9th ICA Mountain Cartography Workshop - 2014 Banff

Thematic Map Design and the Atlas of Yellowstone

James E. Meacham
InfoGraphics Lab
Department of Geography
University of Oregon
jmeacham@uoregon.edu

© 2014 University of Oregon
Acknowledgments - Atlas

Editorial team:

W. Andrew Marcus, Senior Editor James E. Meacham, Cartographic Editor Ann Rodman, Yellowstone Editor Alethea Steingisser, Production Manager and Stuart Allan, Consulting Editor Ross West, Text Editor

Contributions by: 100+ topic experts and 30+ cartographic/GIS staff and students

Funding provided by: Yellowstone Park Foundation, Canon USA, University of Oregon, Montana State University, University of Wyoming, and individual donors

Publisher: University of California Press

© 2014 University of Oregon
The Atlas of Yellowstone is an authoritative reference.

296 pages - 9.5” by 13.5”

- topics – ranging from archaeology, history, art, to geology, geysers, bears, bison, wolves, and waterfalls
- New topographic reference maps of the region and parks
- gazetteer and index
Geographic Themes

The Atlas is organized around four interconnected geographic themes:

- *Importance of Yellowstone*
- *Interaction of Humans and Nature*
- *Yellowstone is Connected*
- *Yellowstone is Dynamic*
The Hayden Survey

Survey Routes

© 2014 University of Oregon
The Hayden Survey

Thomas Moran - Paintings

*Grand Canyon of the Yellowstone, 1871, Smithsonian*
The Hayden Survey

William Henry Jackson - Photography

Crater of Old Faithful, 1871

Teton Range from the West, 1872
Congressional Establishment of Yellowstone, 1872

“the tract of land
...set apart as a public park or pleasuring-ground for the benefit and enjoyment of the people...”
The World’s First National Park

Source: World Database on Protected Areas (WDPA) - International Union for Conservation of Nature (IUCN), and United Nations Environment Programme (UNEP)

© 2014 University of Oregon
American Indians Place Names

Key to Tribal Names

- Crow
- Shoshone
- Kiowas
- Shoshones-Bannock
- Nez Percé
- Salish-Kootenai

Translation to various tribal associations:

- Indian campsite
- Bannock trail
- Nez Perce trail
- Major Indian trails

Map of American Indian Place Names in Yellowstone National Park.

Yellowstone Lake
Ilichilikaashaashe Ko’Bilichk’esh
(Lake at Elk River)
Bahn-doy-fooin
(Water coming out)

© 2014 University of Oregon
Bison Decline

Bison Range 1500–1880

c. 1500

Oakland

Transcontinental Railroad

Omaha

Bison Conservation Herds
1. McKay Alloway herd
2. Goodnight herd
3. Walking Coyote herd
4. Frederick Dupree herd
5. Buffalo Jones herd

© 2014 University of Oregon
Bison Restoration

Bison Range 1500–1880

c. 1500

Oakland

Omaha

Bison Population in Yellowstone National Park, 1901–2010

A combination of management reductions and 3 severe winters results in high mortality

Interagency Bison Management Plan finalized
2005–2010: Severe winters and high population force large migrations across northern park boundary

Bison are translocated to Firehole and Hayden valleys

Bison's winter range expands and crosses park boundaries

 Yellowstone contains only U.S. bison to survive in the wild

Brucellosis first detected at Buffalo Ranch (Lamar Valley)

Management strategy shifts towards reducing bison population to improve range conditions and lessen the risk of brucellosis

Interagency Bison Management Plan finalized 2005–2010: Severe winters and high population force large migrations across northern park boundary

Bison population at low of 226

© 2014 University of Oregon
Bison Movement and Management

Seasonal Distribution of Yellowstone Bison
General patterns of movement during fall and winter, 2000–2006

- Breeding range (July-Aug)
- Fall-winter range (Sept-May)
- Bison movement routes
- Major roads
- Bison management zones

© 2014 University of Oregon
Headwaters of the Nation: Rivers
Rivers – Erik Strandhagen MA Research
The Yellowstone Hot Spot

*Path of the Yellowstone Hotspot*

- Direction of plate movement
- Heise Volcanic Field 6.5 MYA
- Picabo Volcanic Field 10.3 MYA
- Twin Falls Volcanic Field 10.8 MYA
- Bruneau-Jarbidge Volcanic Field 10.8 MYA
- Owyhee Humboldt Volcanic Field 13.8 MYA
- McDermitt Volcanic Field 16.1–14.7 MYA

**MYA** = Millions of years ago

*Yellowstone is Dynamic*
The Yellowstone Caldera
Making the Atlas
Working with Topic Experts-Contributors

- Yellowstone National Park
- Grand Teton National Park
- Montana State University
- University of Wyoming
- Buffalo Bill Historical Center
- Head Waters Economics
- Allan Cartography
- Yellowstone Ecological Research Center
- University of Oregon
Working with the Experts to Capture the Stories

- What are the big stories?
- Data sources/availability
- Data experts
- Initial map/graphic ideas - layouts

Mockup Pages  Flip Chart – Stories list  Tracking Sheet
Production – Work Flow

**Published or Online**

**Map Design:** Adobe Illustrator and Photoshop

**Tabular - Excel**

**Page Layout:** Adobe InDesign

**Map Data - GIS**
Grizzly Bears – Historical Context
Grizzly Bears – Birth

Female Grizzly Bears with Cubs

- National Forest
- Wilderness area
- National Park
- Sighting
- Bear recovery zone

1979–1981
1999–2001
2003–2005
2007–2009


- Females
- Cubs
- Mean litter size

Number of bears

Mean litter size

Year

1975
1980
1985
1990
1995
2000
2005
2009
Grizzly Bears –
Life

Yellowstone area grizzly bears eat a breadth of foods: insects, vertebrates, fungi, seeds. Unlike many other members of the order Carnivora, bears eat a significant amount and variety of vegetation. Bears have several adaptations for eating plants, including large chewing surfaces on molars and long claws for digging. Grizzlies are shrewd feeders, maximizing the quality of their food intake by foraging for many kinds of plants and seeking each plant when it is most nutritious and digestible.
Grizzly Bears – Death

Deaths, 1975–2005

Natural Causes

Hunting

Aggression or Injury

Livestock-Related and Accidental

Causes of Mortality

- Natural
- Hunting-related
- Poached
- Aggression, injury, or human conflicts
- Livestock-related
- Accidental

Age
- Cub
- Yearling
- Subadult (2-4)
- Adult (>4)
- Unknown

Number of bears

- Inside park boundaries
- Outside park boundaries

Grizzly Bears

Historic and Current Range

Grizzly Bear Range

North American grizzly bears are native from northern Alaska in northern Mexico and from the Pacific Coast to western Montana. Bear numbers and range declined dramatically following European American exploitation and settlement west of the Mississippi River. Ranches, farms, and cities encroach on grizzly habitat. People, livestock, and bear encounters become more frequent.

Important bear foods such as salmon, trout, and elk were ever harder to find in human-altered landscapes. By 1875, grizzly bears had been extirpated from Mexico and all but 2 percent of their historic range in the lower forty-eight states. Bears remain abundant in Alaska and northern Canada, their populations stable except in a few areas of rapid human settlement and development. Further south, however, habitat fragmentation, alteration, and disturbance threaten the bears. The Greater Yellowstone Ecosystem is the southwesternmost grizzly range as of 2007 and plays a key role in maintaining grizzly bears populations and genetic diversity.

Female Grizzly Bears with Cubs

<table>
<thead>
<tr>
<th>Natural Forest</th>
<th>Mining</th>
<th>Wildlife Area</th>
<th>National Park</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Forest</td>
<td>Mining</td>
<td>Wildlife Area</td>
<td>National Park</td>
</tr>
</tbody>
</table>

Endangered Species Protection

Yellowstone area grizzly bears were monitored federal protection as a threatened species in 1973. State and federal wildlife and habitat management agencies have worked to reduce both conflicts between bears and people and human-caused bear deaths as well as to increase cub production and survival. The area occupied by the bears has grown from approximately 15,000 square kilometers in the 1970s to 17,000 (1980s) to 24,000 (1990s) to 37,000 (2007). Annual counts of females with cubs are used to estimate grizzly bear population numbers and trends. Both the number of females producing cubs and the total number of cubs produced annually has increased since the mid-1980s. Due to the significant increase in bear numbers and range since then, the U.S. Fish and Wildlife Service removed the bears from threatened status in 2007. The manner is not settled, however; in response to a lawsuit filed by bear advocacy groups, a federal judge ordered grizzly bears returned to threatened status in 2009—a ruling currently under appeal by the U.S. Fish and Wildlife Service.

Seasonal Habitat and Food

Grizzly bears are omnivorous, eating a wide variety of plants, animals, and insects. In the Greater Yellowstone Ecosystem, grizzly bears prefer concentrated high-energy foods such as the carcasses of large mammals, elk calves, spawning cutthroat trout, army cutworm moths, willow berries, and salmon. Bears also consume food during the seven-month period without food while hibernating in winter dens. Bears must locate important food supplies by 12 months. Preferred bear foods are consumed in nature and fluctuate in abundance from year to year. As a consequence, grizzly bears require large home ranges to ensure they can meet their energy needs. Prime spring habitat includes elk and bear-wintering areas where bears scavenge invertebrates and animals, and early plant growth where bears graze succulent vegetation. In summer, bears favor elk-calving areas, streams with spawning cutthroat trout, and high elevation alpine slopes where they eat large quantities of army cutworm moths. Preferred fall habitat contains conifer-producing whitebark pine trees. Grizzlies obtain the fat- and protein-rich whitebark pine seeds by raiding red squirrel caches. In years of low pine nut production, grizzlies forage more extensively on berries, roots, and bark and eat more meat. Grizzly bears scavenge well-killed elk and bears during the spring, summer, and fall.

Mortality

Grizzly bears in the Greater Yellowstone Ecosystem die from many causes including old age, scavenging, drowning, avalanche, and den collapse as well as when killed by other bears, wolves, or humans. A large proportion of non-natural deaths—65 percent which are caused by humans result mostly from management removal of bears involved in conflicts with people, defense of life or property by private citizens, mistaken identification by black bear hunters, poaching, vehicle-killings, and electrocution by downed power lines. Bears come into conflict with people more often during years with poor availability of their preferred foods, especially fall foods, commonly lower conflicts and human-caused bear deaths tend to occur in years when food is abundant. The proportion of bear deaths due to natural causes as compared to human-caused is generally higher within national parks, whereas the opposite ratio is generally found outside park boundaries.

Causes of Mortality

© 2012 University of Oregon, Atlas of Yellowstone (page revised 3/14/12)
Review Session
Telling the Wyoming Migration Story

U.S.’s longest mule deer migration discovered in Wyoming

© 2014 University of Wyoming
The Project and People

Wyoming Cooperative Fish and Wildlife Research Unit – USGS
University of Wyoming

Matt Kauffman  Project Director
Wildlife biologist

Hall Sawyer  Wildlife biologist

William Rudd  Wildlife manager

Matt Hayes  Data analysis

Emilene Ostlind  Text editor

University of Oregon
InfoGraphics Lab
Department of Geography

James Meacham  Cartographic Editor

Alethea Steingisser  Project manager

Lauren Tierney (GTF)  GIS and cartography

Photos: Wyoming Game & Fish Department

© 2014 University of Wyoming
Primary Data Collection

Photos: Mark Gocke Wyoming Game & Fish Department

© 2014 University of Wyoming
Migration Impacts

Impacts of Energy Development

Researchers have developed a solid understanding of how energy development impacts wildlife on winter ranges, but relatively little is known about how it affects migration. One recent study compared mule deer migration patterns before and after coal bed methane (CBM) well development in Wyoming’s relatively pristine Atlantic Rim Project Area.

In 2006, the Bureau of Land Management approved 2,000 CBM wells in eight development areas between the winter and summer ranges of two migratory mule deer populations near Atlantic Rim. Prior to development, researchers monitored migratory movements of 47 male deer and collected 116,000 locations. Results showed that two of the eight proposed development areas, Dry Cow Creek and Wild Horse Basins, overlapped deer migration routes. The 13-square-mile Dry Cow Creek area was split for early development with 7.5 well pads per square mile. Wild Horse Basins was smaller, 6 square miles, and would be less heavily developed with 4.8 well pads per square mile.

As with areas developed from 2008 to 2010, the researchers collected 191,000 GPS locations from 50 collared male deer. They found the deer continued to migrate through moderate development in Wild Horse Basins as they had before. However, in Dry Cow Creek where development was more intensivest, deer often detoured from established routes. Additionally, deer moved more quickly through the developed areas than through the surrounding areas. The researchers also compared how and where the deer stopped to rest and forage before and after development. During the 2006 study, some deer migrated 40 miles away, a typical deer spends 95% of its time in narrower areas where it has access to water and vegetation. (In Wyoming, and the other 15% of the time moving between stopovers. Following development in the Dry Cow Creek area, migrating deer spent 80% of their time in the stopover areas they had used before, dropping to 70% of the time in the southern development area. To benefit from migration, deer need to be able to move to and from specific areas at specific times, especially in spring when new plant growth is most nutritious.

In addition to the new habitat, well-permeable development, such as in the Atlantic Rim area, does allow migrating deer to move through. However, as this study shows, if migrating deer have easy access to the best forage, they may stop using the migration corridor and the stopover time decreases.

Researchers have developed knowledge about how energy development impacts migration on winter ranges, but relatively little is known about what energy development impacts migration on summer ranges. In 2009, a recent study compared mule deer migration patterns before and after coal bed methane (CBM) well development in Wyoming’s relatively pristine Atlantic Rim Project Area.

In 2006, the Bureau of Land Management approved 7,000 CBM wells in eight development areas between the winter and summer ranges of two migratory mule deer populations near Atlantic Rim. Prior to development, researchers monitored migratory movements of 47 male deer and collected 116,000 locations. Results showed that two of the eight proposed development areas, Dry Cow Creek and Wild Horse Basins, overlapped deer migration routes. The 13-square-mile Dry Cow Creek area was split for early development with 7.5 well pads per square mile. Wild Horse Basins was smaller, 6 square miles, and would be less heavily developed with 4.8 well pads per square mile.

As with areas developed from 2008 to 2010, the researchers collected 191,000 GPS locations from 50 collared male deer. They found the deer continued to migrate through moderate development in Wild Horse Basins as they had before. However, in Dry Cow Creek where development was more intensive, deer often detoured from established routes. Additionally, deer moved more quickly through the developed areas than through the surrounding areas. The researchers also compared how and where the deer stopped to rest and forage before and after development. During the 2006 study, some deer migrated 40 miles away, a typical deer spends 95% of its time in narrower areas where it has access to water and vegetation. (In Wyoming, and the other 15% of the time moving between stopovers. Following development in the Dry Cow Creek area, migrating deer spent 80% of their time in the stopover areas they had used before, dropping to 70% of the time in the southern development area. To benefit from migration, deer need to be able to move to and from specific areas at specific times, especially in spring when new plant growth is most nutritious.

In addition to the new habitat, well-permeable development, such as in the Atlantic Rim area, does allow migrating deer to move through. However, as this study shows, if migrating deer have easy access to the best forage, they may stop using the migration corridor and the stopover time decreases.

Researchers have developed knowledge about how energy development impacts migration on winter ranges, but relatively little is known about what energy development impacts migration on summer ranges. (In Wyoming, and the other 15% of the time moving between stopovers. Following development in the Dry Cow Creek area, migrating deer spent 80% of their time in the stopover areas they had used before, dropping to 70% of the time in the southern development area. To benefit from migration, deer need to be able to move to and from specific areas at specific times, especially in spring when new plant growth is most nutritious.

In addition to the new habitat, well-permeable development, such as in the Atlantic Rim area, does allow migrating deer to move through. However, as this study shows, if migrating deer have easy access to the best forage, they may stop using the migration corridor and the stopover time decreases.

Researchers have developed knowledge about how energy development impacts migration on winter ranges, but relatively little is known about what energy development impacts migration on summer ranges. In 2006, the Bureau of Land Management approved 7,000 CBM wells in eight development areas between the winter and summer ranges of two migratory mule deer populations near Atlantic Rim. Prior to development, researchers monitored migratory movements of 47 male deer and collected 116,000 locations. Results showed that two of the eight proposed development areas, Dry Cow Creek and Wild Horse Basins, overlapped deer migration routes. The 13-square-mile Dry Cow Creek area was split for early development with 7.5 well pads per square mile. Wild Horse Basins was smaller, 6 square miles, and would be less heavily developed with 4.8 well pads per square mile.

As with areas developed from 2008 to 2010, the researchers collected 191,000 GPS locations from 50 collared male deer. They found the deer continued to migrate through moderate development in Wild Horse Basins as they had before. However, in Dry Cow Creek where development was more intensive, deer often detoured from established routes. Additionally, deer moved more quickly through the developed areas than through the surrounding areas. The researchers also compared how and where the deer stopped to rest and forage before and after development. During the 2006 study, some deer migrated 40 miles away, a typical deer spends 95% of its time in narrower areas where it has access to water and vegetation. (In Wyoming, and the other 15% of the time moving between stopovers. Following development in the Dry Cow Creek area, migrating deer spent 80% of their time in the stopover areas they had used before, dropping to 70% of the time in the southern development area. To benefit from migration, deer need to be able to move to and from specific areas at specific times, especially in spring when new plant growth is most nutritious.

In addition to the new habitat, well-permeable development, such as in the Atlantic Rim area, does allow migrating deer to move through. However, as this study shows, if migrating deer have easy access to the best forage, they may stop using the migration corridor and the stopover time decreases.

Researchers have developed knowledge about how energy development impacts migration on winter ranges, but relatively little is known about what energy development impacts migration on summer ranges. In 2006, the Bureau of Land Management approved 7,000 CBM wells in eight development areas between the winter and summer ranges of two migratory mule deer populations near Atlantic Rim. Prior to development, researchers monitored migratory movements of 47 male deer and collected 116,000 locations. Results showed that two of the eight proposed development areas, Dry Cow Creek and Wild Horse Basins, overlapped deer migration routes. The 13-square-mile Dry Cow Creek area was split for early development with 7.5 well pads per square mile. Wild Horse Basins was smaller, 6 square miles, and would be less heavily developed with 4.8 well pads per square mile.

As with areas developed from 2008 to 2010, the researchers collected 191,000 GPS locations from 50 collared male deer. They found the deer continued to migrate through moderate development in Wild Horse Basins as they had before. However, in Dry Cow Creek where development was more intensive, deer often detoured from established routes. Additionally, deer moved more quickly through the developed areas than through the surrounding areas. The researchers also compared how and where the deer stopped to rest and forage before and after development. During the 2006 study, some deer migrated 40 miles away, a typical deer spends 95% of its time in narrower areas where it has access to water and vegetation. (In Wyoming, and the other 15% of the time moving between stopovers. Following development in the Dry Cow Creek area, migrating deer spent 80% of their time in the stopover areas they had used before, dropping to 70% of the time in the southern development area. To benefit from migration, deer need to be able to move to and from specific areas at specific times, especially in spring when new plant growth is most nutritious.

In addition to the new habitat, well-permeable development, such as in the Atlantic Rim area, does allow migrating deer to move through. However, as this study shows, if migrating deer have easy access to the best forage, they may stop using the migration corridor and the stopover time decreases.

Researchers have developed knowledge about how energy development impacts migration on winter ranges, but relatively little is known about what energy development impacts migration on summer ranges. In 2006, the Bureau of Land Management approved 7,000 CBM wells in eight development areas between the winter and summer ranges of two migratory mule deer populations near Atlantic Rim. Prior to development, researchers monitored migratory movements of 47 male deer and collected 116,000 locations. Results showed that two of the eight proposed development areas, Dry Cow Creek and Wild Horse Basins, overlapped deer migration routes. The 13-square-mile Dry Cow Creek area was split for early development with 7.5 well pads per square mile. Wild Horse Basins was smaller, 6 square miles, and would be less heavily developed with 4.8 well pads per square mile.

As with areas developed from 2008 to 2010, the researchers collected 191,000 GPS locations from 50 collared male deer. They found the deer continued to migrate through moderate development in Wild Horse Basins as they had before. However, in Dry Cow Creek where development was more intensive, deer often detoured from established routes. Additionally, deer moved more quickly through the developed areas than through the surrounding areas. The researchers also compared how and where the deer stopped to rest and forage before and after development. During the 2006 study, some deer migrated 40 miles away, a typical deer spends 95% of its time in narrower areas where it has access to water and vegetation. (In Wyoming, and the other 15% of the time moving between stopovers. Following development in the Dry Cow Creek area, migrating deer spent 80% of their time in the stopover areas they had used before, dropping to 70% of the time in the southern development area. To benefit from migration, deer need to be able to move to and from specific areas at specific times, especially in spring when new plant growth is most nutritious.

In addition to the new habitat, well-permeable development, such as in the Atlantic Rim area, does allow migrating deer to move through. However, as this study shows, if migrating deer have easy access to the best forage, they may stop using the migration corridor and the stopover time decreases.

Researchers have developed knowledge about how energy development impacts migration on winter ranges, but relatively little is known about what energy development impacts migration on summer ranges.
Migration Responses to Energy Development

Detours

Mule Deer 6

Mule Deer 16

Increased Travel Speeds

© 2014 University of Wyoming