2018 Status of Sierra Nevada Bighorn Sheep Herds in Yosemite National Park

Annual Report to Yosemite National Park

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This report summarizes the data developed in 2018 for the bighorn sheep herds that use habitat within Yosemite National Park. The geographic region in which these herds occur was labeled the northern recovery unit (NRU) in the recovery plan for Sierra Nevada bighorn sheep (U. S. Fish and Wildlife Service 2007) and includes two herd units defined in that plan (Mount Warren and Mount Gibbs herd units), as well as an additional one initiated in 2015 by translocation of Sierra bighorn to the Cathedral Range (Cathedral Range herd unit). Habitat for the Cathedral Range herd lies entirely within Yosemite National Park. The other two herd units straddle the Sierra crest and occupy a considerable amount of habitat on lands east of that crest managed by the U.S. Forest Service (Inyo and Toiyabe National Forests). Data reported here are part of a cooperative effort involving the California Department of Fish and Wildlife Recovery Program for Sierra Nevada Bighorn Sheep, the Sierra Nevada Bighorn Sheep Foundation, and Yosemite National Park.

The NRU lies at the current northern end of bighorn sheep distribution in the Sierra Nevada. As such, it typically receives higher snowfall than most herd units further south. All herd units in the NRU include bighorn sheep that live at high elevations year round where they depend on wind-swept ridges and slopes that are largely snow free in winter. In Lee Vining and Lundy Canyons there are lower south-facing canyon slopes used in varying degrees in the past as winter and spring habitat by members of the Mount Warren herd. While Lundy Canyon may still receive some such use by rams, currently all persisting ewes in the NRU appear to reside at high elevations in winter and spring, except some spring use of lower elevations in Bloody Canyon by sheep in the Mount Gibbs herd.

Mount Warren Herd

This herd epitomizes potential difficulties involved in wildlife restoration. We trace that history here in addition to providing the most recent information from 2018. Mount Warren clearly once supported a native population of Sierra bighorn. Nine skulls of native bighorn have been documented, and near the head of Deer Creek there is a Native American hunting blind strategically located for killing bighorn (Wehausen and Jones 2014). However, the current Mount Warren herd has not used Mount Warren for many years and is now on the verge of extinction.

Interest in attempting to return bighorn sheep to Yosemite National Park began in the late 1970s with winter and summer surveys mostly of high elevation habitat searching for evidence of potential surviving bighorn suggested by occasional reported sightings (Wehausen 1979). Those investigations had the good fortune to include a winter of heavy snowfall (1978) and a winter of scant snowfall (1977). One conclusion from those and subsequent investigations was that Lee

Vining Canyon showed the highest promise for a low elevation winter range, both in terms of snow cover and forage species present (Keay et al. 1987).

In the early 1980s detailed evidence began accumulating that linked domestic sheep to bighorn sheep die-offs due to disease (Goodson 1982, Foreyt and Jessup 1982). One result was that a domestic sheep allotment in Lee Vining Canyon and on Mount Warren had to be terminated prior to attempts to restore bighorn sheep in this area. Yosemite National Park spearheaded that effort through an associated non-profit foundation, and found outside funds to purchase that allotment (Keay et al. 1987, Bleich et al. 1991). Simultaneously, Inyo National Forest put into their draft forest management plan that if that allotment became vacant it would be re-allocated to bighorn sheep.

That action in the mid 1980s allowed a bighorn sheep reintroduction to take place in March 1986, when 27 sheep from the Mount Baxter herd were released in Lee Vining Canyon (Bleich et al 1990, 1991; Chow et al. 1993). A record-breaking series of snow storms immediately followed and caused 7 deaths of translocated sheep, followed by 3 ewes and 2 lambs born in Lee Vining Canyon leaving in October and founding the Mount Gibbs herd. Then it became clear that one or more mountain lions had discovered this new source of prey and began driving it toward extinction. When those sheep were released in 1986, mountain lions were not expected to be a problem because the deer that summered in the region were known to migrate a long distance to the east for winter, i.e. there would not be a source of prey for lions in winter (Bleich et al. 1991).

By the beginning of 1988 the Lee Vining Canyon herd had only 5 adult ewes remaining as its reproductive base (Bleich et al. 1991). That spring it was augmented with an additional 8 ewes and 3 rams, and a program was established to remove lions in winter before they killed any bighorn sheep. One lion per year was removed for 3 years and the bighorn population grew rapidly with annual increase rates as high as 25% (Chow et al. 1993). Lion control then ceased after California passed a ballot initiative called the Wildlife Protection Act that made the mountain lion a specially protected mammal. The growing bighorn population apparently dealt with this cessation of lion control by altering its habitat use patterns so as to avoid using Lee Vining Canyon in winter, instead living high on Mount Warren and delaying feeding at lower elevations in Lee Vining Canyon until spring. A series of mostly drought years enabled this behavior and the population continued to grow and was documented to reach about 80 sheep.

Despite severe winter conditions, in the early months of 1995 only 2 ewes utilized the Lee Vining Canyon winter range, both of which were caught via dropnet and radio collared. That turned into a particularly bad winter for sheep living at high elevations, and most of this population perished. The survivors that descended into Lee Vining Canyon in spring were visibly in poor condition. While the 14 surviving ewes then again began to increase in numbers, this herd was hit by another heavy winter in 1998. That year another lion also was documented to be hunting them in the spring in Lee Vining Canyon, after which the 7 surviving ewes and associated sheep apparently decided to call it quits. There has not been a female using Lee Vining Canyon since the spring of 1998.

Earlier in the first half of that decade, a few other ewes also had abandoned use of Lee Vining Canyon and developed a small sub-population that lived year round on Tioga Crest immediately west of Mount Warren. Their distribution eventually was largely on Mount Scowden at the north

end of Tioga Crest bordering Lundy Canyon. They were first noticed as a separate group in the summer of 1995.

It took a few years to figure out what had happened to the sheep that vacated Lee Vining Canyon in 1998. One of them apparently moved to Mount Gibbs where an unexpected new ewe appeared in 1999 (first detected from DNA isolated from its feces), but the rest were eventually found on the north side of Lundy Canyon, the next canyon to the north, across that canyon from Mount Scowden. The sheep found on the north side of Lundy Canyon were linked genetically via fecal DNA to include some sheep previously sampled at Mount Warren.

There followed numerous years with minimal use of the Mono Basin by mountain lions, and no known predation on Sierra bighorn in Lundy Canyon. Despite that, these sheep never flourished in Lundy Canyon, in contrast to what had previously occurred in Lee Vining Canyon after lion control was initiated. Nevertheless, by 2010 the Mount Scowden and Lundy Canyon groups had grown to a reproductive base of 21 ewes, partly due to an augmentation of the Lundy Canyon group with 6 ewes in 2009 to bolster numbers and genetic diversity. During the 2010-11 winter the Mount Scowden group completely disappeared in multiple winter events, one of which was a snow avalanche in Lake Canyon. In 2011 only 14 ewes remained as the reproductive base on the north side of Lundy Canyon, which increased by 1 a year later; but this herd has not been able to increase since then.

In 2013 lion predation resumed with known winter losses of 2 collared bighorn in Lundy Canyon. Later that year, one ewe with a functional GPS collar began exploring habitat further north above Green Creek, and part of this herd began wintering at high elevations in that area, but continued to use habitat in the Lundy Canyon area in summer. Winter lion predation on this herd continued into the 2016-17 winter, but its full extent was not determined because detection was limited to collared sheep killed (all rams after 2013). The winter of 2016-17 took a heavy toll on this herd, with the only surviving ewes being 5 in the group wintering above Green Creek. They were accompanied by 2 lambs in the summer of 2017, both of which survived to become yearlings in 2018 (one of each sex), but the number of adult ewes dropped to 4 in 2018, and they were accompanied by only 1 lamb. Observations this past summer also indicated the existence of 6 rams, including the yearling. This comes to only 12 remaining sheep in this herd, 1 fewer than in 2017 (Table 1).

Table 1. Summary of minimum numbers of bighorn sheep known in 2018 for herds that utilize habitat within Yosemite National Park. Adult rams listed for the Mount Gibbs subpopulation are for the entire Mount Gibbs herd unit.

Herd/Group	Adult Ewes	Lambs	Y ewes	Y Rams	Adult Rams	Totals
Mount Warren	4	1	1	1	5	12
Mount Gibbs/ Mt Gibbs	17	12	5	6	14	54
Mount Gibbs/ Alger	6	4	2	1		13
Cathedral Range	6	4	0	0	1	11
Totals	33	21	8	8	20	90

Similar to what happened in Lee Vining Canyon, the ewes in this herd no longer use Lundy Canyon and, despite a great deal of effort, could not be located all summer this year. They

finally returned to their wintering area this fall, where they were counted. Also this fall, after about 5 attempts in recent years, these sheep were finally located by a helicopter capture crew and 3 (2 ewes, 1 ram) now carry GPS collars that should provide future information on seasonal habitat use patterns.

Cathedral Range Herd

This herd was initiated in 2015 by the translocation of 10 ewes and 3 rams. Rams have been added multiple times in attempts to get successful reproduction going, but as of the summer of 2017 there had not been a lamb born other than those that arrived *in utero* in 2015, only 2 of which survived. This herd has been living year-round in high-elevation habitat, where only 6 ewes and no rams survived the big winter of 2016-17.

Of the 2 rams translocated to the Cathedral Range in the fall of 2017, one quickly discovered the Mount Gibbs herd and has resided there ever since. The other one found the Cathedral Range ewes and the result was 4 lambs this past summer (Table 1). Perhaps of equal interest is that a Mount Gibbs ram that received a GPS collar in the fall of 2017 moved to the Cathedral range this fall and spent the breeding season with the ewes there, returning to the Mount Gibbs herd area in early December. An important question is whether any other rams traveled with him. In coming months we will analyze genetic diversity of this year's lambs using fecal samples collected this summer. We will do the same for the lambs born next summer and will determine which ram was the father of each lamb. This will be possible because we have DNA from all sheep at Mount Gibbs. The results may answer the question of whether more rams from Mount Gibbs spent the recent breeding season at the Cathedral Range.

Mount Gibbs Herd

As noted above, the Mount Gibbs herd is derived from 3 ewes and 2 lambs that abandoned Lee Vining Canyon in 1986 and found suitable habitat on Mount Gibbs. That subgroup of ewes currently ranges from Mount Dana to Mount Lewis, but occasionally have been documented to use habitat further west on Kuna Crest. In 2015, five ewes were translocated to the Alger Lakes basin south of Mount Lewis. A geographically separate ewe subgroup has developed from that translocation. Consequently, results are presented separately for these two ewe subpopulations.

Mount Gibbs Ewes

The total number of adult and yearling ewes at Mount Gibbs increased between 2016 and 2017 from 19 to 20, despite the intervening snowiest winter on record. That occurred because 3 female lambs survived to become yearling ewes, while only 2 adult ewes died during that winter. Over many years the Mount Gibbs herd has shown a remarkably high annual survival rate. This past year has been an exception in that 3 of 20 ewes (15%) alive in the summer of 2017 died. Two of them carried GPS collars. The first to die was one of 3 high heterozygosity ewes translocated from Mount Langley to Mount Gibbs in 2013 to initiate a genetic rescue experiment. When translocated she already had highly worn incisors, and when re-collared in October 2017 had incisors worn below the gum line. In December of 2017, after rearing a lamb the previous summer, she walked down out of the mountain onto the moraine on the north side of Walker Lake into non-bighorn habitat and was killed there by a mountain lion. Her death was not unexpected given her lack of teeth. The death during winter of a 4 year old ewe collared the previous fall was very unusual and unexpected. The loss of yet another ewe was similarly

unexpected in that any losses above 1 in 20 are unusual for this herd. Late in 2018 John Dittli photographed through the ice on Dana Lake the remains of a ewe at the bottom of the lake. She may have been the third missing ewe, and the death of that ewe was likely due to an accident.

It took many days of field work this past summer to develop a reliable count of the Mount Gibbs ewes and associated sheep, but data from various days eventually provided solid numbers. The difficulty revolved around a missing group of ewes, apparently living on Mount Lewis, that could not be located for a long time. For the second year in a row, in late August all ewes and associated sheep on Mount Lewis temporarily vacated that mountain and joined the ewes on Mount Gibbs. Because of the 3 ewes lost between 2017 and 2018, the number of adult ewes in this sub-population remained the same as 2017 at 17, but the 5 yearling ewes with them increased the total ewe count by 2 to 22 (Table 1).

Alger Lakes Ewes

It took multiple trips to develop complete information for the Alger Lakes ewes. The 6 adult ewes is unchanged from 2017, but 2 yearling ewes with them increase the total ewes to 8. This brings the total ewe population in the Mount Gibbs herd unit to 30, which is a 15% increase over 2017. Total lambs for the Mount Gibbs herd was 16 (Table 1), which again is a record for this herd.

Mount Gibbs Rams

During the summer of 2017 the number of surviving rams at Mount Gibbs was not determined. In contrast, this summer they were easily counted because they visited the top of Bloody Canyon in July when field work there to count ewes was ongoing. First was a group of 3 rams that included one collared ram, followed 10 days later by the rest of the rams. The second group included 3 yearling rams, which is unusual, but proved an essential observation for the total yearling count, which equaled the number of lambs documented in 2017 for this herd unit. That is another example of the remarkable survivorship in the Mount Gibbs herd.

In total 14 adult rams were counted this summer, of which 3 2-year old rams matched the number of yearling rams in the summer of 2017 (again 100% survivorship). Those 3 2-year olds and the immigrant ram translocated in 2017 to the Cathedral Range were not part of the adult ram population in 2017, leaving 10 as the minimum number of rams that survived the 2016-17 winter. Any rams that might have died in the intervening year before this year's count would increase that number. The rams counted in the summer of 2016 that would become adult rams a year later were 5 yearlings and 13 adults. This suggests that the loss of rams over the 2016-17 winter could have been as high as 8 (44%). That contrasts with the overall loss of 18% of the Gibbs and Alger ewes during that winter.

Conservation Issues

The most pressing issue in the NRU is the Mount Warren herd. It needs timely augmentation for both demographic and genetic reasons to persist. Small isolated populations will not persist because genetic drift will continually erode diversity of the gene pool. Small populations can persist only in a metapopulation context with sufficient gene flow between otherwise largely

independent sub-populations. The demographic instability of the Mount Warren herd since it migrated to Lundy Canyon begs fundamental questions about conditions needed for its viability.

The Mount Gibbs and Cathedral Range herds provide an important contrast. It has long been known that bighorn rams will rut outside of their natal home range if other female demes exist (Geist 1971). The creation of the Alger Lakes sub-population was particularly important because it provided an additional deme that should help promote outbreeding within this herd unit.

The Cathedral Range translocation was carried out with the idea that it might provide an isolated herd that could remain uninfected in the event of a disease epizootic. Genetically that would only work if it grew to a large number of sheep not needing gene inflow. It is not clear that this is possible anywhere in the Sierra Nevada. At this point there is question as to whether the Cathedral Range herd will persist as a population, let alone grow to large size. Regardless, the recent documentation of ram movement between the Mount Gibbs herd and the Cathedral Range herd is very important information because it suggests that all of the demes south of Tioga Pass may be able to function as a metapopulation. Even if the Cathedral Range herd remains relatively small, it may serve an important role as yet another deme in this metapopulation. Time will tell how large these different demes can grow, but right now the Mount Gibbs sub-population is the core habitat.

As an isolated herd, it would be undesirable to allow the translocated ram in the Cathedral Range to breed for more than 2 years because of potential father-daughter matings. This may be considerably less of an issue if rams from the Mount Gibbs herd are competing to breed. This is why it is important to determine parentage of the lambs currently *in utero*.

The Mount Warren herd needs a similar metapopulation network to persist. Habitat characteristics and the history of this population indicate that Mount Warren and Lee Vining Canyon constitute the habitat patch that can support the most sheep in this region north of Highway 120. History also has shown that such a deme can interact genetically with the Mount Gibbs herd despite Highway 120; in the past ewes and rams from Lee Vining Canyon have crossed that highway to breed in the Mount Gibbs herd. Given the growing size of the Mount Gibbs herd, it seems likely that gene flow in the opposite direction could occur if bighorn sheep again occupied Tioga Crest and Mount Warren.

It appears that the viability of the Mount Warren herd will depend on re-establishing use of Mount Warren. A Mount Warren deme would have the advantage of potentially serving as a conduit for gene flow connecting sheep from the top of Green Creek (or further north) to the Cathedral Range. While augmentation of the few remaining sheep in the Mount Warren herd appears essential to saving that deme, the history of this herd suggests that it may be a continual augmentation sink in the absence of a larger metapopulation in that region.

Finally, the history of Sierra bighorn also has repeatedly shown that lapses in predation management can significantly delay progress toward recovery. Davis et al. (2012) documented effects of such an experimental period in the southern recovery unit and recommended against repeating such an experiment; but the lapse of the predation program beginning in 2011 was just such an experiment and may have greatly influenced the trajectory and ultimate viability of the current Mount Warren herd. This contrasts with the Mount Gibbs herd unit, where lion predation has had no known influence since the late 1980s, which in part explains the very high

survivorship rates there. The Mount Warren herd unit does not appear to include enough high-elevation year-round habitat with sufficient forage to provide a parallel situation. As such predation management will be an essential part of any attempt to rebuild the Mount Warren herd into a viable herd unit.

Literature Cited

Bleich, V. C., J. D. Wehausen, K. R. Jones, and R. A. Weaver. 1990. Status of bighorn sheep in California, 1989 and translocations from 1971 through 1989. Trans. Desert Bighorn Counc. 34:24-26.

Bleich, V. C., C. D. Hargis, J. A. Keay, and J. D. Wehausen. 1991. Interagency coordination and the restoration of wildlife populations. Pages 277-284 *in* J. Edelbrock and S. Carpenter, eds. Natural areas and Yosemite: prospects for the future. U. S. Nat. Park Service, Denver Service Center, Denver, CO.

Chow, L. S., P. E. Moore, and J. van Wagtendonk. 1993. Ecology of mountain sheep reintroduced in the Sierra Nevada of California. Pages 132-156 in Proceeding of the Fourth Conference on Research in California's National Parks, S. D. Viers, Jr., T. J. Stohlgren, and C. Schonewald-Cox, eds. USDI NPS Transactions and Proceedings Series 9.

Davis, J. L., S. W. Carlson, Craig C. Coolahan, and Dennis L. Orthmeyer. 2012. Sierra Nevada bighorn sheep recovery program: the role of USDA Wildlife Services 1999-2011. U.S.D.A. APHIS Wildlife Services, Sacramento, CA.

Foreyt, W. J., and D. A. Jessup. 1982. Fatal pneumonia of bighorn sheep following association with domestic sheep. J. Wildl. Dis. 18:163-168.

Geist, V. 1971. Mountain sheep: a study in behavior and evolution. The Univ. of Chicago Press, Chicago.

Goodson, N. J. 1982. Effects of domestic sheep grazing on bighorn sheep populations: a review. Bienn. Symp. North. Wild Sheep and Goat Counc. 3:287-313.

Keay, J. A., J. D. Wehausen, C. D. Hargis, R. A. Weaver, and T. E. Blankinship. 1987. Mountain sheep reintroduction in the central Sierra: a cooperative effort. Trans. W. Sect. Wildl. Soc. 23:60-64.

U.S. Fish and Wildlife Service. 2007. Recovery Plan for the Sierra Nevada Bighorn Sheep. Sacramento, California.

Wehausen, J. D. 1979. Sierra Nevada bighorn sheep: an analysis of management alternatives. Unpubl. cooperative report, Inyo National Forest and Sequoia, Kings Canyon, and Yosemite National Parks.

Wehausen, J. D., and F. L. Jones. 2014. The historical distribution of bighorn sheep in the Sierra Nevada, California. California Fish and Game 100:417-435.