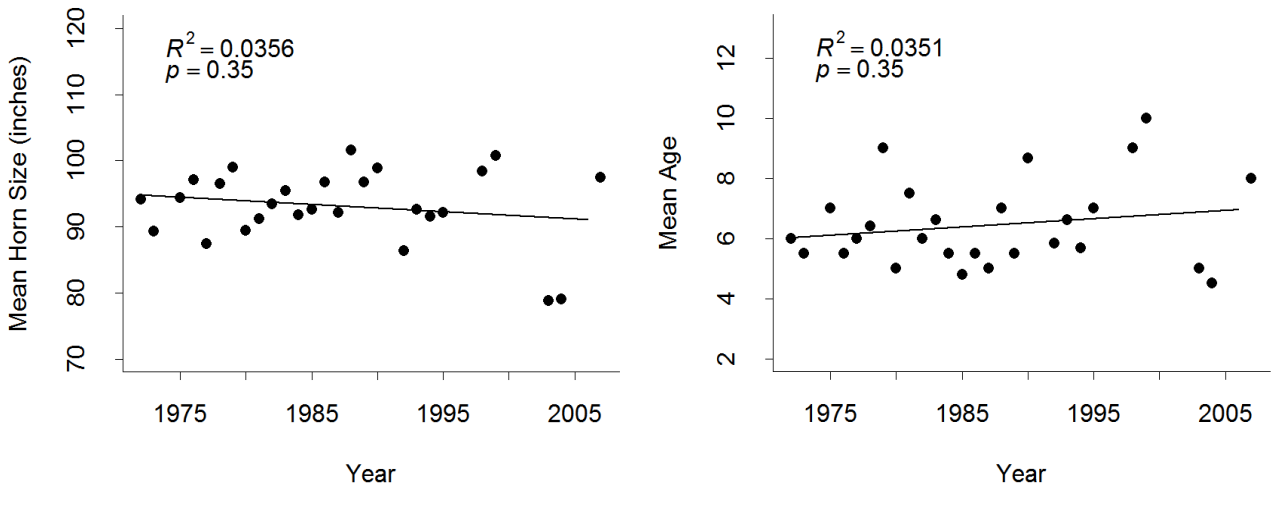


PRELIMINARY RESULTS

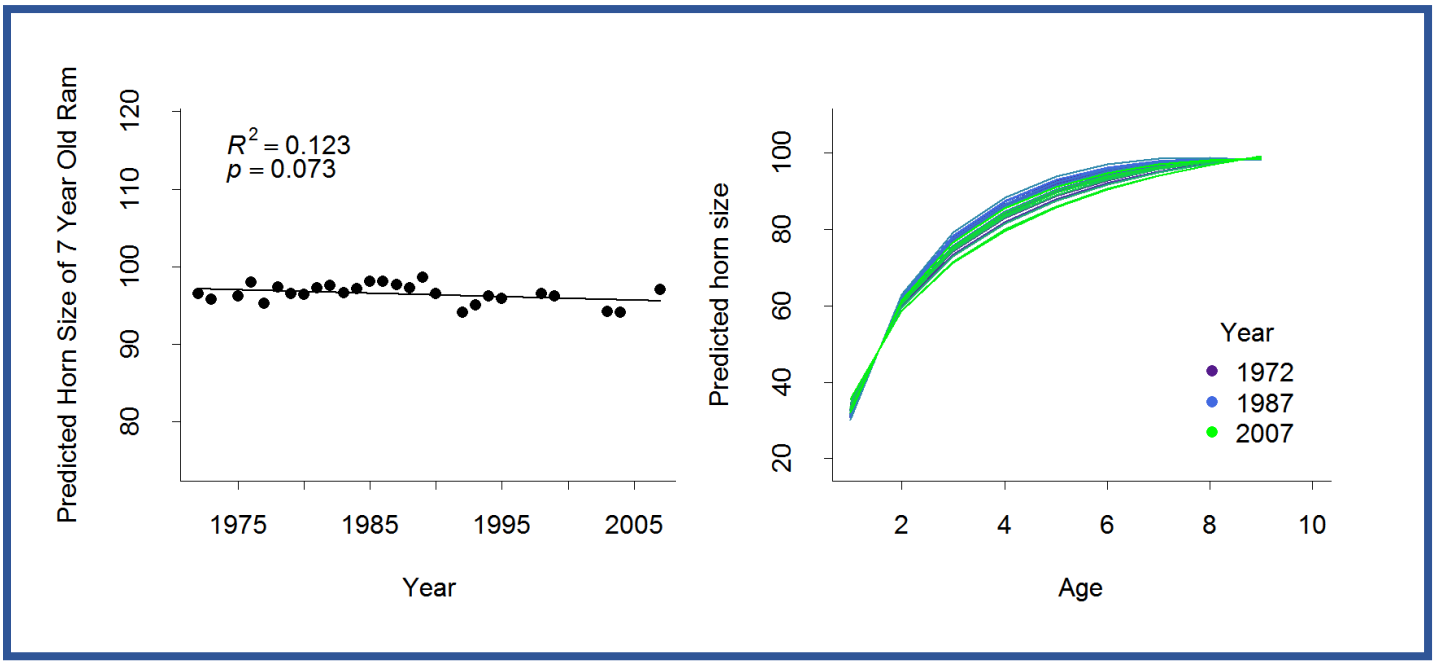
Preliminary analysis of harvest data from 171 hunt units in 11 states throughout western North America revealed 72% (n= 123) of hunt units did not exhibit changes in horn size, after accounting for age, over the past 45 years. Furthermore, of the 48 hunt units that did show a temporal change, 58% (n=28) of those hunt units were declining, whereas 42% (n=20) exhibited increases in horn size through time.

In Wyoming, where sample size for individual hunt units typically was very large, three of the twenty hunt areas we examined exhibited age-specific changes in horn size through time. The largest decrease in horn size in Wyoming was in Hunt Unit 9, with a 2.5" decline in horn size from 1970 – 2015. The largest increase in horn size in Wyoming was 2.8" in Hunt Unit 19 from 1970 – 2015.

Some hunt areas did not exhibit changes in horn size or changes in age at the population level, but did show changes in the size of horns of specific age classes. Accounting for age is critical when addressing the question of how harvest influences size of horns through time, because evaluating population averages alone may not tell the whole story. For example, many populations did not show a change in average horn size or average age through time, but did exhibit changes in horn size of individual age classes.



Average horn size (left) and average age (right) of males harvested in the Ram-Shunda Sheep Management Area from 1972 – 2007. Ram-Shunda SMA is located just east of the Canadian Rockies in Alberta, Canada. Neither average horn size nor average age of harvested animals changed significantly through time.

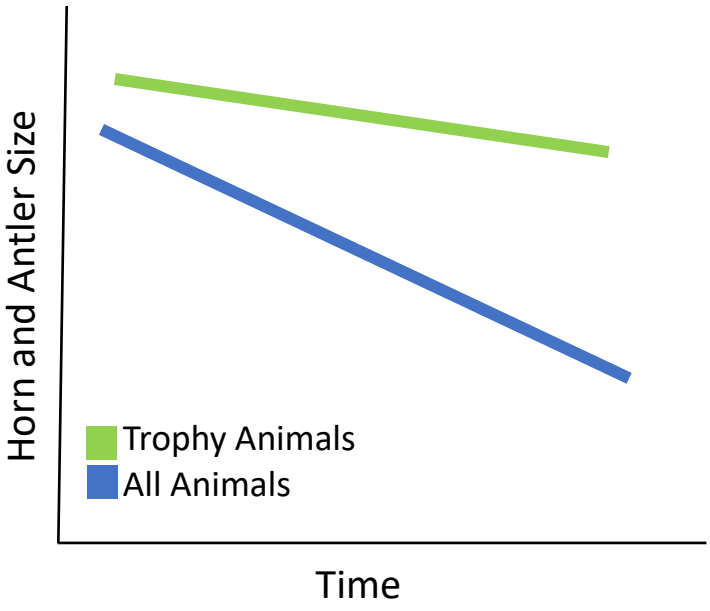


Horn size of 7-year old males (left) and the annual horn growth (right) predicted from a mixed effects model in the Ram-Shunda Sheep Management Area in Alberta. Overall, this SMA exhibited a 1.5" decrease in horn size of 7 year old males from 1972 – 2007.

ASSESSING LONG-TERM TRENDS IN UNGULATE SPECIES

Harvest records of mountain sheep are a valuable tool for assessing long-term trends in the size of horns, and these records are one of the few sources of empirical data that exists for testing the question of how harvest influences the size of horns and antlers through time. The Boone and Crockett Club, the first records program in North America, was created over a century ago to promote conservation and the ethical and sustainable management of one of our greatest natural resources – wildlife. To this day, that goal remains the foundation of numerous records programs throughout North America, and because of the diligence and enthusiasm of the individuals that created records programs, decades of measurement data exist for most species of big game that are harvested in North America. Consequently, the measurements of trophy animals kept by records programs may be one of the most robust and valuable tools available for understanding how harvest influences horn and antler size.

There has been recent criticism, however, of the effectiveness of trophy record books for assessing changes in the size of horns and antlers through time. This criticism stems from the idea that trophy record books are inherently providing truncated samples (i.e., they are limited by a minimum size requirement for entry). If horns and antlers must reach a minimum size to be entered into a record book, the trends seen in record books may be underrepresenting the trends that actually are occurring in populations that include a wider range of horn and antler sizes. A minimum size requirement for entry will mean that all individuals have to be at least a certain size, and even if there are changes through time, the minimum size that all animals must attain to be recorded in a record book may dilute the trends seen through time.



Expected trends in horn and antler size of trophy animals (green) and all animals (blue) of a population if record books do not provide a valid way to assess change through time.

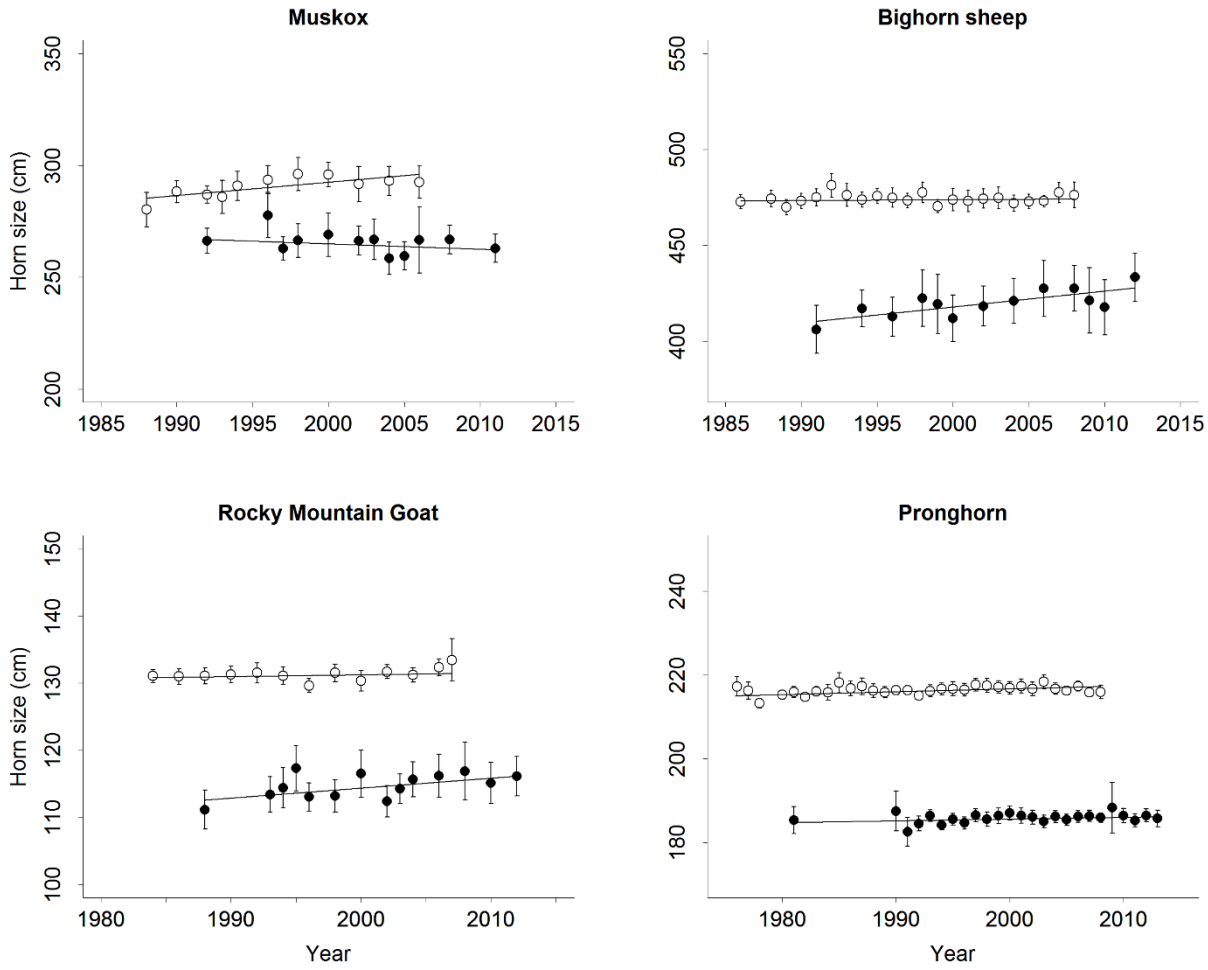
Trophy record books represent one of the best sources of data for testing the effects of harvest on the size of horns and antlers because they are the longest-standing source of measurement data for horns and antlers that exist anywhere. To understand the usefulness of trophy record books for assessing trends in the size of horns and antlers through time, we will evaluate the prediction that lower requirements for entry into a record book (i.e. a record book that includes a wider range of horn and antler sizes; Pope and Young Record Book) will indicate a stronger temporal trend than record books with higher requirements for entry (i.e., a record book that includes a narrower ranges of horn and antler sizes; Boone and Crockett Record Book).

Preliminary results

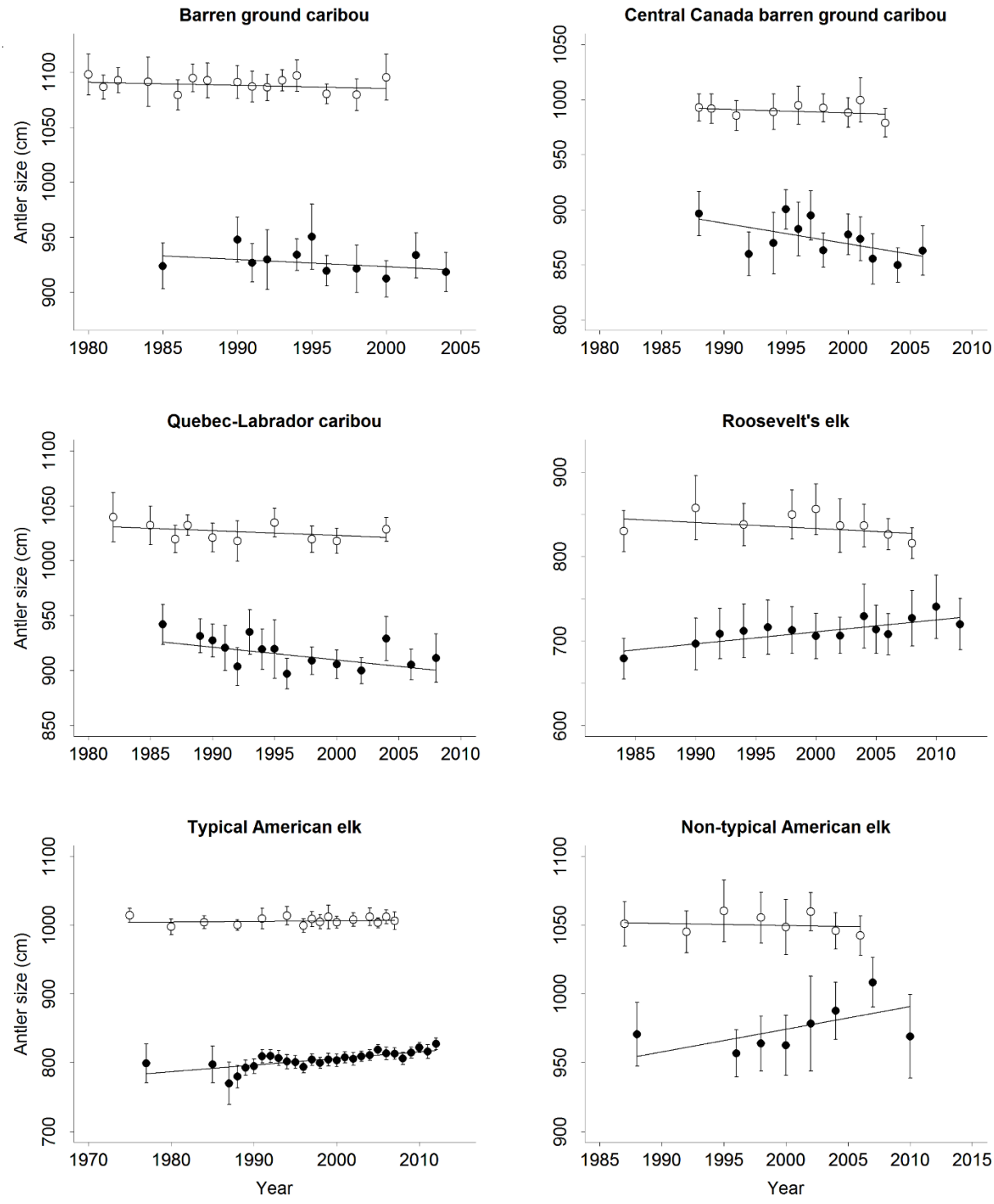
When we compared trends in the size of horns and antlers of two different record books (Boone and Crockett Record Book and Pope and Young Record Book), we found that five of the sixteen categories differed in the direction and magnitude of temporal trends (non-typical white-tailed deer, typical American elk, Roosevelt's elk, muskox and bighorn sheep).

Our prediction that a record book with lower minimum entry requirements (Pope and Young Club) would exhibit trends of greater magnitude through time than a record book with higher minimum entry requirements (Boone and Crockett Club) however, was only supported in three of those trophy categories (typical American elk, Roosevelt's elk and bighorn sheep). Furthermore, although we did observe a divergence in some categories, over two thirds of the trophy categories that we tested did not show significant differences in trends between the two record books. The majority of categories did not differ, which suggests that trends evident in trophy record books may accurately represent trends that are occurring across a broader range of age and/or size classes, and therefore may provide a valid tool for assessing range-wide changes through time.

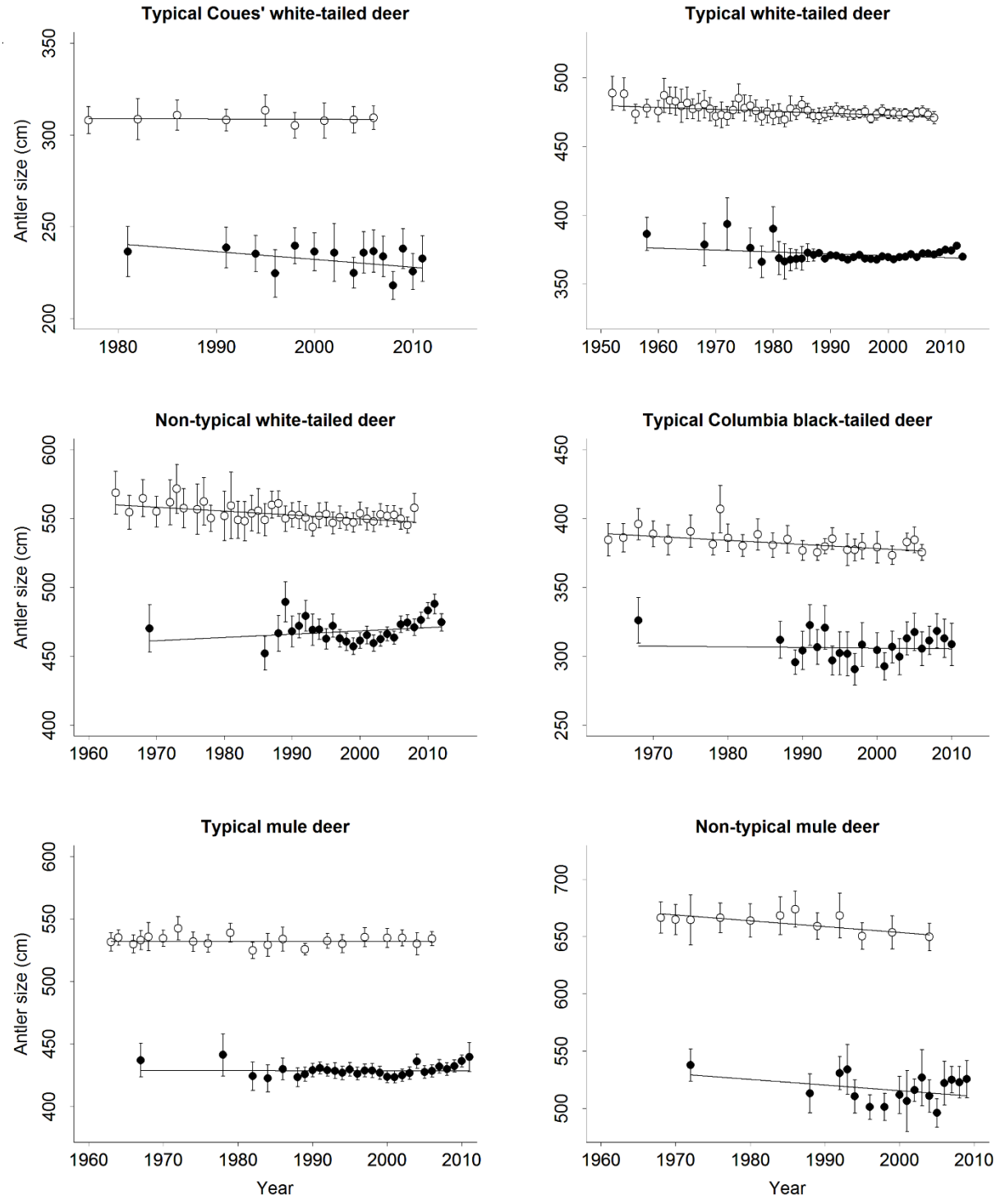
As one of the longest-standing sources of data for large game that are harvested in North America, trophy record books provide a wealth of information, and their potential usefulness as a tool for assessing the effects of management strategies and conservation success was a primary goal of the founders of the records programs. These record books contain information that spans a vast range of spatial and temporal scale and that may indicate how horns and antlers of different species are changing through time. Given their truncated nature, however, care must be taken when interpreting any observed patterns in those data.



Trends in the size of horns in the Boone and Crockett record book (white) and Pope and Young record book (black) for muskox, bighorn sheep, Rocky Mountain goat and pronghorn through time. Trends in horn size of muskox and bighorn sheep are different between record books.



Trends in the size of antlers in the Boone and Crockett record book (white) and Pope and Young record book (black) for barren ground caribou, central Canada barren ground caribou, Quebec-Labrador caribou, Roosevelt's elk, typical American elk and non-typical American elk. Trends in antler size of Roosevelt's elk and typical American elk are different between record books.



Trends in the size of antlers in the Boone and Crockett record book (white) and Pope and Young record book (black) for typical Coues' white-tailed deer, typical white-tailed deer, non-typical white-tailed deer, typical Columbia black-tailed deer, typical mule deer and non-typical mule deer. Trends in antler size of non-typical white-tailed deer are different between record books.

MOVING FORWARD

Preliminary results from the analysis of mountain sheep horn size using harvest records are just the beginning of our efforts to understand how harvest influences horn size through time. Currently, we have only assessed if there have been age-specific changes in horn size, and not what underlying factors might be responsible for those changes. Our next steps are to begin to understand how environmental conditions, including population size, forage quality, and climatic conditions during different stages of life influence patterns of horn growth and size.

Given the growing body of both popular and scientific literature that currently exists on selective harvest in ungulates, it is easy to assume that the harvest practices currently adopted by management agencies throughout North America are causing detrimental changes at the population level. Yet, from our preliminary analyses we have seen that the overwhelming majority of hunt areas in North America have not shown changes in horn size through time after accounting for age. Additionally, only 16% of all hunt units showed age-specific declines in horn size, while 11% exhibited age-specific increases in horn size.

Addressing questions of selective harvest is a critical step in communicating both the effectiveness and value of management of big game species throughout North America to the public. Additionally, we can use these results to identify areas where there are population-level changes occurring as a result of harvest, which will provide the opportunity to reconsider harvest practices for those areas should maintenance of horn size be a management objective.

Alex May

Preliminary results from the analysis of trophy record books indicates that record programs are most likely collecting data that can be a useful tool for assessing changes in the size of horns and antlers from trophy animals through time. As of right now, our results only include sixteen trophy categories; however, we are currently incorporating almost 10 more years of data from Boone and Crockett into the analysis. The inclusion of these new data may allow us to better test our prediction that low requirements for entry into a record book will result in the detection of trends of greater magnitude when compared with record books with high requirements for entry. Additionally, we will include a third trophy record book, Safari Club International, into this analysis. The inclusion of an additional record book will allow us to increase sample size and to compare trends in the size of horns and antlers of three record books, all with different ranges of horn and antler sizes

Harvest plays a critical role in the management and conservation of wild populations. Understanding how harvest practices influence populations is essential for maximizing the effectiveness of wildlife management programs throughout North America.

RESEARCH TEAM

Tayler LaSharr

Tayler LaSharr is a MSc student working under the direction of Kevin Monteith on this project. Tayler grew up in Phoenix, AZ and attended the University of Arizona where she obtained a BSc in Natural Resources with an emphasis in Conservation Biology and a minor in Chemistry in May of 2015. During her time at the University of Arizona, she studied life history tradeoffs in Western and Mountain Bluebirds and the effects of aggression in closely related species on habitat and range dynamics. In the summer of 2015, she began work in the Wyoming Cooperative Fish and Wildlife Research Unit as a technician on a fawn survival study of mule deer in the Wyoming Range. In the fall of 2015, she began work on her own research, which focuses on understanding the effects of harvest on horn size of mountain sheep, identifying the relevancy and use of trophy record books to assess biological trends, and understanding the influence of nutrition and the environment on annual growth of horns in mountain sheep.

Kevin Monteith

Kevin Monteith is an Assistant Professor of the Haub School of Environment and Natural Resources and the Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology at the University of Wyoming. After receiving his BSc and MSc in Wildlife and Fisheries Sciences from South Dakota State University, he went on to obtain his PhD in Biology from Idaho State University in 2011. Kevin's research program is focused on integrating nutritional ecology with intensive field studies of large ungulates to elucidate the mechanisms that underpin behavior, growth, reproductive allocation, predator-prey dynamics, and ultimately, the factors affecting population growth. Kevin and his graduate students are currently conducting research on most of Wyoming's large ungulates; topics are centered on establishing a protocol for habitat-based, sustainable management of ungulate populations, while investigating the effects of predation, habitat alteration, climate change, migration tactics, and novel disturbance through the lens of nutrition.

Ryan Long

Ryan Long is a large-mammal ecologist with over a decade of experience in mammalian research and conservation. Ryan received his PhD in biological sciences studying the effects of climatic variation on behavior of North American elk, and worked as a post-doctoral research associate at Princeton University under Dr. Rob Pringle prior to joining the faculty of the University of Idaho in 2014. His research is focused on understanding how the interplay between individual behavior and physiology scales up to influence the dynamics of wildlife populations in heterogeneous environments. He uses the mechanistic principles of nutritional ecology and bioenergetics as a framework for asking questions about the physiological causes and consequences of animal behavior in complex landscapes. His study species range from elk to elephants and from bushbuck to buffalo, and he and his students currently work at field sites in North America and Africa. Their research combines a suite of field and modeling approaches, and the effective integration of empirical and theoretical methods is at the core of their research paradigm.

Jim Heffelfinger

Jim Heffelfinger is a Certified Wildlife Biologist who graduated with a Master's Degree from Texas A&M University – Kingsville and went on to work for the US government, state wildlife agencies, universities, and the private sector. Jim has coauthored 200+ magazine articles, scientific papers, book chapters, and TV scripts. He is a Boone & Crockett Professional Member, an adjunct professor at University of Arizona, and Chairman of the WAFWA Mule Deer Working Group representing 23 western states and Canadian provinces. He has received the 2011 "Wallmo Award" given to the leading mule deer biologist in North America and the 2009 "Professional of the Year" award from the Mule Deer Foundation. Jim is currently the Wildlife Science Coordinator for the Arizona Game & Fish Department and works closely with the student chapter of The Wildlife Society at the University of Arizona.

Vernon Bleich

Vernon Bleich received BS and MA degrees from California State University Long Beach, and a Ph.D. from the University of Alaska Fairbanks. Now retired, he was an employee of the California Department of Fish and Game for 34 years where he acquired vast knowledge and expertise regarding the distribution, ecology, life histories, and habitat requirements of mule deer, bighorn sheep, and mountain lions occupying arid ecosystems. Vern is also recognized as an expert on the Stephens kangaroo rat, Amargosa vole, Sierra Nevada bighorn sheep, and bighorn sheep inhabiting the peninsular ranges of California, all of which have been designated as endangered by the federal government. He served as a member of the Peninsular Bighorn Sheep Recovery Team and the Sierra Nevada Bighorn Sheep Science Team, and oversaw preparation of the Sierra Nevada Bighorn Sheep Recovery Plan. He currently holds an appointment as Research Professor in the Department of Natural Resources and Environmental Science at the University of Nevada Reno. In recognition of his many contributions to wildlife science and conservation, Vern has been the recipient of numerous awards from academia, conservation organizations, and professional societies.

R. Terry Bowyer

R. Terry Bowyer earned his B.S. and M.S. from Humboldt State University and his Ph.D. from the University of Michigan. He has 37 years of experience as a professional Wildlife Ecologist, having held professorial positions at Unity College, the University of Alaska Fairbanks (UAF), and Idaho State University (ISU). He currently is a Senior Research Scientist and Professor Emeritus of Wildlife Ecology in the Institute of Arctic Biology at UAF. Dr. Bowyer has supervised 3 postdoctoral fellows, and seen 33 graduate students to the successful completion of their degrees. His research is focused on the ecology and behavior of ungulates, and he has published 215 papers in the scientific literature. He was the Outstanding Researcher at UAF and ISU. Dr. Bowyer received the C. Hart Merriam Award from the American Society of Mammalogists, the Distinguished Moose Biologist Award from the North American Moose Conference, the O.C. Wallmo Award from the Western Association of Fish and Wildlife Agencies, and won six Outstanding Publication Awards from The Wildlife Society. He is a Fellow of the American Association for the Advancement of Science and The Arctic Institute of North America, and Fellow and Honorary Member of The Wildlife Society.

Paul Krausman

Paul Krausman was raised in North Africa, graduated from Dreux American High School, Dreux, France, and has lived and worked in arid countries worldwide. He obtained his B.S. degree in zoology from The Ohio State University, his graduate degrees in wildlife from New Mexico State University (M.S.) and the University of Idaho (Ph.D.), and was awarded the Leopold Medal from The Wildlife Society. Krausman was on the faculty of Auburn University, the University of Arizona, the University of Montana, and has taught in India and Portugal. His research interests included large mammals and how they were influenced by anthropogenic factors, international wildlife, educating the next generation of wildlifers, his graduate students, undergraduate teaching, and The Wildlife Society. He most recently retired as the Boone and Crockett Professor at the University of Montana. Paul is currently living in an Island in the Pacific and is the Editor-in-Chief of the Journal of Wildlife Management and the Johns Hopkins University Press and The Wildlife Society Wildlife Conservation and Management Book Series.

Justin Shannon

Justin Shannon graduated from Brigham Young University in 2007 with a bachelor's degree in Wildlife and Wildlands Conservation. In 2008, he graduated with his Master's degree from the same school, where he researched survival rates and habitat use of translocated bighorn sheep. Justin has been employed by the Utah Division of Wildlife Resources for the past nine years. He started out as wildlife biologist in the central and southeast portions of the state. He was quickly promoted to a regional wildlife manager, where he spent time managing cougars, bears, mule deer, and other wildlife. Justin currently serves as the big game program coordinator and is responsible for managing big game species throughout Utah. He also serves on the Leadership Development Committee for the Utah Division of Wildlife Resources, and specializes in working with the public on complex wildlife-related issues. Justin is also involved with the Wild Sheep and Mule Deer Working Groups, which are committees sponsored by the Western Association of Fish and Wildlife Agencies. These committees promote responsible management and conservation efforts for deer and bighorns in the west.

THANK YOU!

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