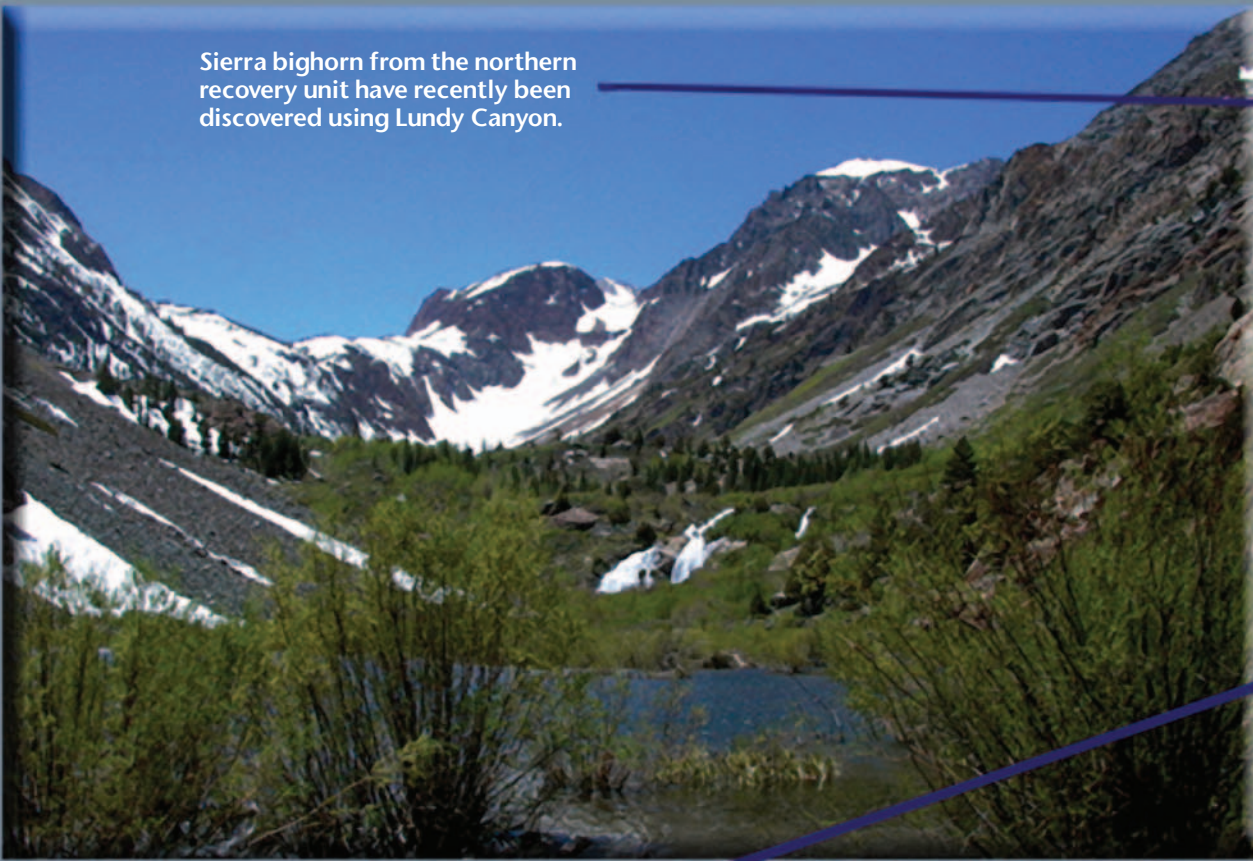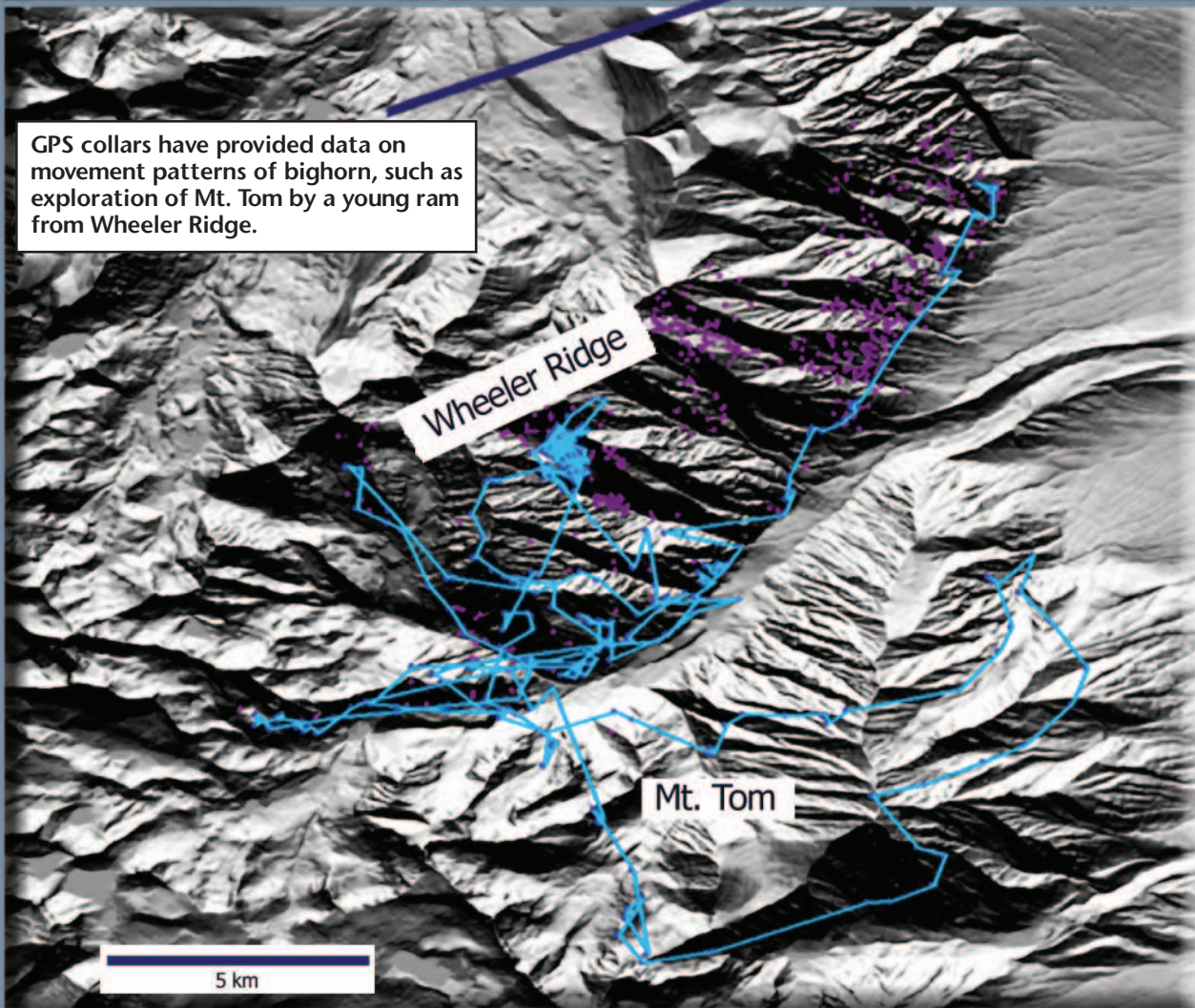Sierra bighorn from the northern recovery unit have recently been discovered using Lundy Canyon.
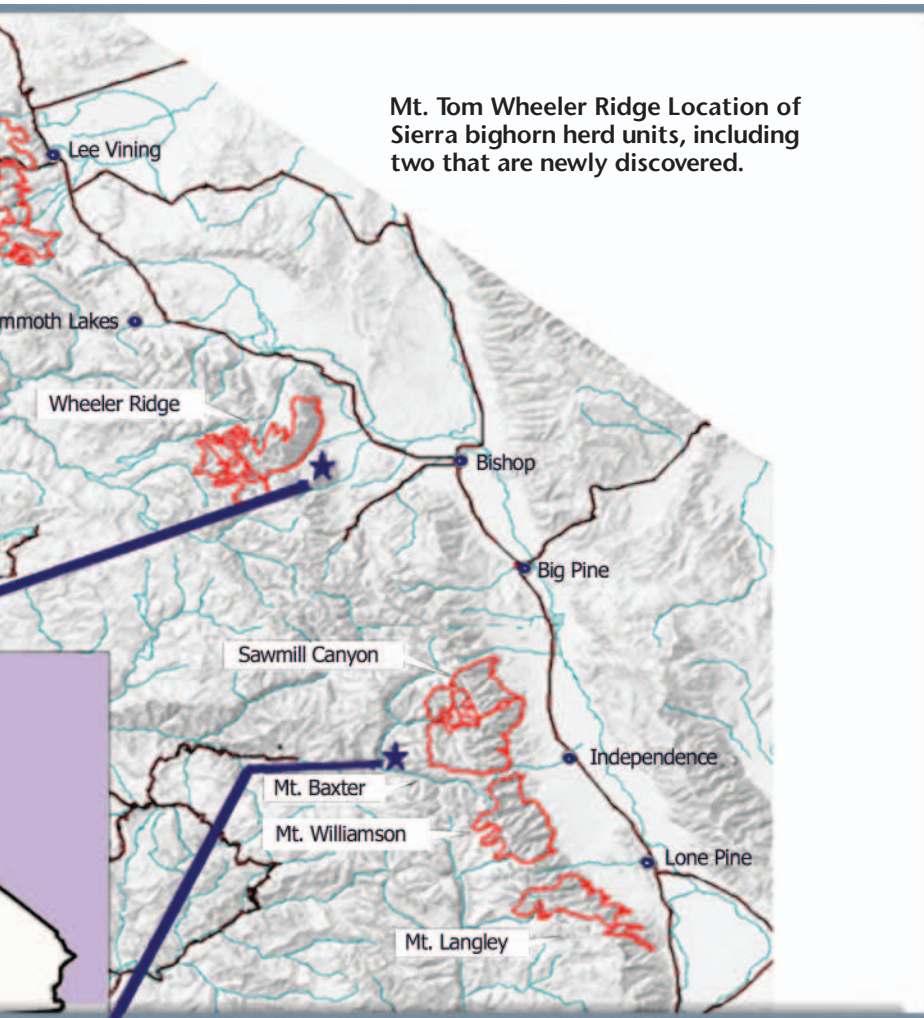
Mt. Warren

Mt. Gibbs

GPS collars have provided data on movement patterns of bighorn, such as exploration of Mt. Tom by a young ram from Wheeler Ridge.

Wheeler Ridge

Mt. Tom

5 km

A new group of Sierra near Mt. Gardiner in t on the west side of th

Mt. Tom Wheeler Ridge Location of Sierra bighorn herd units, including two that are newly discovered.

[map labels: Lee Vining, Mammoth Lakes, Wheeler Ridge, Bishop, Big Pine, Sawmill Canyon, Mt. Baxter, Mt. Williamson, Independence, Lone Pine, Mt. Langley]

...n bighorn was discovered
...he Bubbs Creek drainage
...e Sierra crest.

Discovery of bighorn range expansions

Just how remote are portions of the Sierra Nevada? Well, they are remote enough to conceal the existence of at least 16 bighorn in the vicinity of Mt. Gardiner. How long they have been there in recent times we can't be sure, but they escaped detection until summer 2002 when a climbing guide reported an observation near Charlotte Dome. Their existence and something of their distribution was subsequently confirmed during repeated field surveys during summer and fall 2002. Then, during a winter helicopter survey, 16 animals were seen on cliffs near the confluence of Bubbs Creek and the Kings River in Kings Canyon National Park. These are currently the only bighorn wintering at moderate elevations (8,000 feet) west of the Sierra crest, which raises questions about their ability to survive during severe winters with heavy snowfall.

In May 2003, we discovered bighorn sheep using the north side of Lundy Canyon. We are continuing field surveys to determine the full extent of their range. Since their discovery, lambs have been born in this new range. Of interest also, are movements made by rams. A 10-year-old ram collared in May 2002 in Lee Vining Canyon traveled to Laurel Mountain (more than 33 miles) late in 2002 and remained there for the winter. Because he only wears a VHF collar, we can only presume that he traveled along the crest and over Mammoth Mountain to arrive at his destination. A two-year-old ram, wearing a GPS collar, traveled from Wheeler Ridge to Mt. Tom on several occasions during the past year. The extensive movements made by these males confirm the value of radio collaring rams, and raise concern about the potential for rams to act as disease vectors between domestic sheep and bighorn ewe groups over great distances, and have implications for metapopulation (define term) structure of bighorn in the Sierra Nevada. 🐻

Focus on habitat: A look at weather

Winter ranges of Sierra bighorn are influenced by climatic factors that shape the quality and accessibility of forage, a major factor in ungulate population dynamics. The quantity and timing of precipitation and interaction with temperature and wind speed dictate the depth and persistence of snow cover, location of snow-free areas, and ultimately drive the quality, timing, and elevational progression of forage green-up. We are investigating these, and other weather parameters, to determine how weather affects forage and, in turn, influences movements of Sierra bighorn sheep.

The charts below illustrate interactions among data from weather stations at a high elevation and a low elevation on Wheeler Ridge (other stations have been installed at Lee Vining and Mt. Baxter). The high-elevation station is sited on a windblown summit where little snow persists in cold, windy storms (e.g., December to January), while warmer storms accompanied by lighter winds (e.g., February to March) allow the formation of a hard, wind-resistant surface layer of snow, conditions that would cause great difficulty for movement and feeding by bighorn sheep. At the lower elevation, wind speed and temperature are more moderate and snow persists until warmer temperatures cause melting. Snow cover also is being quantified photographically at Wheeler Ridge, allowing the delineation of snow-free areas, and ultimately providing data to parameterize a model of snow cover dynamics incorporating aspect and elevation.

Weather stations also measure soil moisture and soil temperature, which are expected to drive the timing of green-up and resultant quality of forage. The distribution and behavior of Sierra bighorn sheep will be evaluated in relation to these climatic data to aid in our understanding of how these animals respond to their environment.
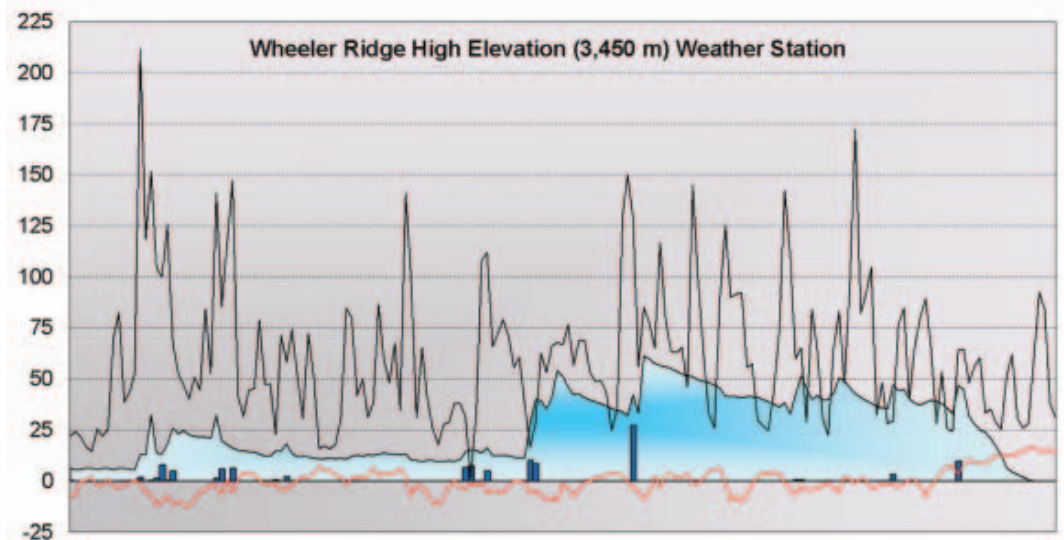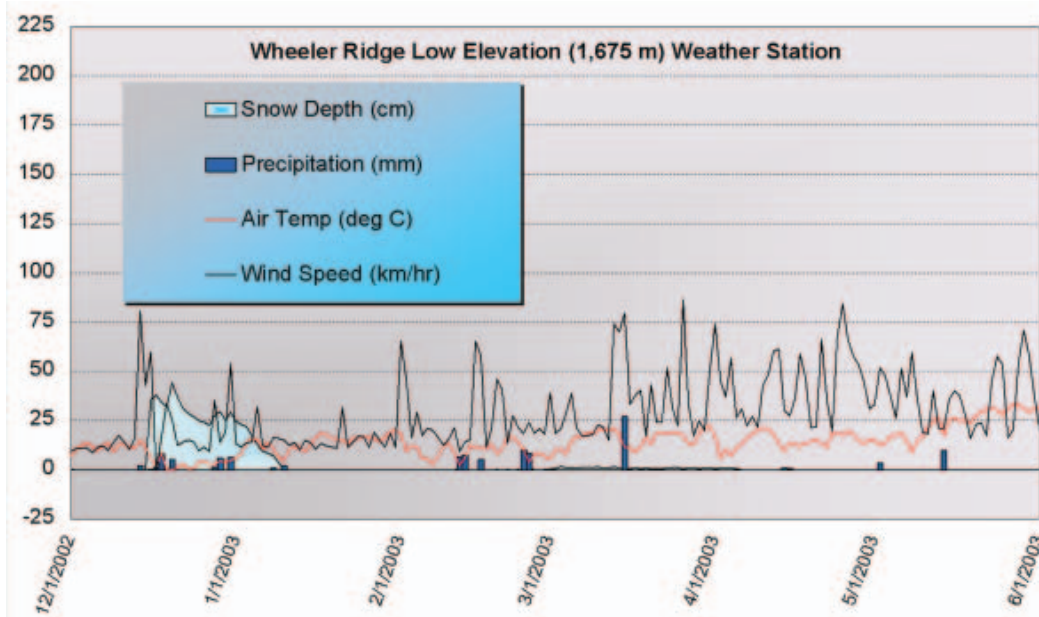
Predator monitoring

The predator monitoring program of the Sierra Nevada Bighorn Sheep program consists of Department of Fish and Game (DFG) seasonal and full-time employees, and contractors from the United States Department of Agriculture (USDA), Wildlife Services Division. Personnel monitor the activity of predators including mountain lions (*Puma concolor*), coyotes (*Canis latrans*) and bobcats (*Lynx rufus*) that may threaten Sierra bighorn, and gather data on the ecology of those predators, particularly in relation to their interactions with Sierra Nevada bighorn sheep.

On rare occasions predator monitoring personnel may deem it necessary to kill an individual predator to protect bighorn from predation, but this decision is made only after intense investigation and careful risk assessment. To improve the information used to make decisions about the management of predators in the Sierra, predators are fitted with radio collars and data collected on their ecology, including movement patterns, feeding behavior, and reproduction. The predator monitoring team 's goal is to increase the understanding of the role predators play in the ecology of bighorn sheep through the gathering of data and to remove predators from the system only when absolutely necessary for the protection of the endangered Sierra Nevada bighorn subspecies.

At this time the only species of predator to be fitted with radio collars is mountain lions. Among potential predators of bighorn sheep, mountain lions have been the primary focus because they pose the greatest mortality threat.

On one occasion a bobcat was found feeding on a bighorn, but investigation by Wildlife Services specialists revealed that the sheep had fallen in a rockslide. Efforts to capture bobcats for the purpose of fitting them with radio collars and monitoring their use of Sierra sheep winter range will be attempted in the future. On several occasions, program personnel have surveyed

Radio collared mountain lion returns to bighorn sheep kill on Wheeler Ridge winter range (December 1994)

Mountain lion kittens in the birth nursery.

Sierra bighorn summer range for the sign of coyotes near lambing areas. No predator sign has been detected near the bighorn during these surveys.

During 2002 there were 14 successful captures of mountain lions that included fitting five new animals with radio collars. One female mountain lion was released without being immobilized because she was obviously due to give birth in the immediate future. Those captures brought the total number of mountain lions tagged or collared in the eastern Sierra Nevada since December of 1991 to 65. Since the beginning of the Sierra bighorn recovery program in 1999, 32 mountain lion captures have resulted in 21 new individuals being tagged or radio collared. Captures included three kittens at a den site, of which two later were fitted with radio collars before dispersing. Of the five new animals captured during 2002, one was near the Mt. Williamson bighorn sheep area, two were near the Wheeler Ridge bighorn sheep range, and two were in Mono Basin near the Lee Vining bighorn sheep range. Although our emphasis has been to catch mountain lions that inhabit bighorn sheep winter range, animals captured and collared in the Mono Basin were primarily byproducts of attempts to recapture a male mountain lion that we knew used Wheeler Ridge, but spent much of his time near the Nevada border. Because mountain lions have very large home ranges and because juveniles born in the Mono Basin could easily disperse to the northern Sierra bighorn winter ranges, we chose to fit the mountain lions caught in the Mono Basin with radio collars. In addition, five other mountain lions were recaptured during 2002. Recaptures were conducted for several purposes including replacement of VHF collars with GPS collars, and use of ultrasonography to determine pregnancy and fetal rates.

Catching mountain lions

In the past, the primary responsibility of the Wildlife Services Division of the USDA was predator eradication. Formerly called Animal Damage Control, personnel working for the Wildlife Services Division concentrated on the removal of animals that were considered pests, including mountain lions that killed domestic livestock. In the last decade, the mission of the Wildlife Services Division has broadened so that the expertise of its wildlife capture specialists can be used to benefit numerous wildlife programs. The Sierra Nevada Bighorn Sheep Recovery Program has contracted two wildlife capture specialists from Wildlife Services Division. Both specialists are houndsmen that have decades of experience in the capture of mountain lions using dogs. Such unique knowledge and skill is a necessary component of the Sierra bighorn program.

Specially bred and trained hounds of several breeds are used to trail mountain lions by following tracks initially located by the capture specialists. When the dogs get close to the cat they are trailing, the mountain lion normally will flee into a tree where it is immobilized using drugs, and then fitted with a radio collar. Radio collars assist the houndsmen in monitoring mountain lions for the purpose of detecting threats and preventing losses to Sierra bighorn from predation. Not only do the capture specialists track and tree mountain lions for the purpose of collaring them, but the capture specialists also investigate the cause of mortality of Sierra bighorn, collect data on the numbers and movement patterns of mountain lions and smaller predators, humanely remove predators that are confirmed to have killed bighorn sheep and pose a continued threat, and assist in the locating and monitoring of bighorn. The cooperation of the DFG and Wildlife Services Division is an important aspect of the recovery program that maximizes the effectiveness of the overall program and greatly enhances the chances of recovery for Sierra Nevada Bighorn Sheep. 🐻

Wildlife Services capture specialists use their unique skills and those of their hounds to safely capture mountain lions.

Ultrasongraphy of mountain lions

With support from the California Deer Association, the bighorn sheep team has access to a new light-weight, portable ultrasound machine. During the past year, the machine was used to test for pregnancy of two mountain lions. Although neither was pregnant, the view from the ultrasound machine was clear and consistent with what was expected to be seen, based on experience with other species: fetuses were absent, the bladder and kidneys were clearly discernable and were similar for both individuals. The team hopes to test ultrasonography on a pregnant mountain lion in the near future. This new technique should allow for a more accurate determination of the reproductive status and success of female mountain lions in the population which helps predict future population trends. Two of the most difficult life history parameters to determine for a mountain lion population are reproduction and survivorship, yet those data can be extremely important in helping biologists predict future population trends and overall health. Locating mountain lion dens, and handling the kittens within several days of birth, has traditionally been the only method of determining the number of kittens born in a litter, and the mortality rate of young mountain lions in the area before dispersal. Unfortunately, it is difficult to locate mountain lion dens immediately after the mother has given birth, and sometimes the team catches new mountain lions that are traveling with

one or more juveniles. When those situations occur there is no way to know the original litter sizes or if offspring have died. Bighorn recovery program personnel have been using ultrasonography to determine pregnancy and fetal rates of large mammals for many years. The success of this technique with wolves in Alaska makes the team confident that it will be useful for mountain lions in the eastern Sierra Nevada. 🐻

GPS radio collars

Advances in technology have enhanced the ability of wildlife biologists to track the movements of large mammals including bighorn sheep and mountain lions. As part of the Round Valley Mule Deer Project, two mountain lions were fitted with GPS radio collars in 1998. Those collars recorded location data for several months using satellite triangulation. During this trial, data for both mountain lions were downloaded from the radio collars after recapturing the animals, and the collars proved that detailed information could be obtained about the movement of mountain lions using GPS technology. These early collars required the recapture of animals to download the data. Furthermore, the collars were too large to place on female mountain lions. During 2002, we obtained GPS collars with remote-download capability. The new collars also were small enough to place on female mountain lions, and in March 2002 a female mountain lion that frequents the Wheeler Ridge bighorn sheep winter range was fitted with a GPS collar. Since then, eight mountain lions (five female, three male) have been fitted with the new GPS radio collars. Those mountain lions all frequent areas near or within bighorn winter ranges. The GPS data have provided us with improved ability to track their movements and determine the threat they may pose to populations of Sierra bighorn in near realtime.

Because mountain lions usually cache ungulate kills and return to feed on them for several days, GPS data have been useful in helping us locate kills made by mountain lions. When data from the GPS collars are plotted on maps using our geospatial database, clusters of points often indicate the location of a kill made by the mountain lion. Fifteen location clusters have been investigated using GPS data from mountain lions. Thirteen locations provided solid evidence of a deer kill, while at two locations no lion sign was found. The two locations where no evidence was found were both investigated more than three months after the mountain lion was known to have been at those locations.

The longest period that has elapsed where evidence of a kill was still apparent was 56 days. Continued investigation of locations over different time periods may provide program personnel with an estimate of the maximum time period in which definitive conclusions about predation events on deer and bighorn can be drawn. In addition, a model to determine the probability of a predation event having occurred based on location data collected from GPS collars may be developed in the future. This would allow managers to estimate within a certain level of confidence, the probability that an ungulate kill was made by a specific mountain lion at a specific location and time, using GPS data alone. GPS cluster data, in conjunction with tracking data, have not identified any Sierra bighorn killed by mountain lions through 2002. Intensive monitoring of mountain lions, including the added data provided by GPS radio collars, has allowed us to establish a surgical approach to predator control whereby only individual mountain lions that pose an immediate threat to Sierra bighorn will be removed.

New GPS radio collars have remote download capability, and are smaller and lighter than those previously used in the eastern Sierra Nevada.

Geospatial database

Bighorn Sheep Program personnel spent a portion of 2002 developing a geospatial database that integrates ArcView GIS (Geographic Information System) and a Microsoft Access database, allowing us to view GPS data in a spatial data format. Geospatial data are being collected on a daily basis by all personnel working with the Sierra Nevada Bighorn Sheep Recovery Program; however, when the data reside only on hardcopy data sheets, it is difficult to see patterns or analyze information.

Thanks to the geospatial database, personnel can quickly integrate information that has been gathered over the past four years. Predator monitoring personnel carry hand-held GPS units that record their survey routes and the location of any important predator sign or sightings of bighorn sheep. Data are downloaded at the end of each month and linked with the information recorded by personnel in an Access database. The geospatial database can then be viewed to answer questions about the locations of individual animals, tracks, kills, sightings or to determine areas that need more search effort. Clicking on any of the symbols displayed on the ArcView maps brings up the information about the animal, track or sign from the Access database. Data
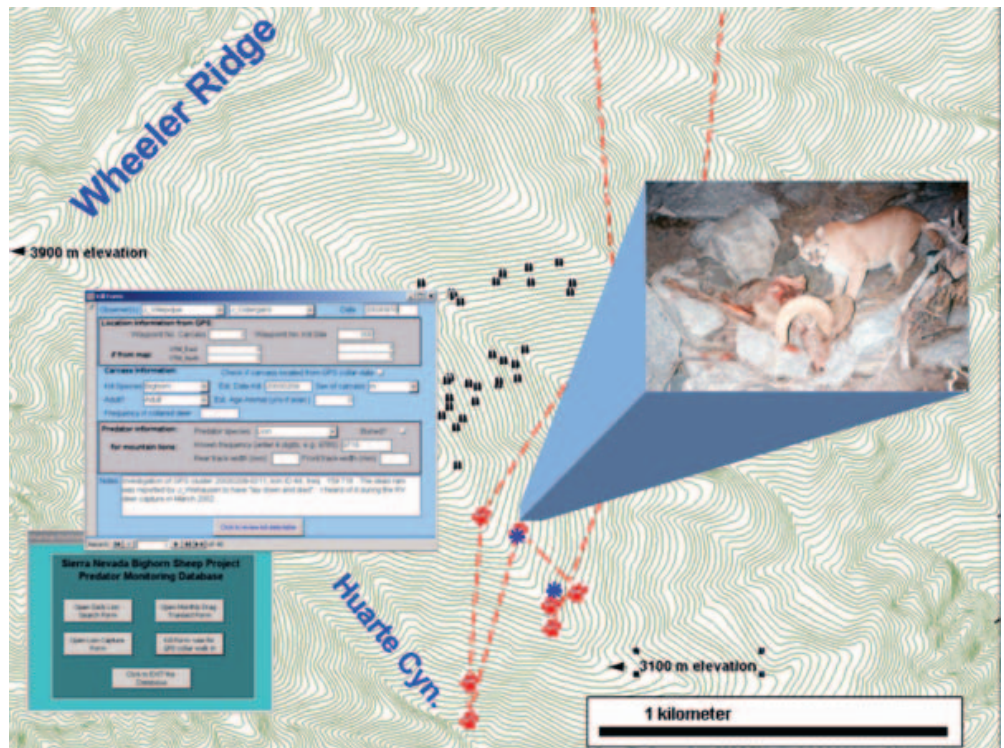
can also be edited in the ArcView format.

In the future, the geospatial database will be a critically important tool for answering queries about seasonal movement patterns of predators and bighorn sheep, habitat use by bighorn sheep and mountain lions, distances between predators and bighorn sheep

groups, density estimates for predators in different regions of the Sierra bighorn recovery area, and responses of bighorn sheep to movement by predators, along with a number of other questions that will be important for understanding the ecology of bighorn sheep and predators in the eastern Sierra Nevada. 🐻

This program brought to you by ...

Mule deer in the Eastern Sierra

The dynamics of populations of large mammals such as Sierra Nevada Bighorn Sheep, mule deer, and mountain lions are inextricably linked. Round Valley, a broad alluvial area located adjacent to Wheeler Ridge, has been the site of long-term investigations of ecological relationships between mule deer and their primary predator, mountain lions. Round Valley is typical of most winter ranges used by mule deer in the eastern Sierra Nevada, and vegetation is characteristic of much of the western Great Basin. Species of great importance to deer include bitterbrush, sagebrush, blackbrush, mountain mahogany and, during the late winter and early spring, ephemeral grasses and forbs. Production of forage is a function of the timing and amount of precipitation that occurs prior to the onset of vegetation growth each spring. The population of mule deer in Round Valley has been under study since 1984, when nearly 6,000 animals inhabited the area.

Mule deer in Round Valley.

The population declined substantially over the next several years, reaching a low of 950 animals in 1990. Since then, there has been a gradual increase in the deer population, to about 2,300 animals during January 2003.

Following the rapid decline in deer numbers, the mountain lion population in Round Valley declined at a very low rate. In the early 1990s, an average of 6.1 mountain lions were present in Round Valley on any given day; by 1999, however, the average number of lions had declined to 0.6, approximately 10 percent of the value in 1992. We do not know the number of lions that used Round Valley during the period of rapid decline in deer numbers, but it may have been much higher than in the early 1990s. The low rate of decline in lion numbers, which occurred even as the deer population was recovering, suggests a substantial time lag in the decline of mountain lions.

During the late 1980s, and especially the early 1990s, a marked increase in the number of depredation incidents and public encounters with mountain lions occurred. It is probable that declines in the primary prey resulted in some changes in mountain lion diets, which are reflected in increased rates of depredation on livestock and other domestic animals. Presumably, "prey switching" may have resulted in increased rates of predation on the native sheep in the Sierra Nevada, and distribution of sheep may have changed as a result of increased rates of predation. As deer numbers recently increased, lion numbers have begun to increase, and predation rates on sheep have declined.

Climate, which drives forage dynamics in most systems inhabited by large ungulates, is an extremely important factor affecting the dynamics of both mule deer and bighorn sheep. Mountain lions, which respond to changes in prey density, affect the dynamics of different species of prey at different rates. And, as prey numbers change, densities of predators change. The dynamics of predators and prey in the eastern Sierra Nevada are complex, but long-term research in Round Valley is providing insight into the ways that these species interact, and their responses to annual differences in weather. Information learned in Round Valley will be applicable to other similar systems, and long-term investigations are the only way that the complexities of multi-prey systems will be understood. One goal of the Sierra Nevada Bighorn Sheep Recovery Program is to gain adequate understanding of those interactions, and to put that knowledge to use on behalf of bighorn sheep, mule deer, and mountain lions in an intact ecosystem that requires little intervention to ensure the viability of all of those species.

Remote weather station on Wheeler Ridge.