

Big Game in the Era of Climate Change

by Kaush Arha, Boone and Crockett Club, with research assistance from Jeffrey Wright and thoughtful reviews by Jack Ward Thomas, Paul Krausman, Hal Salwasser, Val Geist, Steve Mealey and Robert Model

The rebuilding of the country's big game population is the great American conservation success of the 20th century. Today's challenge is sustaining this legacy in the face of climate change. The fundamental question big game face is whether they will have the freedom to move and adapt to altered conditions, given the constraints that humans place on the landscape. Populations that are isolated, unable to adapt or barred from moving to suitable habitats will certainly decline and may face extinction.

Climate change will affect big game food resources, life-history events and habitat range.

Climate change will alter plant phenology

The timing of plant life-cycles (phenology) is critical to big game: The most nutritious plant growth must be available when demands on the animals' energy are greatest. For example, in order to recover from winter weight loss and have sufficient energy to nurse their young, most ungulates (e.g., deer, elk and moose) have evolved to give birth when forage greens in the spring. Disruptions in the coincidence of food availability and life-history events such as migration and birthing can be damaging to a large mammal's balance of energy.

Over the past decade, drivers of plant life-cycles — the onset and length of warm seasons — has changed markedly in the temperate latitudes of North America. Of nearly 1,600 plant and animal species studied, 60 percent exhibited shifts in distribution, phenology or both over a time horizon that varied from 20 to 140 years. If big game are not able to keep pace with changes in plant phenology, the costs — while not precisely predictable — will be high.

Climate change will cause shifts in plant ranges

Projected changes in precipitation and temperature could cause dramatic shifts in the composition, distribution and functions of terrestrial ecosystems, thus altering availability of big game food and cover. As warm-weather species invade or as sub-dominant species displace dominant species, plant communities will change. Boreal forests may invade present tundra, while temperate forests and grasslands may move toward the north. Deserts are expected to expand northward. Across large portions of western mountain ranges, alpine habitats are likely to diminish. Some scientists contend that the rate of climate change will outstrip the migration rates of most plants, leaving slowly migrating species to go extinct in their present environment.

Climate change will cause changes in temperature and precipitation

Rising temperatures will increase energy demands on most cold-adapted large mammals. Unlike bovids such as goats and sheep, cervids (e.g., deer, elk, caribou and moose) evolved in cooler climates. Rising air and water temperatures will stress these species' thermo-regulatory systems and cause them to expend more energy in moderating their body temperatures.

Arctic sea ice is now melting faster than most models had projected, drastically altering the behavior, condition and composition of sea-ice-dependent, large-mammal communities, including those of polar bears, walrus and seals.

Climate change will increase pests and pathogens

Warming temperatures will cause the range and virulence of pests and pathogens infesting big game populations and habitats to expand. Warm summers abet growth rates. Mild winters enhance larvae survival. While other plants and animals adapt to changing climatic conditions more slowly, pests and pathogens could lead a rapid and alarming migration toward the pole.

Under a warming climate, American forests have become more vulnerable to infestations of insects such as pine and spruce bark beetles. In 2006 pine beetle outbreaks killed about five million lodgepole

pinus in Colorado — a four-fold increase from 2005. Forest die-offs following insect infestations set conditions for catastrophic fires with severe repercussions on big game populations.

Climate change will promote forest fires

Frequent, low-intensity fires improve forage quality for most big game. However, hot fires that burn large stands of timber may directly harm large mammals and render portions of their habitat unusable. As climate has warmed in recent years, forest fires in the United States, especially in the northern Rockies and the Sierra Nevada, have dramatically increased in number and intensity. In 2008, approximately 800,000 wild fires burned 68.6 million acres in the United States; over the previous four decades, annual fires were more numerous — about 1.15 million per year — but burned less area — an average of 34.5 million acres. Hot and frequent fires will combine with the spread of invasive species (e.g., cheat grass) in the Big Basin and of temperate grasses in the Arctic tundra to change those ecosystems' dominant plant species and consequently affect big game food supplies

Climate change will compound the effects of the human presence

Relocating cropland, developing alternative energy sources and migrating to more comfortable northerly climates are likely ways the nation's citizens will respond to global warming. Supported by new roads and infrastructure, these responses would fragment and damage connectivity among big game habitats and create additional barriers hindering wildlife movement.

How Big Game Will Respond to Climate Change

Big game are expected to adapt to global climate change as flatland-dwelling mammals have done during warming periods for eons: by moving northward or to higher elevations. Availability of suitable habitat and barriers to animals' movement could limit the success of these migrations.

The present warming trend is markedly different from others occurring since the last ice age in two important ways: The current rate of warming is much faster, which increases pressure on big game populations to adapt quickly; and the pervasive human presence riddles the landscape with development that not only displaces animal habitats but also bars animal movement.

Big game species are likely to respond to climate change in the following ways:

Mountain goats and sheep, bears, musk ox and caribou

Species relatively less mobile and with highly specialized habitat needs are most vulnerable to the effects of climate change. Mountain goats are among the most threatened species because of their fidelity to alpine habitat and their limited capacity to disperse to other environments. The fast disappearance of their favored climes could force goat populations to compete for increasingly isolated, fragmented and diminished habitat areas. Consequently, goats would suffer declining birth rates, increased predation, enhanced vulnerability to disease and intensified competition from wild and domestic sheep.

Many populations of mountain sheep are similar to goats in their restrictive habitat requirements and their limited ability to disperse. Though their habitat zone is larger than that of mountain goats, mountain sheep will face similar pressures, including heightened susceptibility to diseases transmitted by domestic sheep.

Human development already limits mountain goats and mountain sheep to "islands" of suitable, high-elevation habitats. Without continual management efforts, it is probable that isolated mountain goat and mountain sheep populations will vanish as climate change alters habitat conditions.

As warmer oceans reduce their hunting and foraging opportunities, wildlife habituated to Arctic sea ice could weaken and starve. Although polar bears have high dispersal abilities, when confronted with the steady shrinking of their specialized, sea-ice habitat, they are highly vulnerable to climate change.

Under climate change, interactions and competition between polar bears and brown bears will become more frequent. Black bears and brown bears are opportunistic feeders and wide-ranging generalists, but for eons they have closely tied their denning and reproduction to seasonal changes in the length of daylight hours. It is not known if these animals will modify timing of their breeding, inactivity and reproduction in response to changes in weather and consequent alterations in plant phenology. For grizzly bears, a warming climate could diminish important food sources, including whitebark pine and cutworm moths.

Although highly mobile, caribou and musk ox populations face inexorably shrinking habitats as tundra vegetation gives way to more temperate plant types. Alterations in the composition of plant communities and increases in fire-prone conditions could reduce winter habitat and forage. Severe winter storms and weather extremes causing variable snow depth and snow crusting could deprive animals of access to forage, resulting in high over-winter mortality among caribou herds. In springtime, warmer temperatures and variable precipitation might affect caribou migration and reproduction. Expanded numbers of harassing insects could drive caribou to reduce the time they spend in feeding and lead to declining health and vigor.

The experience of musk ox under global warming will be similar to that of caribou, although their digestive tolerance for shrubs provides them a larger forage base.

Moose

Evolved to withstand severe cold and snow, moose are intolerant of warm temperatures. Studies correlate an increase in mean summer temperatures with the prevalence of disease and declines in moose populations. Warmer temperatures force moose to expend more energy on thermal regulation, depress fecundity and lower survival rates. Additionally, rising temperatures would shrink the riparian and wetland vegetative habitats that moose prefer and reduce the availability of foods comprising the highly specialized moose diet.

Moose populations are expected to shift northward, with populations in the Rocky Mountains, Great Lakes and the Northeast predicted to

decline. Extirpation of moose in some of their current habitats is likely.

Elk, mule deer, white-tailed deer and pronghorn

Highly mobile and able to use diverse habitats, elk and white-tailed deer are among the big game species least vulnerable to climate change. Rather than directly affected its consequences, the health and adaptive success of individual elk, deer and pronghorn populations will be influenced by

- pressures from human development
- barriers to movement
- presence and density of predators
- susceptibility to pathogens
- nutritional quality of newly evolving plant communities

In the short term, wetter summers may lead to increased forage production. Warmer winters may enhance access to forage and improve survival rates among elk, deer and pronghorn. But where warm winters and wet summers converge, in the absence of ecologically effective populations of predators these species' numbers could exceed the long-term carrying capacity of local conditions.

Elk are well suited to exploit habitats altered by changing weather patterns. However, predators and barriers to movement could substantially affect an elk population's survival. Changing conditions will cause elk, deer and antelope to shift their ranges northward and to develop new migratory corridors. White-tailed deer are expected to continue their westward march along riparian zones, leading to increased competition with mule deer.

Yesterday's Programs Can't Solve Today's Problems

Traditionally, efforts undertaken by state and federal agencies and private organizations to conserve big game have focused on improving productivity of seasonal habitat and enforcing hunting regulations. There is little detailed information on how climate change will affect individual wildlife populations, and wildlife management agencies have no strategies in place to assist big game facing climate change.

Existing funds are inadequate to gather needed data and to facilitate wildlife adaptations to altered conditions. New funding for wildlife conservation in a changing climate is urgently needed.

What Can be Done: Project Types

Fish and wildlife professionals recognize that they can't rely on yesterday's programs to address the consequences of global climate change. The first step toward innovation is to see clearly the broad categories within which new ideas can take shape. The following survey of project types offers that perspective.

Assessment projects

To aid big game conservation in a changing climate, each state must undertake a comprehensive assessment of its big game populations to

- identify both climatic and non-climatic factors limiting big game health and survival
- collect and analyze all existing information on big game movements and potential corridors
- determine the current status and probable future trends of productivity, diversity and connectivity in big game habitat

Computer modeling of all habitat limitations will assist in developing conservation strategies to facilitate big game adaptation to climate change.

Habitat productivity, diversity and redundancy projects

Projects enhancing habitat diversity and redundancy across landscapes will bolster big game resiliency and resistance to climate change. Robust buffer zones contribute to habitat redundancy, as do hydrological improvements, seeding and prescribed fire. Historically, western mountain states have focused on improving winter range productivity for wild ungulates; climate change may cause management agencies to shift their focus to improving spring and summer ranges.

Methods to improve big game habitat include

- reseeding native grasses, forbs and shrubs to improve forage for wild ungulates
- conducting prescribed burns to improve nutrient cycling and forage quality
- thinning overstocked forests to
 - reduce vulnerability to drought, insects and fire
 - open the forest floor to more sunlight
 - induce growth of more productive and diverse big game foods
- planting vegetation, installing fences to exclude domestic livestock and implementing other restoration measures to improve riparian habitat for cover and forage
- using mechanical means to
 - improve stream drainage and habitat cover
 - contain, reduce or remove exotic species
 - accomplish other habitat enhancements

Corridor and connectivity projects

Most big game conservation efforts have focused on identifying and improving habitat on seasonal ranges. Less attention has been devoted to identifying migratory corridors among seasonal ranges for individual populations or wildlife pathways between two or more populations.

Specific projects to improve corridors and connectivity among big game populations include.

- **redesigning fences:** Use smooth instead of barbed wire for the bottom strand and increase fence height to 18 inches to allow pronghorn to crawl under the fence.
- **seeding and planting trees:** Improve both forage and cover for wild ungulates along critical stretches of corridors. Improving habitats particularly along riparian corridors benefits other classes of wildlife as well as big game.
- **constructing overpass and underpass crossings:** Build passageways allowing wildlife to avoid roads, often the most significant barrier to big game movement.
- **securing conservation easements:** Develop agreements between state or private parties and willing landowners to allow wildlife movement across private property.

- **mitigating development:** Identify and execute proper mitigation measures, either on- or off-site, for energy, residential and other development projects that affect wildlife movement.

Habitat monitoring projects

Data derived from monitoring big game habitat productivity, diversity, redundancy and disturbance are integral to formulating management decisions. Standard monitoring protocols should be developed and monitoring schemes coordinated among all agencies and conservation groups. Widespread use of remote sensing technologies can improve accuracy and greatly reduce habitat monitoring costs.

Solutions for Big Game: A Case Study

Editor's note: Fish and wildlife professionals contending with the effects of global warming need a framework to consider the factors of a successful field project. The following case study demonstrates an approach to common project components such as goal identification, implementation barriers and costs.

Project location

Big game populations range within and across state boundaries. The Wildlife Corridors Initiative (WCI) is conducted among the 19 states that are members of the Western Governors' Association (WGA).

Background

Big game species will adapt to a changing climate principally in two ways: by moving to suitable habitats and by adjusting the physical and biochemical characteristics of offspring through the process of natural selection.

Assisting big game in adapting to climate change requires anticipating habitat shifts and identifying present and probable future wildlife corridors and barriers to big game movement. Such information does not currently exist at state or regional levels in a format that management agencies can use.

Project goals

The goal of the WCI is to increase the success of big game species adapting to a changing climate by identifying, enhancing and protecting wildlife corridors in 19 western states. Through collaboration among state and federal resource management agencies, the initial project will

- develop current, comprehensive and compatible maps
- identify present and probable future wildlife corridors
- identify present and probable future barriers to wildlife movement
- develop integrated policies and programs that permit economic development while preserving wildlife corridors

Implementation barriers

Designing and executing a wildlife corridor initiative face financial, institutional, programmatic and developmental barriers, of which financing is by far the most challenging. The WCI requires substantial effort to map and gather information in the field and to organize and coordinate numerous state and federal agencies responsible for implementing appropriate policies. Funds for this work are limited and dependent on federal financial support.

Lack of information about wildlife habitat and movement is a major barrier to protecting and enhancing wildlife corridors. Other barriers include difficulties in developing and executing coordinated policies among various state and federal agencies and problems stemming from incompatible information databases. Updated information accessible to all involved parties will facilitate establishing regional wildlife corridors spanning multiple states.

Project tasks, timeline and costs

The tasks, timeline and estimated costs for a wildlife corridor initiative spanning 19 states are outlined below.

Tasks	Narrative	Cost
Years One - Three		
Develop decision support system (DDS)	<ul style="list-style-type: none"> Enhances mapping of corridors and crucial habitat areas across western states to inform decisions on energy and transportation infrastructure and residential development \$1 million/year/state X 19 states X 3 years: 	\$57,000,000
Establish a wildlife adaptation advisory council	<ul style="list-style-type: none"> Consists of state and federal agencies, academic institutions and science-based non-governmental organizations to assess climate-change effectson wildlife and wildlife habitat \$100,000/year/state X 19 states X 3 years: 	\$ 5,700,000
Establish a regional information clearinghouse	<ul style="list-style-type: none"> Communicates information on wildlife corridors and crucial habitat \$100,000/year X 3 years 	\$ 300,000
Address habitat fragmentation	<ul style="list-style-type: none"> Uses incentives to encourage landowners to appropriately manage habitats and wildlife corridors on private lands \$1 million/year/state X 19 states X 3 years 	\$57,000,000
Encourage collaboration among working groups	<ul style="list-style-type: none"> Includes groups conducting hydrologic strategic planning, hydrologic climate modeling, water storage development and state invasive species strategies \$100,000/year X 3 years 	\$ 300,000
Total Costs		\$ 120,300,000

Conclusion

The future of big game in the United States rests on species' ability to adapt to climate-induced alterations in habitats and to stresses resulting from human manipulation of the landscape.

State and federal agencies are rich in experience and have a record of success in undertaking landscape-level resource planning and management. With federal funding assistance, states have recently completed wildlife action plans to conserve sensitive species, and a similar effort is needed to develop climate action plans to conserve big game.

The administration and Congress must again exercise historic leadership on wildlife conservation issues and develop a funding structure enabling state and federal resource agencies to manage and preserve big game in the face of global warming.