Sierra Nevada Bighorns vs. Mountain Lions

Adapted from: **"Counting Sheep: Bighorn Sheep and Mountain Lions in the American West"** by Elizabeth Clark Department of Biology, Washington University in St. Louis

Objectives:
Students analyze a less traditional endangered species conflict: a legally protected but common predator, the mountain lion, is preying on and driving towards extinction an endangered herbivore, the Sierra Nevada bighorn sheep. Biologists concerned with the preservation of bighorn sheep want to reduce the lions (cull) to prevent further harm to the sheep, while mountain lion activists oppose killing of lions for any reason. Students examine the two perspectives, debate, and finally vote as a mock California State Senate on whether to allow culling of lions that kill bighorns.

Grade level: Suggested 5th-12th
Duration: 2-3 class sessions
Group Size: Whole class/ small group
Setting: indoors
Materials:

- *Cougars Wiping Out Sierra Bighorn Sheep, Scientists Say* article
- Pre-Case Discussion Questions worksheet
- *History of Sierra Nevada Bighorn Sheep Recovery*
- Voting Ballot
- Optional: *The Cost of the Bighorn Comeback* news article

NGSS Standards:

- 5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect Earth's resources (bighorn or mountain lions in this case) and environment
- MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

Common Core State Standards:
A variety of Speaking & Listening standards would fit in here, for example:

- CCSS.ELA-LITERACY.SL.11-12.1.B Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed.
- CCSS.ELA-LITERACY.SL.11-12.1.C Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives.

Background:

Genetically distinct from all other wild sheep on the continent, Sierra bighorn form an irreplaceable part of the landscape in which they make their homes. Beyond the ecological consequences of extinction, the loss of the Sierra Nevada bighorn sheep would have repercussions across centuries of natural and human history, leaving this great mountain range impoverished forever.

There is a lack of historical information needed to pinpoint the exact chain of events that led this species to the brink of extinction, but the earliest information on disease problems dates back to the 1870s after the introduction of extensive domestic sheep grazing throughout the Sierra Nevada. Unregulated hunting, especially market hunting near mining towns may have also played a role. More recently, an episode of particularly high mountain lion predation appears to have played a role.

Restoration efforts during 1979-88 were successful in re-establishing populations in three areas, but governmental regulatory constraints ultimately hindered continuing recovery of these sheep relative to management of predation (from mountain lions) and threats from domestic sheep grazing very close to Sierra bighorn. It was deficiencies in governmental regulatory mechanisms that led to the seeking of federal endangered status in 1999. The total population of Sierra bighorn has shown a remarkable recovery since its low ebb of about 100 animals in 1995 to more than 600 in 2014.

Historically, mountain lions were heavily persecuted in California. Classified as a bounty predator from 1907 to 1963, 12,462 mountain lions were killed in California during this bounty process, which was enacted to reduce the number of livestock and pets they killed, as well as human safety issues as the human population of the state continued to grow. The passage of the California Wildlife Protection Act of 1990 (Proposition 117) by California voters established that mountain lions are a "specially protected mammal" in California and cannot be killed.

With the mountain lion being the main predator of bighorn sheep, a conflict arose in California as biologists who wished to increase herds of the endangered Sierra Nevada Bighorn were unable to cull (reduce the population of mountain lions) to help the small number of bighorn grow in population.

Focus:

The primary focus of this case is to teach students to formulate an opinion on an issue by taking ethics, science, and politics into consideration. Students are often accustomed to hearing about conflicts between human and environmental interests, but this case introduces a new kind of conflict. Here the conflict is between an endangered species (Sierra Nevada bighorn sheep), and its charismatic predator (the mountain lion). Students should be forced to consider the bases for their positions on the conservation of endangered species and the ethics of hunting, and use this when coming to a resolution on the issue.

Procedures:

1) Inform students that they will become members of the California State Senate and they are in charge of debating and then voting on a bill (law). Explain that this is a very heated and debated issue in California. You may even pretend to go back in time to 1998 during the most heated discussions in California (and when the news article was written).

2) Before giving them any background on the situation, it is suggested students fill out the two pre-case discussion questions.

3) Provide background on the Sierra Nevada bighorn. This could be through video means (one good 9-minute video is the YouTube video *Yosemite Nature Notes: Bighorn Sheep – Episode 27*) or reading *History of Sierra Nevada Bighorn Recovery*. The article only goes up until the issue with mountain lions preventing the comeback.

4) Further introduce and focus on the issue at that time, that the Sierra Nevada bighorn population, even with current efforts to reestablish them, were in jeopardy. One of the main issues seen by scientists was the predation due to mountain lions. Have a class discussion of general ideas of both sides: reduce mountain lions to help bighorns, or continue to allow populations of mountain lions to stay constant even though it may impact bighorns. Begin to allow students to see where their opinion is on the mater. Read the article from the time called *Cougars Wiping Out Sierra Bighorn Sheep, Scientists Say* to allow students more time to gather information to form an opinion.

5) Debate groups form based upon opinions. Allow time for each side to get together to form strong arguments to back up their opinion. Write these down to be used during the "formal" Senate hearing.

6) Officially introduce that the class is now the California State Senate and they have a heavy task of officially deciding on the issue. Remind them, that as elected officials, they all have a responsibility of put their own opinions aside when voting on the law, and that this debate is to try to bring out ALL the issues and ALL the possible facts to make an informed decision. That although each student currently has an initial opinion, it is important to listen to every person's perspective and voice to help them make a final vote at the end of the debate. Let the debate begin. Perhaps encourage students to create a Pro/Con chart during debate discussions. Teacher may also do this on the board.

7) After the debate, each student (Senator) would fill out an official voting ballot. Explain that during official votes, our elected officials vote is not confidential, but that the public is allowed to know how each person voted. This often helps determine if the person is re-elected based upon them voting as the majority of their constituents wish them to vote based upon emails, phone calls, etc. they receive on issues. Perhaps have a tally chart on the board with each option and as the teacher reads the Senator's name from the voting slip, add a tally into the appropriate column, eventually leading to a visual of how many voted for each side and the total decision based upon majority.

8) Return to the pre-case discussion questions originally answered. Re-address these at the end of the case to bring closure to the case by reminding students of their initial responses and allowing them time to analyze why any opinions have changed. This could be a good time for some sort of assessment, such as a reflection on why many issues in our society are not easily fixed and how there are many sides to each situation.

9) Perhaps explain where the issue is today. You can find the rest of article *History of Sierra Nevada Bighorn Recovery* for a discussion after the debate/lesson at https://www.nps.gov/yose/learn/nature/sheep-history.htm and perhaps reveal the decision that **"The California State Legislature, reacting to media attention**

over the fate of Sierra bighorn, in a rare almost-unanimous vote, approved a change in the 1990 initiative to allow control of mountain lions to protect bighorn sheep in California. In another unprecedented action, that legislature also initiated financial support for a state-led recovery program for these sheep—a program that continues today. Such action by the state legislature for an endangered species was—and remains—unprecedented." Additionally, an article written in 2017 does a good job of explaining the outcome and how this has transferred to another range of sheep in Arizona at the Santa Catalina mountains. During this time, teacher could introduce and read the news article *The Cost of the Bighorn Comeback*. A video of Catalina Mountains and the lions there can be seen at https://www.youtube.com/watch?v=IVj12ZtOFUk

Assessment: Possible assessments:

- Writing a reflection on the process and what was learned.
- On the back of the initial Pre-Case Discussion Questions, students could write a formal re-evaluation of their initial thoughts and how those have or have not changed and why.
- Teams create a "newscast" video which explains a quick historical background of the Sierra Nevada bighorn, the controversial issue of managing mountain lions to protect the sheep, and the final outcome of "todays" Senate decision.

Videos:
https://www.youtube.com/watch?v=qCf47SrgDss&t=127s (Sierra Nevada Bighorn history, found on YouTube: *Yosemite Nature Notes: Bighorn Sheep -Episode 27*)

Can rent a 60-minute film on the issue at https://www.greenplanetfilms.org/product/counting-sheep-restoring-the-sierra-nevada-bighorn/ for $2.99

https://www.youtube.com/watch?v=IVj12ZtOFUk (News Cast of Mountain Lions in Catalina Mountains of Arizona with similar issue)

https://www.youtube.com/watch?v=1EYDNwDYZNI&t=487s (Video on Catalina Mountain herd and controversial issues with mountain lions. Begin at 13min 54 seconds)

Websites:
https://sierrabighorn.org

NAME_____

Pre-Case Discussion Questions

1. *Why do we preserve a particular species? Is it because of its value to the conservation of overall biodiversity (having a variety of life in the world and within ecosystems), or because of an intrinsic right to exist (each animal has the right to live)? Explain.*

2. *Why is it socially or ethically acceptable to hunt certain species but not others? Can you provide any examples? Where and why does society draw the line of what animals to hunt?*

*Pre-Case Discussion Questions – **Teacher Background***

1. *Why do we preserve a particular species? Because of its value to the conservation of overall biodiversity, or because of an intrinsic right to exist?*
The purpose of this question is to force students to evaluate the basis for their opinions. Some students may support environmental goals such as the conservation of biodiversity because of an animal- or individual-rights perspective, while others are more concerned with the bigger picture of ecosystem services and sustainability. Having the students identify which is more important to them, the well-being of individuals or the overall health of the system, will be important later on.

2. *Why is it socially or ethically acceptable to hunt certain species but not others? Where and why do we draw the line?*
Students may answer that some species, such as chimpanzees or gorillas, seem too similar to humans in their capacity to think and feel to justify hunting and/or eating them, while other species, such as elk or ducks, lack these human-like capabilities and this makes them acceptable to hunt. They may also identify "cute" mammals, such as a panda bear or canine and feline relatives to pets as animals that are unacceptable to hunt. Answers will vary, but it is useful to make sure one (or a few) method(s) for determining when to draw the line are identified.

Cougars Wiping Out Sierra Bighorn Sheep, Scientists Say

Glen Martin, Chronicle Staff Writer for SFGate Newspaper

Sep. 21, 1998 Updated: Feb. 3, 2012

Mountain lions may be pushing endangered Sierra Nevada bighorn sheep to extinction, and wildlife biologists say they are unable to do anything about it. The scientists maintain that a simple solution to the problem exists but that it cannot be carried out because of the growing trend of crafting public policy -- including wildlife policy -- at the ballot box.

Cougars were given sweeping protection in a 1990 state ballot initiative after widespread popular concern about the stability of their population. The big cats multiplied dramatically, and they began gobbling up the bighorns with a vengeance.

Wildlife biologists would like to eliminate a few of the most voracious cats to give the sheep a little breathing room. But the 1990 initiative allows cougars to be killed only if they threaten people, pets or livestock. Endangered species are not covered in the exemption.

And to the frustration of the scientists, supporters of the big cats are fighting any moves to change that part of the law. "They have no vision of conservation," said bighorn expert John Wehausen, a biologist with the University of California's White Mountain Research Station, in criticism of the Mountain Lion Foundation, his primary opponent on the issue. "They're an animal rights group, not an environmental group," said Wehausen. "We (wildlife biologists) are concerned with habitat preservation and maintaining rich biodiversity, but they're concerned with the life of a particular animal in a particular place. They essentially reject science."

Lynn Sadler, the executive director of the Mountain Lion Foundation, countered that the link between mountain lion predation and bighorn declines has not been adequately demonstrated. "Predators eat endangered species all the time," she said. "It's what they were put on this planet to do. Not far from here, great horned owls are eating endangered Swainson's hawks." Mountain lions do eat some bighorns, Sadler acknowledges, "but it has never been proven that eliminating lions will take care of the bigger problems bighorns are facing." Sadler said Sierra Nevada bighorn sheep live in a harsh alpine environment that makes survival problematic under any circumstance.

Besides, said Sadler, killing sheep-eating lions would probably do little good because the cats have a highly developed sense of territory. "When one lion is removed, another moves in," she said. "Younger mountain lions are always waiting for the opportunity to exploit territory controlled by an older animal."

Until the past few years, Sierra Nevada bighorn sheep -- cousins of the more numerous desert bighorn -- were staging an impressive comeback after dancing on the brink of extinction for almost a century. Although they had once ranged across the spine of the Sierra, these magnificent animals had been reduced to a few isolated herds by 1900.

Disease and unregulated hunting were the primary culprits during the early year, especially as mining towns grew and miners had to be fed. Bighorns are exceedingly susceptible to domestic sheep maladies, and bighorn meat was considered so succulent and delicious that it was featured on the menus of restaurants in Bodie, now a deserted mining town on the eastern slope of the Sierra.

By the late 1970s, only about 250 sheep were left. They lived in two herds in the central Sierra, one on Mount Baxter and another on Mount Williamson. In 1986, biologists began transplanting animals from the Baxter herd to Lee Vining Canyon, just outside Yosemite National Park.

The animals thrived, and other transplants followed, to both the Lee Vining Canyon area and Mount Langley in the southern Sierra. By 1991, the Sierra Nevada bighorn population stood at about 400 animals and was expanding rapidly. "It was fantastic," recalled Wehausen, a lean, gangly man with a spare ginger-colored beard. "The herds were growing at 24 percent a year -- that's a remarkable rate."

But that began to change, biologists say, with the passage of Proposition 117 in 1990.

The state's cougar population climbed quickly after the measure was approved and is now estimated at 5,000 animals. Within two years of the initiative's passage, biologists began to note a dramatic increase in the number of sheep killed by lions. Further, researchers say, the lions were changing the bighorn's behavior in a way that was anything but healthy for the bighorns.

"We always knew that lions killed sheep," said Leslie Chow, a biologist with the U.S. Geological Service who studies cougars in Yosemite National Park through a grant from the Yosemite Fund. "But as the '90s went on, we saw more and more predation from lions," said Chow, "especially during the winter, when the sheep are stressed from the weather and lack of food."

And the problems were compounded when the sheep retreated to higher altitudes to escape the lions. "It got to the point that the sheep stopped going down to the lower terrain where the winter feed was good," Chow said. "Instead, they wintered out higher up." And the higher the range, the less forage there is during the brutal Sierra winter, Chow said. Sheep emerge from the snowy months in poor condition, making them particularly vulnerable to disease, parasites and predators. "They also have fewer lambs, since breeding success is pegged to good winter nutrition," said Chow.

Wehausen said Sierra Nevada bighorns are about to become extinct, and the only hope for their salvation is a captive breeding program similar in scope to the one undertaken for the California condor. "It's not a matter of maybe," he said. "We're at the crisis point right now. There are fewer than 100 Sierra Nevada bighorns left -- that's totaling all the herds. Somehow, we have to come up with funding by this winter so we can start capturing some of the animals."

Such a solution is hardly ideal, said Wehausen. Bighorns breed readily in captivity but they lose many of their natural instincts when penned, making them easy pickings for predators when and if they are re-introduced to the wild. Great care must also be taken with the breeding program to ensure that the offspring are not excessively inbred, Wehausen said. "These are incredibly valuable genes," said Wehausen, "and it would be tragically easy to lose them."

The biologists say there is a far better and simpler solution to the problem than captive breeding -- selective control of the cougars. Chow thinks that mountain lion populations are at an all-time high in California, exceeding the numbers that existed in the centuries before European contact. In those days, grizzly bears may have kept cougars in check, Chow said. Grizzlies are now extinct in California.

"It's not as though the situation now is 'natural,' " Chow said. "California's wild ecosystems have been dramatically manipulated for centuries. There's compelling evidence that a lion population of this density is quite unusual." Lions are highly individualistic animals, said Chow, and quickly develop specific tastes when it comes to prey. "As a species, they heavily favor deer," he said. "But some get particularly adept at taking other prey -- bighorns, for example. When we could still legally take lions, we found that removing one or two problem animals from bighorn range greatly reduced (sheep) mortality."

The California Department of Fish and Game concurs with that view and supported a bill introduced in the state Assembly last year that would have allowed a limited take of lions in the Sierra under a special research program. "It was apparent to us that a few lions -- or even one lion -- could have a devastating effect on the remaining Sierra Nevada bighorns," said Steve Torres, a Fish and Game biologist in charge of the agency's bighorn sheep programs.

"All the rules of predator/prey relations don't really apply when the prey is in danger of extinction," said Torres. "In any wildlife management scenario, the predator should not eliminate the prey."

But the legislation promptly died when the Mountain Lion Foundation indicated its opposition. "Under Proposition 117, (killing lions) is strictly against the law," said Sadler. "We're not opposed to studying possible solutions to the bighorn problem, nor are we opposed to relocating problem lions. But the people of California have made it plain that they don't want to see mountain lions hunted and killed."

Besides, said Sadler, she is by no means comfortable with Fish and Game's evaluation of the problem. "Fish and Game's science has proved highly suspect in the past, and I believe that could certainly be the case here," she said. "The bighorn's problems didn't start with mountain lions, and they don't end with them. Unregulated hunting years ago, domestic livestock diseases and habitat loss are far more pressing problems."

Yet Torres reiterates that the crisis facing the Sierra Nevada bighorn demands immediate action and says the sheep's plight points to a larger issue. Increasingly, he said, wildlife policy is determined by voters rather than biologists. "More and more, the (initiative process) is controlling the way we manage our wildlife," Torres said, "with sentiment and emotion often counting for more than science. You end up with these broad-brush approaches that don't allow biologists the flexibility they need to address regional problems."

History of Sierra Nevada Bighorn Sheep Recovery

National Park Service
https://www.nps.gov/yose/learn/nature/sheep-history.htm

In the late 1990s, all that remained of the Sierra Nevada bighorn sheep was six herds numbering 125 total animals scattered along the eastern edge of the Sierra Nevada. Facing imminent extinction, the Sierra Nevada bighorn sheep was listed as a federally endangered subspecies in 1999. The reality of the fate that had recently befallen these bighorns brought an increased urgency to an extraordinary effort already underway to save this subspecies from extinction. The quest to save these wild sheep provides one of the most gripping yet heartwarming chapters in Yosemite National Park's history.

Sierra Nevada bighorn sheep evolved long ago as a genetically distinct subspecies of bighorns and, as their name implies, they exist only in the Sierra Nevada. The historical records of bighorn sightings in the Sierra, together with archeological evidence including from American Indians, confirms their past existence in the most rugged and remote wilderness of the southern and central Sierra Nevada, where they were perfectly suited to thrive in alpine landscapes.

The security of the wild sheep's undisturbed habitat was breached soon after the California gold discovery by settlers with their guns and disease-carrying domestic sheep. Lacking natural resistance to certain diseases transmitted from domestic sheep, infected herds began dying out in the 1870s in a progression of losses that continued to the mid-20th century. Only 24 years after the designation of Yosemite as America's third national park, rangers in 1914 noted the absence of bighorns within the park's boundaries. Any hope that herds in adjoining wilderness lands would move to restore the Yosemite herds were dashed when all adjacent herds also perished. The only bighorns to survive 75 years of decimation were in the southern Sierra. By 1978, three herds totaling only 250 animals were all that remained of the Sierra Nevada bighorn sheep, and that number reflected an apparent recent population increase from much lower numbers.

In 1981, the near extinction of this wilderness icon resulted in the initiation of a pivotal and timely collaborative effort between the National Park Service and other agencies, known as the Sierra Nevada Bighorn Sheep Interagency Advisory Group (SNBSIAG). The formation of this group resulted from a recommendation by the pre-eminent Sierra bighorn researcher, Dr. John Wehausen, who played a central role in this advisory group through its existence. This group continued the important work of restoring Sierra bighorn to their historical habitat that Dr. Wehausen had initiated in 1977 as a graduate student.

Biologists successfully reintroduced three herds during 1979-88, and under the guidance of SNBSIAG, released 27 bighorns in Lee Vining Canyon, east of Tioga Pass, in 1986. Because the western edge of this area included Yosemite National Park lands, this herd became known as the Yosemite Herd, and the specific goal of that reintroduction was to return this iconic species to that park. This important event heralded the restoration of the animal that John Muir called "the bravest of all the Sierra mountaineers" to Yosemite National Park after an absence of over 70 years.

In its first year, the Yosemite Herd split into two herds, the Mt. Warren and Mt. Gibbs herds, with sheep in the Mount Gibbs herd moving seasonally between Inyo National Forest lands and the high-elevation border with Yosemite National Park. Overall, these fledgling sheep herds initially lost numbers, in part due to mountain lion predation, until that trend was reversed by an augmentation of 11 more sheep to Lee Vining Canyon and the initiation of mountain lion control in 1988. Those efforts worked and, by 1994, the total population was approaching 100 animals; but sheep were increasingly avoiding use of low-elevation winter range in Lee Vining Canyon, where mountain lion control ceased after a state initiative in 1990 made mountain lions a specially protected mammal. The winter of 1994-95 proved to be devastating for some Sierra bighorn herds that appeared to be avoiding mountain lion predation on lower elevation winter ranges by attempting to live year around at high elevations. The Mount Warren herd was one of those, with only 34 sheep in the Mount Warren and Mount Gibbs herd surviving that winter.

All bighorn herds in the Sierra Nevada experienced similar major population declines in the 1990s after shifting winter habitat use patterns away from lower-elevation winter ranges.

Despite the wholehearted efforts of SNBSIAG, by 1995, the total population of Sierra bighorn was about 115—38% of their numbers a decade earlier. Following little subsequent population increase, late in 1998 SNBSIAG, decided to pursue endangered species status for these sheep. In 1999, Dr. Wehausen drafted petitions for state and federal endangered status. A quote from The Sierra Nevada Bighorn Sheep Foundation, one of five environmental organizations that submitted petitions, conveys the depth of concern for the animals: “Beyond the profound ecological consequences of extinction, the loss of the Sierra Nevada bighorn sheep would have repercussions across centuries of natural and human history, leaving this great mountain range impoverished forever.”

Both the California Fish and Game Commission and the United States Fish and Wildlife Service quickly granted endangered status to these bighorns in 1999.

Official Voting Ballot
California State Senate

In the issue at large, between the management of the species of Sierra Nevada bighorn as well as the mountain lion in the state of California, I vote to:

☐ Maintain the current passage of the California Wildlife Protection Act of 1990 (Proposition 117) by California voters established that mountain lions are a "specially protected mammal" in California and cannot be killed, even to help the protection of the Sierra Nevada bighorn.

☐ Change the current California Wildlife Protection Act of 1990 (Proposition 117) to allow for the managed culling (managed reduction) of mountain lions when science data shows it would help increase the Sierra Nevada bighorn population.

Senate Signature _____ Date _____

Printed Name _____

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Senate Signature _____ Date _____

Printed Name _____

High Country News

KNOW THE WEST

The cost of the bighorn comeback

In California's Eastern Sierra, bringing back bighorn has meant killing more mountain lions.

Julia Rosen | **May 29, 2017** | *From the print edition*

Standing in the middle of an icy trail on a bright December day, Tom Stephenson sweeps an H-shaped antenna overhead, searching for something he already knows is there. Through the blizzard of static on his handheld speaker, faint beeps confirm that a herd of bighorn sheep wearing telemetry collars hides somewhere in this valley on the eastern edge of California's Sierra Nevada. But spotting the buff-colored ungulates can be tricky.

"There's an element of luck to it," says Stephenson, an environmental scientist with the California Department of Fish and Wildlife. A rangy man with graying blond hair, he squints through binoculars at a craggy slope draped in morning shadows and snow. It's a challenging backdrop even for Stephenson, who leads the Sierra Nevada Bighorn Sheep Recovery Program.

Like other bighorn populations across the West, Sierra bighorn were nearly wiped out after European settlers arrived in California, bringing domestic sheep that introduced virulent diseases. By the mid-1990s, scarcely more than 100 bighorn remained — just 10 percent of historic estimates. So the state launched the recovery program in a desperate bid to save this unique subspecies.

"There they are!" Stephenson says, handing me the binoculars and switching to a long scope. He counts 11 bighorn grazing at the base of a cliff — six ewes, two rams and three stub-horned lambs. By 2016, thanks to the efforts of Stephenson's team and a run of favorable weather, the bighorn population had soared to roughly 600 animals living in 14 herds scattered across the range.

The bighorn's recovery has been a remarkable success, but it's come at a price. Ranchers in the Eastern Sierra have lost access to certain pastures, as managers cleared away domestic sheep to prevent another disease outbreak. Two dozen mountain lions lost their lives, too.

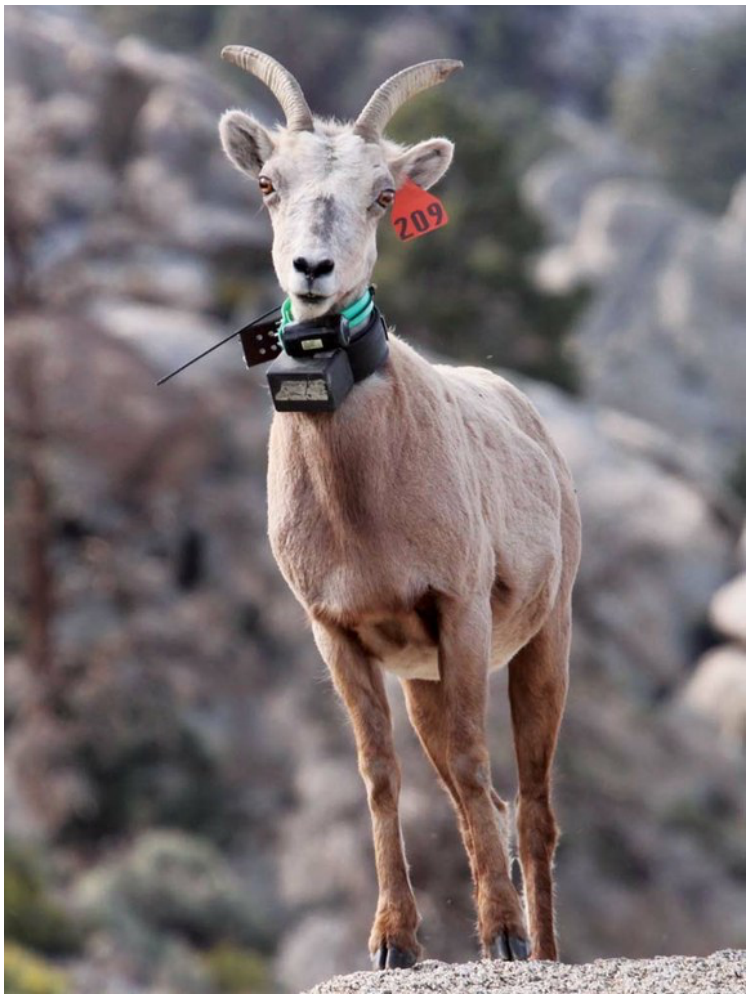
Healthy bighorn populations can handle natural levels of predation from mountain lions, their primary predator. But studies show that cougars can decimate struggling herds, like those in the Sierra. Managers often target the big cats when vulnerable bighorn populations can no longer withstand even minor losses.

Most scientists agree that predator control — often a sterile euphemism for killing lions — is sometimes necessary to protect endangered species. But lion advocates object when such measures take an unnecessary toll or drag on for too long. At best, they say, removing predators is a temporary stopgap. "The more complex discussion is, how do you get to this place in the first place," says Mark Elbroch, the lead puma scientist at Panthera, a wildcat conservation organization. "Why is it even on the table?"

The answer, at least in the Sierra Nevada, is sadly familiar: Centuries of human impacts have left no simple solutions to ensure the sheep's recovery. Those who want to see bighorn and big cats coexist again must reckon with the legacies of past wrongs while trying not to commit new ones — no easy task.

"None of this is what we would like to have to be doing," says Stephenson. "But if we want to try to restore this ecosystem, it's one of the realities that we're having to deal with."

Thirty miles southeast of where Stephenson and I spotted the bighorn, a modest building sits on the outskirts of Bishop, California. John Wehausen, thin and bespectacled, leads me there on cattle-worn trails through the sagebrush scrub. He swings open the door to reveal heaps of salvaged scientific equipment and tables brimming with paper lunch bags full of lamb manure. This is where Wehausen analyzes bighorn DNA, including what he extracts from these Grape-Nut-sized pellets. “It’s the only genetics lab with a wood-burning stove,” he jokes.



A Sierra bighorn sheep, radio collared and tagged, before being released in the Eastern Sierra Nevada.

Steve Yeager

Wehausen started studying Sierra bighorn in the late 1970s as a graduate student at the University of Michigan. He’s now technically retired after spending decades at the University of California’s White Mountain Research Center, but he still helps with bighorn recovery, mostly for free. “It’s been my life’s work,” he says. And it’s been a rollercoaster.

When Wehausen conducted the first Sierra bighorn census, there were roughly 250 left. They were disease-free, so he helped convince the state to launch a restoration project. They would take sheep from two surviving populations in the remote Southern Sierra and begin re-establishing herds throughout the range. Wildlife managers wanted to use only native sheep, since Sierra bighorn differ genetically from their Rocky Mountain and desert kin.

The effort started off well. Three new herds were seeded, including one on Wheeler Ridge, which is visible from Wehausen's lab. Back then, he says, "I would have told you that we would have them back to all their historic range by the turn of the century." But that's not what happened. In the mid-1980s, the herds began to shrink, forcing the department to put translocations on hold.

Mountain lions are one of the threats to the bighorn population, and some have been killed to protect them.

Josh Schulgen/California Department of Fish and Wildlife

Over the previous decade, Wehausen had begun documenting more and more lion tracks and kills. He counted 49 bighorn killed by lions between 1977 and 1988, representing 70 percent of recorded deaths. Coming back from a long hike in Sawmill Canyon, he actually saw a cougar tackle a ewe on a rocky ledge. "One bound," he recalls, "and it was on her." Entire herds also stopped descending from the high country to graze in the low-elevation winter ranges they shared with mule deer, the lion's primary prey. Wehausen believes the bighorn abandoned these areas because of increased cougar activity. And the loss of such a valuable food source only amplified the effects of direct predation on the herds.

Wehausen suspects that predation increased because of an anomalous surge in lion numbers. Lions had begun to recover after California stopped offering bounties for killing them in 1963, and then, in 1972, imposed a moratorium on sport-hunting the animal. Along the Eastern Sierra, evidence suggests the lion population peaked in the 1980s, fed by an abundance of mule deer, which had benefited from irrigated

agriculture and clear-cutting in their summer habitat across the mountains. “These dynamics were derived from all these past human influences,” Wehausen says, and bighorn got caught in between.

Others believe that weather, not predation, drove the sudden bighorn decline. A drought began in 1987, the year the largest herd abandoned its winter range, and the valley never greened up. The mule deer population plummeted, and bighorn likely suffered, too, says California Department of Fish and Wildlife biologist Jeff Villepique, who studied Sierra bighorn for his doctorate in the 2000s. Bighorn are well suited to alpine life, he says, and they clung to the safety of the mountains because there was no food to lure them down and no heavy snow to push them out.

In his research, Villepique also struggled to find evidence that lions had kept sheep away from their winter ranges. For instance, when Villepique tracked bighorn movements with GPS collars, he found that they actually seemed to prefer areas with more lions. The lions followed the deer, and the deer followed the choicest vegetation. Bighorn seemed willing to risk getting eaten to join the feast.

These competing hypotheses echo a long-standing debate: whether predators control populations from the top down, or whether food controls them from the bottom up. The lack of a clear explanation in this case still bothers Vern Bleich, who ran the recovery program from its inception until 2008, when he retired and Stephenson took over. He wanted to understand how the sheep ended up in such a bind, but the answer proved elusive. “That has been a great disappointment to me,” he says.

One way or another, the bighorn population plunged to its lowest point in 1995. Even if predation wasn’t the primary cause, managers felt it now posed a serious threat. There was little published science on this at the time, but studies from Alberta to the Mojave have since demonstrated that lions can depress or even extirpate small bighorn populations.

Managers felt the best option was to kill lions. However, a 1990 California ballot measure had made the earlier moratorium on lion hunting permanent. Sheep advocates petitioned — successfully — to have Sierra bighorn protected under the

federal Endangered Species Act in 1999. The new status gave managers the power to override state law, which the Legislature later amended anyway. And soon after listing, the state launched the recovery program with predator control as a central component.

Tom Stephenson listens for a signal from radio-collared bighorn in McGee Creek Canyon this winter.

Julia Rosen

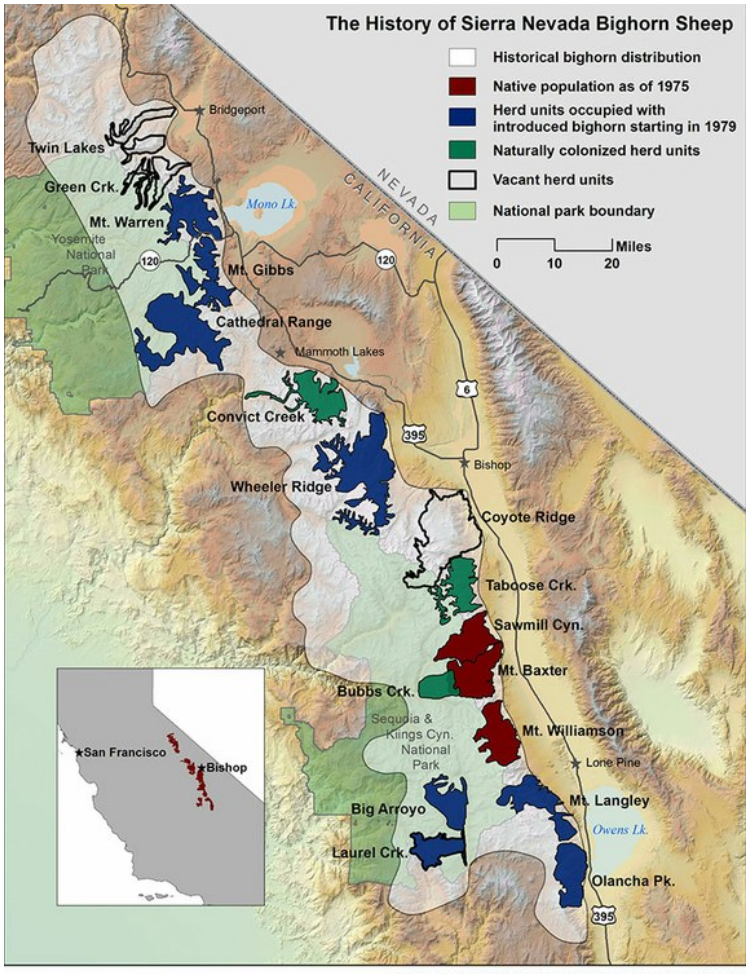
The next fifteen years were kind to Sierra bighorn as managers forged ahead on the other aspects of the recovery program, shuffling sheep around to help populations grow. Using net guns and helicopters, they would move a ewe to boost a herd's numbers, or relocate a ram to increase genetic diversity. A few adventurous bighorn split off, colonizing several new herds on their own, and starting in 2013, managers established the final four herds required for recovery.

Meanwhile, managers worked to stamp out the risk of a disease outbreak by moving domestic sheep away from bighorn habitat. Though perhaps 1,000 sheep still graze in high-risk proximity to bighorn, thousands more were cleared off some 57,000 acres of pasture — mostly in the Inyo National Forest and on land owned by the Los Angeles Department of Water and Power. As a concession to ranchers, managers decided not to re-establish herds at the northern end of the range, where the most intense ranching still occurs. It began to seem possible to down-list the sheep from endangered to threatened by 2017, the official goal of the recovery plan.

The final version of that plan was hammered out over eight years with input from a diverse group of stakeholders, and it also detailed when lions could be removed. The nonprofit Mountain Lion Foundation participated in the negotiations and acknowledged the need to kill lions, says Chris Papouchis, a conservation biologist who served as its representative. But the foundation insisted that managers take out only lions that threatened sheep. That would minimize the impact on lions, they argued, and perhaps also prove most effective at reducing predation.

Lion populations can't survive on bighorn alone, and many experts believe that only some cats specialize in sheep. Villepique recalls one astonishingly long-lived cougar — it reached 18 in the wild — that regularly hung around bighorn, but appeared to dine only on mule deer. From a bighorn's point of view, it was a "good" lion. And predator biologists say that removing a good lion simply makes room for a potential sheep-eater to move into town.

Rob Wielgus, who leads the Large Carnivore Conservation Lab at Washington State University, has also found that removing too many lions — especially males — can actually *increase* predation. His work on the cat's relationship with endangered mountain caribou showed that killing male lions brought an influx of new males. They killed kittens and forced females to higher elevations, where they killed *more* caribou, instead of choosing the vastly more abundant deer at lower elevations. In cases like these, he says, "we screw it all up."



SOURCE: CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

Becky Pierce, the former predator biologist for the Sierra sheep recovery program, was especially worried about

other lions straying into bighorn habitat from the surrounding wilderness. So Pierce's team collared resident lions to find out exactly which cats were killing sheep and to track down the offenders.

Under Stephenson's direction, however, Pierce felt that the program became more aggressive and less discriminating. She accused Wildlife Services — the federal agency contracted to kill the lions — of doing its job inhumanely, and also illegally. She says that one orphaned litter of kittens was left to starve; another was mauled to death by a houndsman's dogs. She also learned that government hunters had caught lions using snares, which she believed violated state law. "I'm not an animal-rights activist," Pierce says, pointing out that she had authorized many removals herself, but the incidents still disturbed her.

So she filed a complaint against Stephenson and the department with the California branch of the watchdog group Public Employees for Environmental Responsibility in 2010. Later that year, a state legislative counsel concluded that snares were indeed illegal, and soon after, the predator control program ended. Pierce, who no longer works on the project, also sued the department for defamation and retaliation for whistleblowing. That suit was settled out of court in September.

Stephenson says that the program did ramp up lion removals under his watch, but only because of a troubling uptick in predation, especially in source herds used for translocations. Stephenson emphasizes that the department still targeted only "problem" lions, and that it was unclear that snares were illegal prior to the 2010 ruling.

"We don't have anything against lions," Stephenson says. However, he had a clear mandate to restore bighorn. "Sierra sheep were the endangered animal and mountain lions are quite abundant in California," he says. And the faster sheep recovered, the sooner the state could cease predator control altogether.

John Wehausen in the lab where he analyzes bighorn DNA.

Julia Rosen

Around the time Pierce filed her complaint, the Arizona Game and Fish Department began contemplating its own bighorn restoration project in a mountain range near Tucson. The Santa Catalinas rise above Tucson in muscular layers of igneous and metamorphic rock, and until the 1990s, they hosted a population of desert bighorn. The sheep's disappearance remains mysterious, but bighorn advocates and state officials saw an opportunity to re-establish the herd after fires restored desert and forest habitat that had been overgrown by brush.

Proponents expected that the effort would have to involve killing lions. The source herds couldn't provide enough bighorn to re-establish a large population in one go, so the herd would be vulnerable at first. But the department also anticipated that would rile Tucson's environmental community. Like many state wildlife agencies, the department had been criticized for managing predators with a heavy hand. Some say that stems from agencies' allegiance to hunters, who often see predators as competition for deer, elk, and other game animals, and who provide a major source of funding through their purchase of hunting licenses.

So a group of citizens formed an advisory committee to help design a biologically and politically viable project in the Santa Catalinas, just as happened in the Sierra a decade earlier. It included Mike Quigley of the Arizona chapter of The Wilderness Society and Brian Dolan, an avid hunter who became heavily involved with bighorn

restoration after the life-changing experience of bagging a sheep in 1995. They still debate whose idea it was. “I had a couple of beers with Quigley and we talked about it,” says Dolan. “He credits me with it, and I credit him.”

The resulting deal appeased everyone, including Quigley and the hardline Center for Biological Diversity, another environmental nonprofit. Predator control would be temporary and surgical. Nearly every bighorn released into the Santa Catalinas would wear an expensive GPS collar, and government scientists would follow up on sheep deaths immediately and report them to the public. If a lion had been responsible, a houndsman would track and kill it.

Today, after four years of translocations, the project has achieved its goal: 85 sheep roam the Santa Catalinas. Lions did kill some, particularly in the first year, and eight cats were removed. But last fall, as promised, the department curtailed the houndsman’s contract. “Now we’re back to business as usual,” Quigley tells me. “The sheep and lions are going to have to figure it out.”

Still, the reintroduction has served as something of a Rorschach test. Dolan notes that, because of the punishing terrain, the houndsman couldn’t catch every lion that killed sheep. To him, that suggests predator control may have been unnecessary.

To others, however, the challenge of catching lions underscores the need to remove some animals beforehand. “You’re going to end up taking that lion anyhow, you might as well take it before you trade two or three or four sheep,” says Eric Rominger, a biologist who has worked on the California restoration effort and informally consulted on the Arizona project.

Rominger, known for his ardent support of predator control and his Sam Elliott-style mustache, thinks bighorn need extra help where lions are “subsidized” by large populations of deer or livestock; lions subsist on these prey while opportunistically hunting bighorn to extinction. His own research suggests that range-wide lion control helped drive down predation on state-endangered bighorn in New Mexico and boost the population from less than 170 in 2001 to more than 1,000 today.

But Rominger admits that there have been few controlled scientific experiments testing the effects of predator control in situations like these. And scientists have only compared the impacts of targeted versus indiscriminate lion removals in models. In reality, Rominger says, managers usually find themselves in a crisis, like he was in New Mexico. “I had no inclination to leave half those herds as controls only to find out that, guess what, they went extinct because of lion predation.”

A bighorn ram killed by this year’s harsh winter, which dropped more than 40 feet of snow in parts of the Sierra Nevada. Between the weather and a spike in predation by mountain lions, roughly 15 percent of the sheep population has perished.

Steve Yeager

On a bluebird day in late January, Stephenson skis back into the valley we visited the previous month, this time on a grim mission: to investigate the deaths of three bighorn. He finds them in the creek, their broad-set eyes and coarse fur preserved by the frigid water. He suspects they died of hypothermia when they couldn’t scale the 6-foot-tall snow bank on the far shore.

These are just a few casualties of what has been a brutal winter for Sierra bighorn. More than 40 feet of snow has fallen in places, and Stephenson says the animals struggled to move around and find food. On top of that, predation has spiked again in one of the main herds used for translocations. Two lions killed 12 ewes, out of a population of 50. “That’s beyond the point where we get concerned,” Stephenson says.

It's a devastating double-whammy. "If it was just one or the other, it would be serious, but it would be that much easier to try to manage," Stephenson says. At least 91 sheep have died — roughly 15 percent of the total population.

Just a few months ago, the bighorn's recovery seemed imminent. The number of breeding females had grown close to threshold for down-listing, and managers had recently won a hard-fought battle to vacate one of the last grazing leases next to occupied bighorn habitat — a plot of county land near Yosemite. In December, Stephenson had told me that the bighorn were doing well enough to handle some predation.

But this year's losses will almost certainly put off down-listing the animal. With luck, Stephenson says, "we might only be looking at a delay of another two or three years." Otherwise, managers will have to step in again. Stephenson says all options are back on the table, including removing lions. In a tragic twist, an act of nature may drag them back into the crosshairs again.

However, Stephenson remains hopeful. "We're still a heck of a lot better than where we've been 15 years ago," he says with a sigh. "You just have to realize that it's just going to be a tougher effort than you always think it's going to be."

A mountain lion that shares habitat with bighorn sheep in the Eastern Sierra Nevada of California.

Steve Yeager