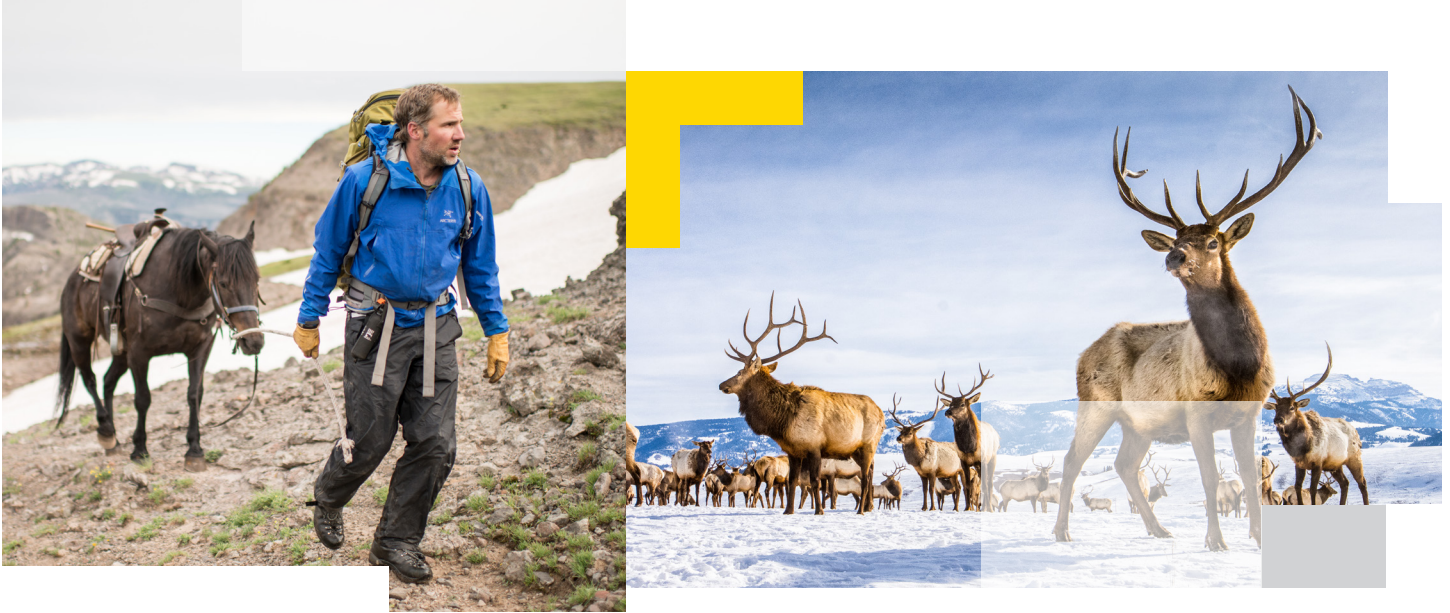


PROTECTING ELK MIGRATION IN THE GREATER YELLOWSTONE ECOSYSTEM



From left to right, the photographs above are courtesy of Joe Riis and Charlie Hamilton James.

What can studying elk and other large mammals teach us about the ecosystems of the American West? Wildlife ecologist Arthur Middleton, a professor at the University of California, Berkeley, explores questions like this. The answers can help us make decisions that strike a balance between preserving and developing natural places.

When Middleton was a boy in the 1980s, he spent a lot of time at his grandparents' home on an island in South Carolina. His grandmother encouraged him to go out and explore, looking for frogs, toads, snakes, and birds. "I'd make notes about them and try to catch them," recalls Middleton.

These experiences fed an interest in wildlife that continued through college, when Middleton took field-assistant jobs. He learned how to teach falcons to hunt and conducted nest surveys on raptor populations. From the study of raptors, he developed a strong interest in predator-prey relationships.

Then, in graduate school at the University of Wyoming, Middleton explored another predator-prey relationship: wolves and elk. He questioned why elk calves were dying in greater numbers in herds

migrating in the Yellowstone National Park region of the Rocky Mountains. Were wolves to blame? From 2007 to 2010, Middleton studied interactions between elk and wolves. As he learned more about elk, he grew curious about their migrations.

Middleton looked for information about elk migrations in the Greater Yellowstone Ecosystem. The area, centered around Yellowstone National Park, is one of the largest and best-preserved North American temperate ecosystems. Middleton found that since the early 2000s, biologists had been putting GPS collars on elk in the region to track their movements via satellite. The GPS data were scattered, though. No one had pulled the information together in one database.

Middleton asked agencies such as the Wyoming Game and Fish Department, the National Park Service, the Wildlife Conservation Society, and Iowa State University to share their GPS data with him. He collected and mapped the GPS information to visualize where the elk traveled. Where he saw gaps, he collared additional herds to fill in those missing pieces. The resulting map showed a web of migration corridors moving outward from Yellowstone Park into an area five times its size.

Though he had begun to see what the migratory paths looked like on a map, Middleton still had many questions about the details of the migrations. He decided to single out one herd—the Cody herd, one of the least understood—and follow it closely. Understanding the migration of one herd in detail could help him and other scientists grasp the impact of migration at the ecosystem scale. It would also allow him to bring back images and stories of a major migration to share with curious people.

Asking a Geo-Inquiry Question

Once abundant, elk were hunted nearly to extinction in the late nineteenth century. Their populations have since rebounded and can be found again in much of their former range. Why is this animal's continued presence important? A healthy elk herd, one that is fat and productive, is a critical food source for other animals, such as grizzly bears, wolves, and mountain lions. Scavenging birds and mammals feed on elk carcasses, too. The herds grazing on natural grasses also contribute to ecosystem balance. Healthy wildlife helps support the local economy and culture, as hunters and tourists bring income into the area.

Elk are one of six hoofed-mammal species that migrate across this ecosystem. Some of the mammals, such as mule deer and pronghorn, face serious obstacles to migration. Understanding and protecting elk migration could help with the protection of these other species, as well. That knowledge could be useful in places around the world, where human and environmental impacts are interfering with animal migrations. In many areas, not just Yellowstone, animal movements connect parks to their surrounding landscapes. Showing the importance of keeping open areas outside park boundaries could help preserve other migrating species worldwide.

Middleton began his research with one key question: What is the elk migration really like? He broke this main question into subquestions: Not all elk migrate, so how common is elk migration in this ecosystem? Why do they migrate? What triggers them to migrate? How much time do elk spend on national parkland versus other public land and private land? What are the threats to their migration? What are the opportunities to protect migration routes?

Acquiring Geographic Information

The Cody herd's migration path, which is about 70 miles long, begins in an area south of Cody, Wyoming, and ends in the southeast corner of Yellowstone National Park. This area,

called the Thorofare, is extremely remote. The ranger station in Thorofare is the farthest building from a road in all the lower 48 states.

Middleton studied the herd's migration as data points on a map, but he wanted to relate this remote data to real features and materials on the ground, a process called ground truthing. He and his team, including wildlife photographer Joe Riis, decided to travel the rugged—and at times treacherous—migration route of the Cody herd themselves.

They traveled much of the route on horseback. Along the way, Riis set up camera traps on the trails. Triggered by motion, these cameras photographed the elk—in both still images and videos—as they passed by. The cameras captured the migrations in action, even when Middleton and his team weren't there in person. The team also put GPS collars on more members of the herd to fill in knowledge gaps about the migration path. Over two summers, Middleton and Riis traveled 1,500 miles, walking up and down the trail repeatedly, checking the cameras and exploring different sites.

Also important to Middleton was developing a deeper understanding of the larger ecosystem. What other animals were in the area? What was the plant life like? To capture visuals of the entire scene, Middleton enlisted the help not only of photographer Riis, but also artist James Prosek and filmmaker Jenny Nichols.

Organizing and Analyzing Geographic Information

Middleton added the new GPS tracking data to the existing data he had gathered from other experts in the Greater Yellowstone Ecosystem. Altogether, he had about 5 million GPS locations collected from Yellowstone elk herds over 15 years.

He and his team organized those GPS locations in a database, constantly updating them with new data. They used the location points from a number of different analyses. One analysis looked at factors that influence migratory behavior. Each of the 5 million GPS locations was referenced with other data, including snow level, measurements of vegetation greenness, measurements of human activity (such as roads, buildings, and irrigated agriculture), and hunting pressure at the time the location was sampled. Taken together, these data gave Middleton and his team a virtual snapshot of what the

conditions were like as the elk were moving. In the future, these studies will help scientists understand the impact of climate change because snow and green vegetation are the main factors that influence elk migration behavior and timing.

Developing a Geo-Inquiry Story

Through mapping, data analysis, and ground truthing, Middleton developed a rich appreciation for the elk herd's life cycle. He found that the Cody herd winters mainly on private lands. In the spring, they make an incredible journey, traveling up and down 12,000-foot elevations, treading through deep snow, climbing steep slopes covered in loose rock, and crossing raging rivers swollen with snowmelt.

Why do elk make these migrations? Mainly for food, Middleton confirmed. Grass is hard to digest and the elk prefer young, green shoots that come up after the spring snowmelt, so they follow grassy areas from the valleys in the winter to the mountains in the summer, making the elk healthy and productive. As the herd migrates, it also serves as prey for predators in the ecosystem.

Elk rely not just on protected public lands in the park but also private lands in the Wyoming rangeland. In the winter, some herds spend as much as 80 percent of their time on private ranch lands. When ranches go out of business, the land is often subdivided. Middleton's team found that human development (such as housing) and energy development (such as drilling for natural gas and windmill farms) on formerly undeveloped land were having an effect on the herd. Even on ranches that were still intact, structures such as high fences prevented elk from following their migration trail. Middleton's research showed that the loss of open land can keep elk from the best food sources.

Middleton used the data collected and mapped from the collar trackers, the images from the camera traps, the artwork, and the video to tell the remarkable story of how these elk herds migrate and why it's important to the ecosystem. "Science should not just be words on a page—which is what it's been for way too long," says Middleton. "It needs to go further with a life in photographs, film, and the arts, all at once."

Taking Action

Middleton recognized that sharing what he had learned could encourage people with a variety of interests to work together to maintain open areas for migration. He and his team made a film about the migration. They also created a traveling exhibit that includes scientific information, migration maps, photos, art, and

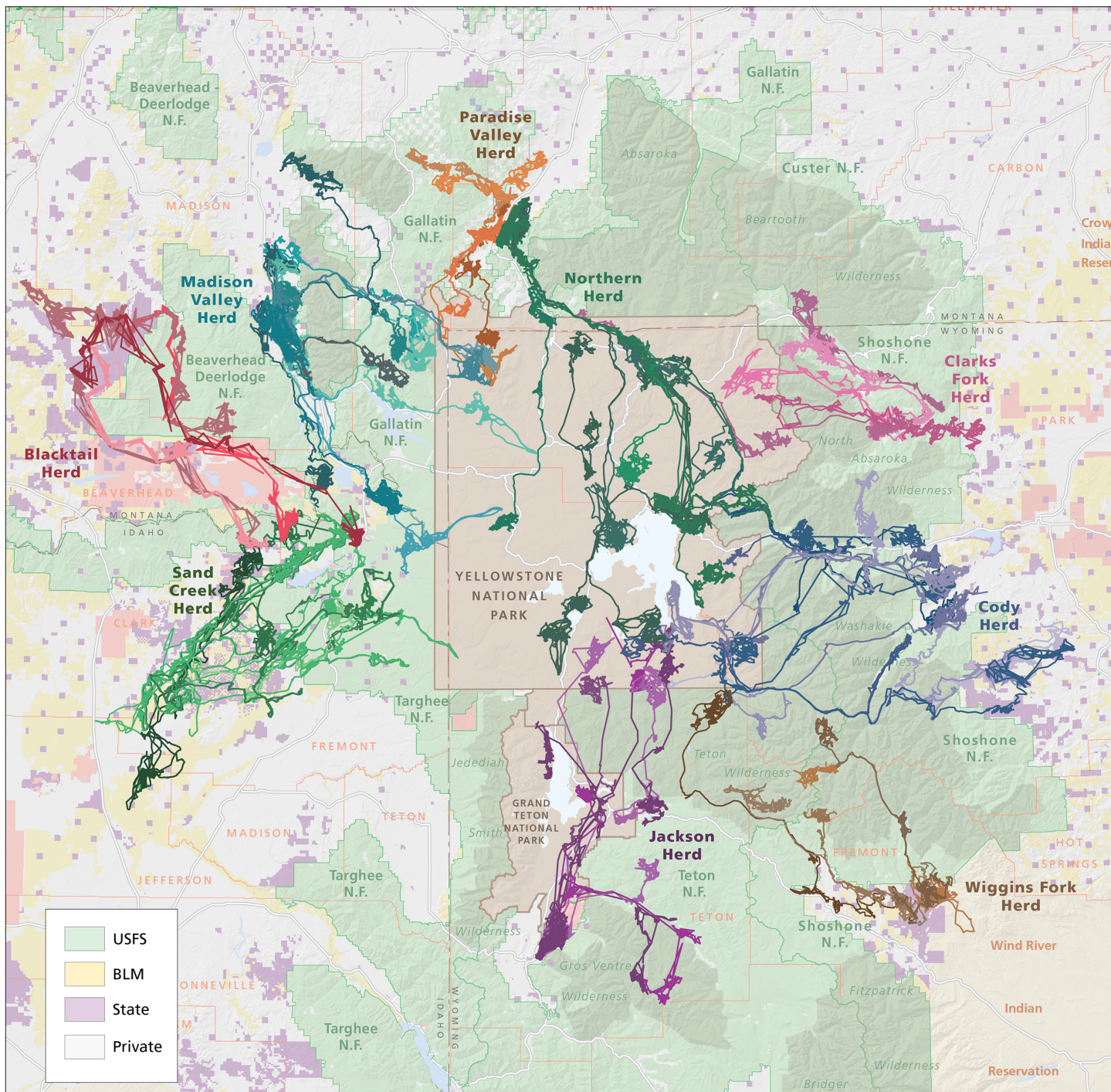
film. National Geographic magazine published a feature article about the Cody herd migration in an edition focused solely on Yellowstone. A book was also published featuring Joe Riis's stunning photographs of the migration.

Middleton met with public officials and leaders to share what was learned and garner support from ranchers, energy developers, and other stakeholders. The purpose was to get them all focused on preserving migration routes for unimpeded access by the elk.

Though elk and other large mammal migrations remain threatened, the work of Middleton and his colleagues has helped encourage leaders to take steps to preserve this incredible natural behavior. In 2016, the Wyoming Game and Fish Commission, which oversees wildlife management in the state of Wyoming, instructed land and wildlife managers in the state to minimize development and disturbance in migration corridors. In 2018, the U.S. Secretary of the Interior signed an order directing more resources toward protecting the migration routes of elk and other big game in the West. Middleton's detailed maps are also inspiring local groups to find compromises between conservation and development.

Why are these elk migrations so important to Middleton? When he views the trails on a map, he sees the ecosystem's veins and arteries. The movement in and out of Yellowstone is like the pulse of the ecosystem. He hopes that understanding the importance of these migrations will lead people to rethink the boundaries of Yellowstone National Park and other protected areas around the world. After all, the man-made lines on a map do not represent the real-life territory animals need to survive.

"I think that we really need to reimagine Yellowstone as a park that is inextricably connected to a wider world—a wider world that it gives many riches to but to which it's also vulnerable," says Middleton. He hopes that this enlightening story from Yellowstone will inspire new thinking about the management of lands around parks elsewhere in the world.



Elk Migrations of the Greater Yellowstone Ecosystem

- Blacktail Herd
- Clarks Fork Herd
- Cody Herd
- Jackson Herd
- Madison Valley Herd
- Northern Herd
- Paradise Valley Herd
- Sand Creek Herd
- Wiggins Fork Herd



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 Source: Atlas of Wildlife Migration: Wyoming's Ungulates (in production)
 Cartography: University of Oregon InfoGraphics Lab
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Map courtesy of Arthur Middleton