Distribution and Abundance of Tule Elk in the Owens Valley
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This final report fulfills the objectives that were outlined in the "Owens Valley Elk Movement" project proposal with a project start date of spring 2015

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EXECUTIVE SUMMARY

In 2019, the minimum count for the Owens Valley population of tule elk (*Cervus canadensis nannodes*) was 343 elk with an annual recruitment rate of 0.37; the historic average annual population and recruitment rate were 335 and 0.30, respectively. The Owens Valley population of tule elk is distributed between lowland habitat, concentrated mainly around the Owens River and east of U.S. Highway 395, and upland habitat, which is located on the west side of Highway 395 along the base of the Sierra Nevada mountains. The lowland population is comprised of the Bishop, Tinemaha, Independence, and Lone Pine sub-herds with a current population of 196 tule elk. The upland population is comprised of the Tinemaha West, Tinemaha Mountain, Goodale, and Whitney sub-herds with a current population of 147 tule elk. There are no known cow elk occupying the Tinemaha Mountain sub-herd at present.

In February 2019, 30 tule elk were translocated from the Central Valley to the Owens Valley. Eight bulls and twelve cows were translocated from the San Luis National Wildlife Refuge (SLNWR) in Los Banos on February 2 and one bull along with nine cows were translocated from the Tupman State Reserve in Buttonwillow (near Bakersfield) on February 3, 2019. A total of fifteen translocated cows were observed with six calves during the 2019 survey. The recruitment rate for observed translocated cows was 0.40. In 2019, 11 elk were harvested from the Owens Valley.

The pregnancy rate for captured cows was 0.79 in 2015 and 0.69 in 2016. The calf mortality rate of sampled cows was 0.40 in 2015 and 0.40 in 2016, based on field observations of cows known to be pregnant. Verified and documented elk mortalities due to causes other than legal harvest from the period of 2010 through 2019 is 44, this is an annual average of 4.4.

We focused our movement analysis on cow elk. The home range size for the Owens Valley herd was 429 km^2. The home range sizes for each of the individual sub-herds were as follows: Bishop 64 km^2, Tinemaha 38 km^2, Tinemaha West 63 km^2, Independence 98 km^2, Goodale 76 km^2, Lone Pine 45 km^2, and Whitney 116 km^2. The sum of these individual home range sizes was 500 km^2. Sub-herd home range over-lap accounted for the additional 71 km^2.

Management recommendations include: 1) review and amend Owens Valley Elk Management Plan sub-herd population objectives, and 2) consider historic annual Owens Valley 4.4 elk/yr mortality rate when developing hunt tag recommendations.

INTRODUCTION

Background

Prior to European settlement, the American elk (*Cervus canadensis*) had the largest range of any deer species in North America. By the early 1900s, elk populations throughout the continent had been reduced from an estimated 10 million down to 100,000 individuals (United States Department of Agriculture 1999). Populations declined due to unregulated hunting, habitat destruction, competition with domestic livestock, urbanization, and westward expansion (United States Department of Agriculture 1999).

There are four extant subspecies of elk in North America: Manitoban elk (*C. c. manitobensis*), Rocky Mountain elk (*C. c. nelsoni*), Roosevelt elk (*C. c. roosevelti*), and tule elk (*C. c. nannodes*) (Meredith et al.

2007). Tule elk are the smallest of all North American elk subspecies, however, whether this is due to poorer habitat quality or genetic differences is unknown. Tule elk are endemic to California, and originally ranged from the Sacramento Valley to the San Joaquin Valley, to the Sierra Nevada foothills, and all the way to the Pacific coast. They prefer river valley grasslands and marshes (McCullough 1969).

Tule elk populations remained pristine until approximately 1800 at which time the population was estimated to be roughly 500,000 (McCullough 1969). The statewide population started to experience a decline starting with the establishment of Spanish settlements, followed by hide and tallow hunters along with the fur brigades between 1800 and 1840 (McCullough 1969). Increasing settlement along with associated livestock saw further range reduction in the period from 1840 to 1849 (McCullough 1969). Between 1849, immediately following the gold rush, and 1860, market hunters had exterminated elk from all but the large marshes of the Delta and Suisun Bay, Tulare and Buena Vista Lakes, and in the hills on the west side of San Joaquin Valley (McCullough 1969). By 1870 only a few elk survived in the Buena Vista Lake area. In 1874 or 1875, when a drainage canal was put in for Buena Vista Lake, only a single pair of tule elk remained in the marshes on the largest cattle ranch in California, near Bakersfield (McCullough 1969). It is a widely held belief that the current statewide population of tule elk descended from this single pair.

By 1895 the number of tule elk grew slowly from this single pair to 28 head; this was the beginnings of the Buttonwillow herd (McCullough 1969). The herd grew rapidly after 1895, and by 1905 agricultural damage and fence destruction caused by the elk was becoming severe. Translocation of elk from this herd took place from 1904 through 1934 and was mostly unsuccessful (McCullough 1969). Efforts to establish a herd in Yosemite National Park began in 1920 with the completion of a 28-acre enclosure on the valley floor. Elk were translocated to this enclosure in 1921 and 1922 where they remained and gradually grew until their release in 1927 into the park (McCullough 1969). Due to damage and the danger to visitors by the bulls during the rut, the elk were rounded up and returned to the enclosure that same year (McCullough 1969). In 1928 National Park policy opposed the display of caged animals, and finally in 1933 the entire herd was transported in individual crates to Owens Valley (McCullough 1969).

The tule elk herd was established in Owens Valley on October 10, 1933. Twenty-six tule elk, 7 bulls, 3 yearlings, 11 cows, and 6 calves, were brought from Yosemite National Park to an enclosure in the Owens Valley near Aberdeen and held for several days before their release. Four months later, 28 more elk were brought from Buttonwillow (which became the Tupman Tule Elk State Reserve) to augment that initial release. These original translocated elk have since expanded in size and range and have formed eight distinct tule elk sub-herds located throughout Owens Valley.

In 1971 the California Fish and Game Commission established a maximum limit of 490 animals within the Owens Valley tule elk herd (Fish and Game Code 3951). In 1988 the Owens Valley Tule Elk Habitat Management Plan (Plan) was created. This Plan adopted the established maximum limit for the Owens Valley herd and in addition established maximum population recommendations within each of the six (now eight) distinct tule elk sub-herds located throughout Owens Valley.

The 2018 Elk Conservation and Management Plan (California Department of Fish and Game 2018) listed population objectives for each sub-herd as follows:

- Bishop: 80-100
- Tinemaha: 80-100
- Goodale: 50-70
- Independence: 60-80
- Lone Pine: 60-80
- Whitney: 40-60

The current sub-herds (units) are, from north to south, Bishop, Tinemaha, Tinemaha West, Tinemaha Mountain, Independence, Goodale, Whitney, and Lone Pine. The Lone Pine herd consists of two distinct population segments; the Lone Pine Alabama Gates (AG) herd and the Lone Pine Estuary (Est) herd. The largest population size of Owens Valley tule elk was estimated at 609 animals in 1984.

Given recent population declines, we were interested in quantifying changes in the distribution and abundance of elk in the Owens Valley. Identifying habitat utilized by elk will assist with management of tule elk.

Objectives

Our primary goals were to obtain distribution and movement information to assist in survey techniques and timing along with setting harvest regulations.

Objective 1: Population Assessment – To estimate population and composition of sub-herds. Data from GPS collars was analyzed to refine timing and location for future survey efforts.

Objective 2: Distribution and Movement – To determine the distribution and movement patterns of sub-herds within the Owens Valley. Data received from GPS collars was analyzed to accomplish the following:

1) Determine area of use (home ranges) and calving areas for the sub-herds.
2) Determine movement patterns and timing of movements for sub-herds of elk.

METHODS

Study Area

The Owens Valley Tule Elk Management Unit (Unit) in Inyo County is oriented along a north-south axis from the cities of Bishop to Olancha and lies between the crest of the Sierra Nevada mountains to the west and the crest of the White and Inyo Mountains and Saline Valley to the east; it is approximately 80 miles long and varies up to approximately 33 miles at its widest. The Unit is located along the eastern edge of the Central Valley Province and Sierra Nevada Province and the western edge of the Deserts Province as identified in the California State Wildlife Action Plan (California Department of Fish and Wildlife 2015) and outside historic tule elk range (McCullough 1969).

The Owens Valley floor elevation ranges from 3600 feet at the Owens Lake to 4200 feet in Bishop. Average annual precipitation is approximately 5 inches. Summer temperatures can exceed 100 ^{o}F;

winter lows can reach 0 °F. U.S. Highway 395 is a primary thoroughfare along the west side of the valley. The Owens Valley is a semi-arid desert environment within the rain shadow of the Sierra Nevada mountains. Tule elk inhabit the valley floor from the town of Bishop southward to Owens Lake. Vegetation consists of Great Basin and Mohave Desert shrub communities (McCullough 1969). Saltbush (*Atriplex* spp.), rabbitbrush (*Chrysothamnus nauseosum*), and sagebrush (*Artemisia* spp.) dominate the uplands of the valley, while greasewood (*Sarcobatus vermiculatus*), saltgrass (*Distichlis spicata*), and shadescale (*Atriplex confertifolia*) dominate the lowlands (Bleich et al. 2001). The Owens River flows south through the valley creating a riparian area of willow (*Salix* spp.), cottonwood (*Populus fremontii*), and cattail (*Typha domingensis*) marshes. Cattle graze throughout the valley, and agricultural crops consist primarily of alfalfa fields. Tule elk bulls have been observed in the Tinemaha Mountain sub-herd in the Sierra Nevada Mountains at elevations up to approximately 11,000 feet where dominant shrubs include Bitterbrush (*Purshia spp*), mountain mahogany (*Cercocarpus montanus*), and Ceanothus (*Ceanothus spp*).

The Unit contains approximately 915,000 acres (3,701 km^2). Public agencies administer over 95% of the land that supports elk and access is very good. The Los Angeles Department of Water and Power (DWP) acquired bottomlands along the Owens River in the early 1900s for water rights. The United States Department of Agriculture Forest Service (USFS) administers the foothills of the Sierra Nevada, White, and Inyo mountains, whereas the United States Department of Interior Bureau of Land Management (BLM; Bishop Field Office), administers most of the remaining land between DWP and USFS land. Land uses include livestock grazing, recreation (hiking/fishing), and agricultural crop production (primarily alfalfa). Recreational activities involving elk within the Unit include hunting, photography, viewing/nature study, and shed collecting. Elk are visible from U.S. Highway 395 and a wildlife viewing point near Tinemaha Reservoir provides viewing opportunities (California Department of Fish and Wildlife 2018).

Population Monitoring

Tule elk were captured utilizing helicopter net gun techniques in 2015 and 2016 (following University of Montana Institutional Animal Care and Use Protocol 024-07MHWB-071807). Processing teams were deployed from the helicopter to each captured elk for animal processing. Captured elk were secured, examined, and collared. For each captured elk, heart rate, respiration, and body temperature were monitored throughout the processing period. Processing teams collected blood samples, administered appropriate broad range antibiotics, and fitted Very High Frequency (VHF) or Global Positioning System (GPS) collars before releasing each animal where it was captured. The GPS collars we used were manufactured by Followit AB (formerly Televilt International), and Vectronic Aerospace GmbH, and fix rates varied between these types of collars.

The number of elk that were planned to be captured was proportionate to the number of elk in each sub-herd. More elk were captured and collared in the largest sub-herds, Lone Pine, Independence and Goodale. In some cases, such as Tinemaha and Whitney sub-herds, cow elk were difficult to locate, and therefore a smaller number of elk were captured and collared than was planned.

Tule elk blood samples were assayed for pregnancy using BioPRYN Wild (Biotracking, Moscow, ID). The BioPRYN test measures the level of Pregnancy-Specific Protein B (PSPB) in serum. PSPB is by the the placenta and enters the mother's blood when a fetus is present. (Sasser and Ruder 1987) The pregnancy

rates for 2015 and 2016 are derived by dividing the total number of cow elk that tested positive for pregnancy into the total number of cow elk that were tested for pregnancy.

Neonatal calf mortality is determined from field observations and trail cameras. The mortality rate was derived by dividing the number of field observed cows that tested positive for pregnancy by the number of those same cows that tested positive for pregnancy and were observed without calves. This two-month natality observation period occurred from late April through June. All pregnant cows were assumed to have given birth.

Unique birthing and calving habitats (post-natal) were delineated from field observations by locating collared cows with calves during the birthing period and tracking their movements and locations through the calving period. Post-natal habitats were defined as unique habitat that is only utilized by cow elk for giving birth and rearing calves through their first to second month. Cow elk can also utilize other habitats within the herds home range for calf birthing and rearing as well but those habitats are also utilized by the herd for year-round occupancy.

Unique summer and winter habitats were delineated from field observations and collar locations. Unique summer and winter habitats are defined as habitats that are utilized by elk sub-herds for the given season and then avoided by most of those same animals at season's end.

Minimum count surveys are conducted each year and are a combination of ground counts, aerial fixed-wing flights and counts from game trail cameras. Ground counts are conducted at locations within each sub-herd where elk can easily be found, usually in the more open habitats, and flights are used to locate elk that are typically found in dense riparian and tule marsh habitats where elk observations are obscured from the ground. Ground counts are conducted in the months of July through September and flights occur in July during the early morning hours on two consecutive days. Game trail cameras are typically utilized after the completion of sub-herd ground counts and elk are not located during the day, always in alfalfa fields and wet meadows where elk occupancy is nocturnal.

Home Range Analysis

We used GPS location data to define home ranges of seven elk sub-herd units: Bishop, Tinemaha, Tinemaha West, Goodale, Whitney, Independence, and Lone Pine. These sub-herd units are also the hunt zone units. Individuals within a given sub-herd were compiled and analyzed together within the sub-herd they were captured in. GPS collars had different fix rates, and different amounts of data per animal, which was not accounted for in the home range analysis.

We calculated 99% MCP home ranges using the adehabitatHR package in R (Calenge 2006). MCP estimators require a large sample size (100 to 300 locations) to reach asymptotic levels (Seaman et al. 1999); our dataset met this criterion. With the ks (Duong and Hazelton 2005) and adehabitatHR (Calenge 2006) packages in R (Version 3.5.3, R Core Team 2019), we used a KDE (Worton 1989) to calculate a spatial probability density function. We used a Gaussian (bivariate normal) kernel. We used a plugin bandwidth estimator to get a smoothing parameter (Duong and Hazelton, 2003, Section 4). From these functions, we determined home ranges by creating contour polygons for each population. We then calculated the area of each polygon (sub-herd) separately, and we calculated the area of the entire Owens Valley herd without overlapping sub-herds.

RESULTS

Objective 1: Population Monitoring

In 2019, we counted a total of 343 elk in the minimum count ground survey (Table 1), including 18 of the remaining 25 elk from the February 2019 translocation. The historic annual average is 335 total elk.

Table 1. *2019 Owens Valley minimum count ground survey results.*

Zone	Bulls	Spikes	Cows	Calves	Total	Bulls/100 Cows	Bull+Spikes /100Cows	Calves/100 Cows
Bishop	5	4	14	6	29	0.36	0.64	0.43
Tinemaha	8	3	15	6	32	0.53	0.73	0.40
West Tinemaha	6	4	19	11	40	0.32	0.53	0.58
Tinemaha Mountain	0	0	0	0	0	na	na	na
Goodale	10	4	36	15	65	0.28	0.39	0.42
Independence	11	12	40	7	70	0.28	0.58	0.18
Lone Pine-AG	17	0	16	5	38	1.06	1.06	0.31
Lone Pine-EST	8	0	12	7	27	0.67	0.67	0.58
Lone Pine-Total	25	0	28	12	65	0.89	0.89	0.43
Whitney	11	4	20	7	42	0.55	0.75	0.35
TOTALS	76	31	172	64	343	0.44	0.62	0.37

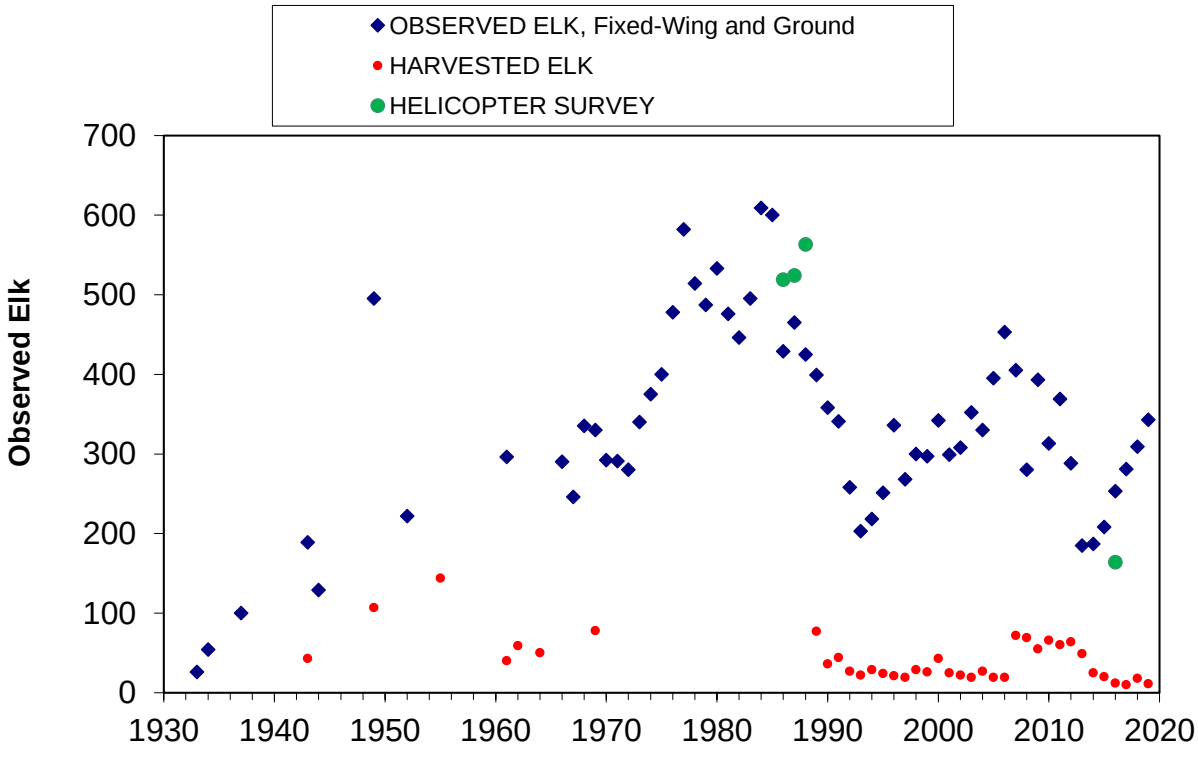

Figure 1. *Annual survey results of elk conducted by ground and air between 1933 and 2019, along with the number of recorded harvested elk during years of elk hunts up to 2019.*

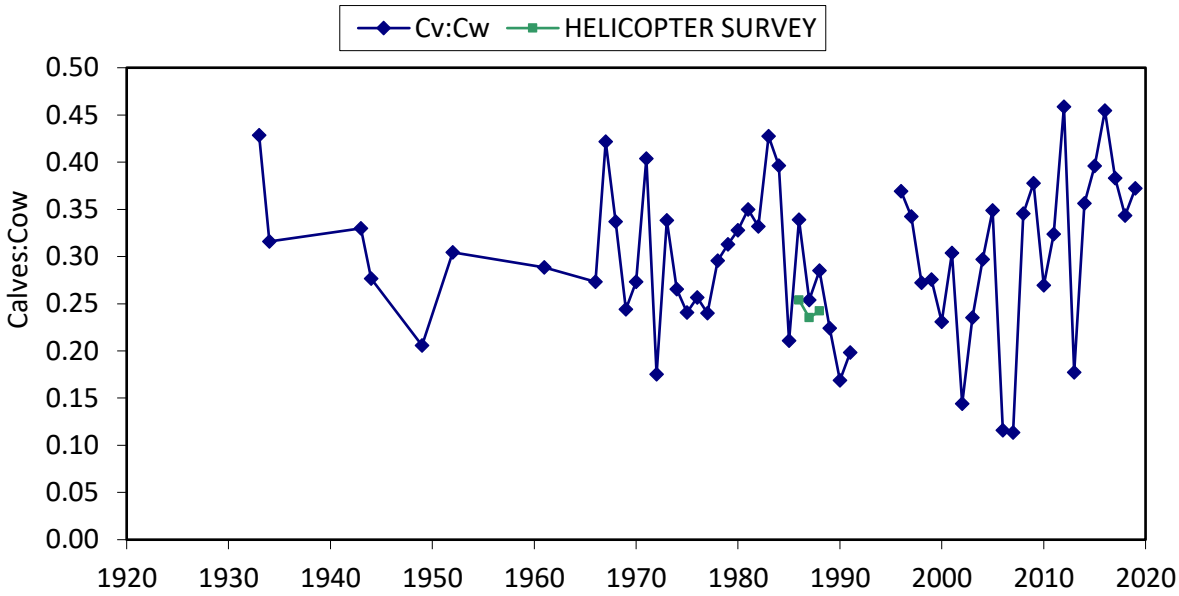

Figure 2. *Annual calf:cow ratios from 1933 to 2019 for the Owens Valley tule elk herd. The historic annual average is 0.30.*

Translocation

In February 2019, 30 tule elk were translocated from the Central Valley to the Owens Valley (9 males and 21 females, Table 2). Eight bulls and twelve cows were translocated from the San Luis National Wildlife Refuge (SLNWR) in Los Banos on February 2 and one bull along with nine cows were translocated from the Tupman State Reserve in Buttonwillow on February 3, 2019. Nineteen of the elk were released with orange Vectronics Globalstar Survey GPS collars. All 30 elk had ear tags applied to both ears for easier sight-ability; elk from SLNWR had metal tags in their left ears and orange plastic tags in their right ears, and elk from Tupman had metal tags in their left ears and lavender plastic tags in their right ears (Table 2).

Translocation Recruitment

The recruitment rate for observed translocated cows was 0.40. Fifteen of the translocated cows were observed during the 2019 ground survey, 14 with collars and 1 without a collar. Three collared cows were observed in the Lone Pine sub-herd without a calf; six collared cows observed in Tinemaha had three calves, and five collared cows observed in Bishop had two calves. One ear-tagged cow was observed in the Bishop sub-herd with one calf. A total of fifteen translocated cows were observed with six calves.

Table 2. *2019 Tule elk translocation from the Central Valley to the Owens Valley.*

2019 TOTAL TRANSLOCATED ELK							
Date	Source	Sub-herd	Bulls (Collared)	Spikes (Uncollared)	Cows (Collared)	Sub-adults (Uncollared)	TOTAL
2/3/2019	SLNWR	Lone Pine	3	1	3	4	11
2/4/2019	Tupman	Tinemaha	0	4	5	0	9
2/4/2019	Tupman	Bishop	0	1	8	1	10
TOTAL			3	6	16	5	30

Mortalities

Beginning in 2010 we started to document reports of dead elk that were discovered in the field, usually with bodies intact (Table 3). From 2010 through 2019 we documented 44 elk that died from various causes. The top causes for these mortalities were vehicle collisions (9), poaching (9), and entanglements (4). Unknown causes were 14. The annual average number of elk mortalities that were reported for the 10-year period between 2010 and 2019 was 4.4.

Table 3. *Verified Owens Valley tule elk mortalities not related to legal harvest, 2010-2019.*

Date	Location	Cause (UK-Unknown)	Bulls	Spikes	Cows	Calf	Unk	Total
2010	W. Tin.	UK					2	2
2010	Bishop	Poached (criminal case)					3	3
2010	Lone Pine	motorcycle collision			1			1
2011	Lone Pine	tie down entanglement	1					1
2011	Tinemaha	vehicle collision	2					2
2011	Indep.	vehicle collision	1					1
Sep-12	Indep.	Poached					1	1
Sep-12	Lone Pine	diseased elk harvested, 2nd tag issued	1					1
Oct-12	W. Tin.	Poached			1			1
Nov-12	Whitney	UK			1			1
Dec-12	Whitney	gored during rut	1					1
Apr-13	W. Tin.	UK		2	3			5
Jul-13	LP	Poached (criminal case)	1					1
Aug-13	LP	UK	1					1
Jul-14	Bishop	Caught in H395 fencing	1					1
May-15	Tinemaha	UK	1					1
May-15	Indep.	UK			1			1
Jul-15	Bishop	UK	1					1
Aug-15	LP	UK			1			1
Aug-15	Whitney	vehicle collision	1					1
Oct-15	Bishop	Poached-bull tagholder			1			1
May-16	Goodale	vehicle collision				1		1
Jun-16	Bishop	Fence entanglement (ranch)	1					1
Jul-18	Indep.	Drowned in ditch				1		1
Aug-18	Indep.	Roadkill, Hwy 395	1					1
Jan-19	W. Tin.	Roadkill, Fish Springs Road		1				1
Spring 2019	Lone Pine	Probably capture/translocation related	3					3
Spring 2019	Bishop	Probably capture/translocation related			2			2
Oct-19	Whitney	Poached-antlerless tagholder	1					1
Nov-19	Tinemaha	Old age-Bacterial/fungal infection?	1					1
Nov-19	Indep.	X9C deer hunter poached		1				1
Nov-19	Bishop	Fence entanglement-east Klondike Lake			1			1
Dec-19	W. Tin.	Roadkill, Hwy 395			1			1
Total			**19**	**4**	**13**	**2**	**6**	**44**

Pregnancy Rates and Calf Mortalities

In 2015, 23 of the 29 tule elk tested were pregnant, resulting in a pregnancy rate of 0.79 (Table 4). The pregnancy rate in 2016 was 9 out of 13 tested, or 0.69 (Table 4).

The mortality rates of calves based on the observed pregnancy rates of captured cows was 0.40 in 2015 and 0.40 in 2016 (Table 4), assuming all of the elk testing positive for pregnancy successfully gave birth. The calf mortality rate is derived from observing calves with 10 of the 29 pregnant cows that were observed in the field from the 2015 capture and 10 of the 13 pregnant cows that were observed in the field from the 2016 capture.

In 2016, seventeen elk that were captured 2015 were observed in the field. From fifteen of these elk that tested positive for pregnancy, ten were observed with calves and five without calves. One cow testing negative for pregnancy in 2015 was observed with a calf in 2016 and one cow testing negative for pregnancy in 2015 was observed without a calf in 2016 (Table 4).

***Table 4**. 2015 and 2016 Owens Valley tule elk pregnancy rates and calf mortality rates.*

Year	Sample Size	Pregnancy Rate	Calf Mortality Rate	2015 Pregnant, 2016 Observed With Calf	2015 Pregnant, 2016 Observed Without Calf	2015 Not Pregnant, 2016 Observed With Calf	2015 Not Pregnant, 2016 Observed Without Calf
2015	29	0.79					
2015	10		0.40				
2016	13	0.69					
2016	10		0.40				
2016	17			10	5	1	1

Objective 2: Home Range Analysis

In 2015 and 2016, 42 cow elk were captured and collared (29 in 2015 and 13 in 2016) in the Owens Valley. A total of 42 collars were deployed over the two-year period, 40 GPS collars and 2 VHF collars. In total, 40 GPS collars recorded 105,576 locations between April 2015 and May 2018 (Table 3). The number of GPS locations recorded per sub-herd varied between 2,829-23,310 points (Table 5). The home range size for the Owens Valley herd totaled 429 km^2. The home range size for the summed sub-herd units totaled 500 km^2. Sub-herd habitat over-lap accounted for the additional 71 km^2.

Table 5. *GPS collar data from 40 Owens Valley female tule elk captured in 2015 and 2016, delineated by sub-herd. GPS locations were acquired from April 2015 through May 2018. Home range was calculated using a Kernel Density Estimator at 99% isopleth.*

Sub-Herd	GPS Collars	Locations	Home Range Size (km^2)
Bishop	5	23,310	64
Tinemaha	1	7,665	38
Tinemaha West	4	9,628	63
Independence	8	21,151	98
Goodale	6	9,598	76
Lone Pine	12	31,395	45
Whitney	4	2,829	116
Total	**40**	**105,576**	**500**

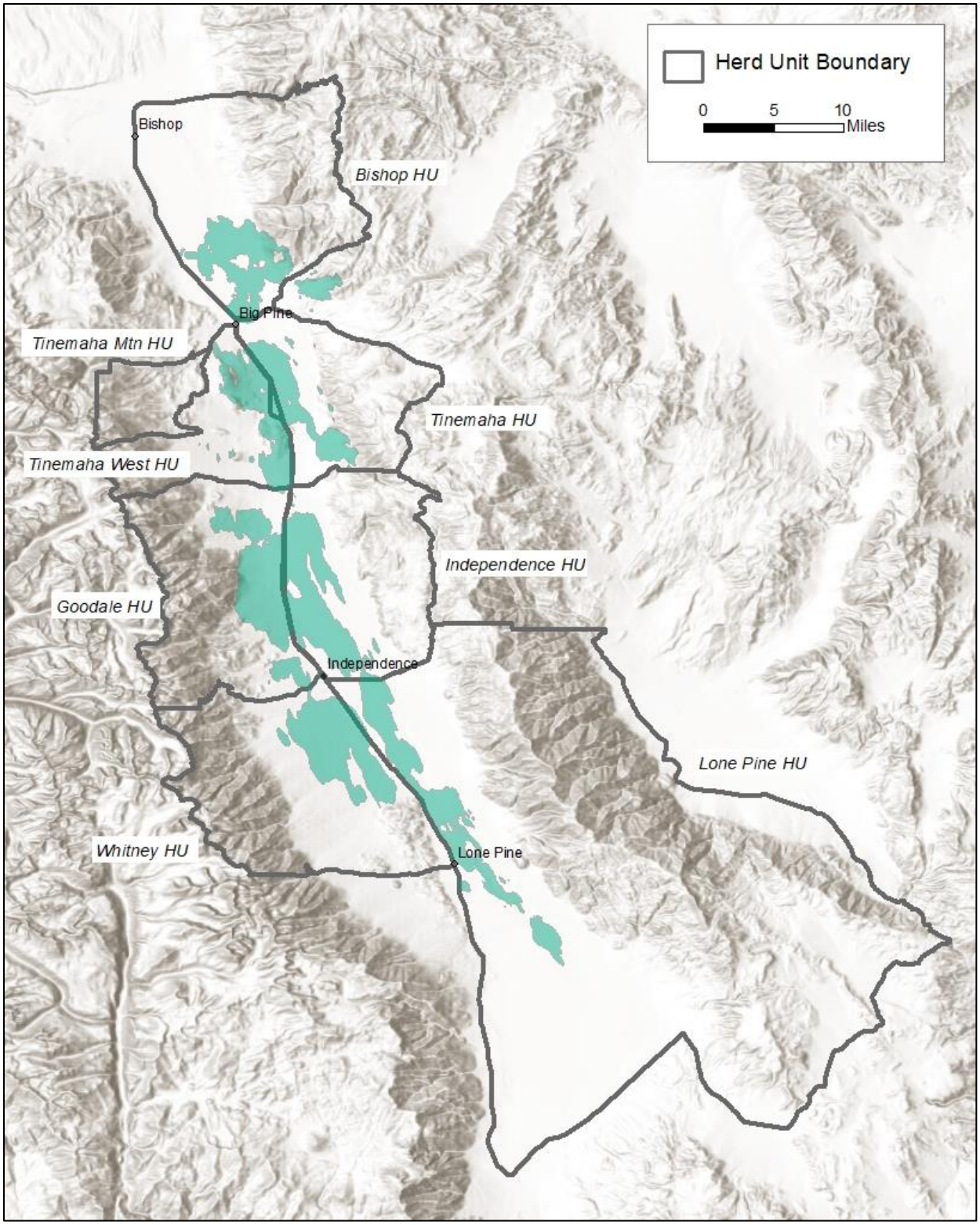

***Figure 3**. Owens Valley cow tule elk herd home range, 2015-2018, 429 km^2. "HU" refers to the 7 sub-herd units in the Owens Valley.*

DISCUSSION

Population Monitoring

The current Owens Valley (OV) population is estimated at 343 animals. This number is slightly higher than the historic annual average of 335. The highest survey estimate for OV elk was 609 in 1984 and the lowest count was 185 in 2013. Hunting was used as a population control tool from 1943 until 1969 when seven annual hunts, resulting in a total harvest of 521 elk (McCullough 1969). That is an annual harvest average of 74 elk for the seven years the hunts occurred. Hunting was discontinued after the 1969 hunt until 1989 when hunting was authorized once again, and hunting has been used to control the elk population every year since.

We suspect that the number of elk prior to 2008 was much higher than survey results indicated. For instance, during the period between 2006 and 2011 the population fluctuated up and down between 453 (2006) and 369 (2011). This five-year period shows a reduction of 84 elk in the population when the actual harvest of elk during this period totaled 341. We question whether recruitment could explain the difference, especially when non-hunting related mortalities (Table 3) are factored in. Beginning in 2008, we began to dedicate more time and effort towards maximizing elk observations in annual ground surveys. After several years we developed a good understanding of where and when to look for elk during the ground survey period (July through September). This is demonstrated when in 2011 the annual population trend became linear and now coincides more accurately with harvest and recruitment (Figure 1).

Hunting and Population Objectives

Hunting tags were increased beginning in 2007 until 2013 in order to reduce the elk numbers in some of the sub-herds where agricultural damage was occurring at rates that were becoming costly to alfalfa producers and ranchers. We received complaints from Los Angeles Department of Water and Power (DWP) property leaseholders of range competition between cattle and elk, reduced alfalfa production, and costly fence repairs. The Tinemaha West pastures were taken out of production for many years, according to leaseholder Mark Johns, because elk had overpopulated his fields and taken up permanent summer occupancy. This is no longer the case since the numbers in this herd have been reduced to a level that allows the rancher to once again utilize his pastures for cattle grazing.

We currently use hunting to manage elk numbers in several sub-herd units in relation to their impacts on agricultural and livestock production. These impacts occur on ranches that are in the Tinemaha, Tinemaha West, Goodale, and Whitney sub-herds. We manage these hunts to sustain the sub-herd population at levels that are generally lower than the population objectives outlined in the 1988 Owens Valley Tule Elk Management Unit Management Plan (Plan). We manage these numbers lower because, although there is enough suitable habitat in these units to support higher numbers, the elk utilize only the habitat that is in production for cattle grazing (Tinemaha West) and alfalfa (Tinemaha, Goodale, and Whitney) during the late spring through early fall seasons. Until elk fencing is installed on the production acreages within these sub-herds, the existing Plan's population objectives for these sub-herds should be reviewed and amended accordingly.

There have been changes to the Tinemaha sub-herd boundaries since the implementation of the Plan. The old Tinemaha sub-herd is currently divided into three units. This division has created two new units in addition to the Tinemaha unit which is located on the east side of highway 395. The two new units are the Tinemaha West unit which bounds highway 395 on the west and the Tinemaha Mountain unit, which is located between the Tinemaha West unit and the Pacific Crest. This division results in three smaller units from the original Tinemaha unit. The Plan needs to be amended to reflect the unit changes and population objectives need to be developed for the three smaller units

Translocation

Thirty tule elk were translocated to the Owens Valley from two locations in the central valley. Following release, several cows emigrated to different sub-herds. Two moved from the Bishop herd to the Tinemaha herd, and one moved from the Tinemaha herd to the Bishop herd. Three-bull elk that were released to the Lone Pine herd and two cow elk that were released to the Bishop herd died that spring. None of the non-collared translocated elk that were released into the Lone Pine sub-herd were observed during the 2019 survey. These elk are currently under observation to analyze post translocation survival and recruitment.

Mortalities

Mortalities from causes other than legal harvest have been documented to accumulate at the rate of 4.4 per year during 2010 through 2019. These are elk mortalities that are discovered and reported by CDFW biologists, wardens, hatchery personnel, Caltrans, CHP, hunters, and ranchers. It is reasonable to assume that this annual mortality rate is higher given the number of undiscovered mortalities that likely occur. We should consider the annual mortality rate in future hunt tag recommendations.

Recruitment

The 2019 recruitment rate was 0.37. The annual recruitment rate for the last six years has been higher than the historic rate of 0.30 (Figure 2). The recruitment rate can be quite variable between sub-herds during the same year. For example, in 2019 the recruitment rate for the Goodale herd was more than double the Independence recruitment rate with four less cows available in Goodale to birth (Table 1). These two units parallel each other and are divided by highway 395. The sub-herd units have different types of habitat, as Goodale is upland where an alfalfa ranch is the main food source in the summer, while Independence is lowland.

Home Range Analysis

The home range analysis indicated that no cow elk occupied the Tinemaha Mountain sub-herd unit during the project period. The home range size of all of the combined sub-herd units that define the Owens Valley herd was 500 km^2 (123,553 acres), while the home range size of the Owens Valley herd, excluding sub-herd overlap (Figure 3) was 429 km^2 (106,008 acres). Cow tule elk occupied approximately 11.6% of the 3,701 km^2 (915,000 acres) that comprise the Owens Valley Tule Elk Management Unit. The elk population predominantly occupied the valley floor habitat while there was little use of the surrounding montane habitat and the Owens Dry Lake to the south.

The home range analysis showed significant sub-herd overlap of the Whitney, Tinemaha West, and Goodale sub-herds (see Appendix III, IV and VI). Sub-herd overlap is defined as habitat within one sub-herd unit that is utilized by elk from at least two sub-herds. There are also sub-herd habitats that are not utilized by elk from that same sub-herd but are utilized by elk from another sub-herd. An example of this would be in the north Lone Pine unit. Elk from the Lone Pine sub-herd occupied and utilized habitat central and south within the unit whereas elk from the Independence sub-herd occupied the north Lone Pine unit throughout much of the summer. Also, there was habitat being utilized by elk that are outside of the Owens Valley unit. Bishop cows travel into the Inyo Mountain foothills which are south of the Bishop unit and north of the Tinemaha unit for the birthing and calving (post-natal) period.

The habitats that were utilized exclusively by females for giving birth and raising calves for the first two months of their lives is referred to as post-natal habitat (see Appendices). Post-natal habitat was not delineated on all the sub-herd maps because post-natal habitat was also utilized for other behaviors throughout the year, such as, bedding, feeding, rutting, and daily or seasonal migration. The same is true for winter range habitat (see Appendices). Identified wintering areas are only utilized by elk during the winter months, however, there are habitats within sub-herd units, such as, Tinemaha West, Goodale, and Whitney, where sub-herd overlap occurs, that are used by resident elk for summer habitat and migratory elk from these three herd units as winter habitat. These areas are delineated as winter habitat only for the non-resident elk during winter occupancy. Specifically, results of this project reveal that for approximately a three-month period ranging from November through February, cow elk from the Tinemaha West, Goodale, and Whitney herds come together and behave as one herd. This group of elk spends these winter months migrating north and south between the Fish Springs Ranch in the Tinemaha West unit and the Shepperd's Creek alfalfa pasture in the Whitney unit. Elk then return to their home sub-herd unit usually some time during February.

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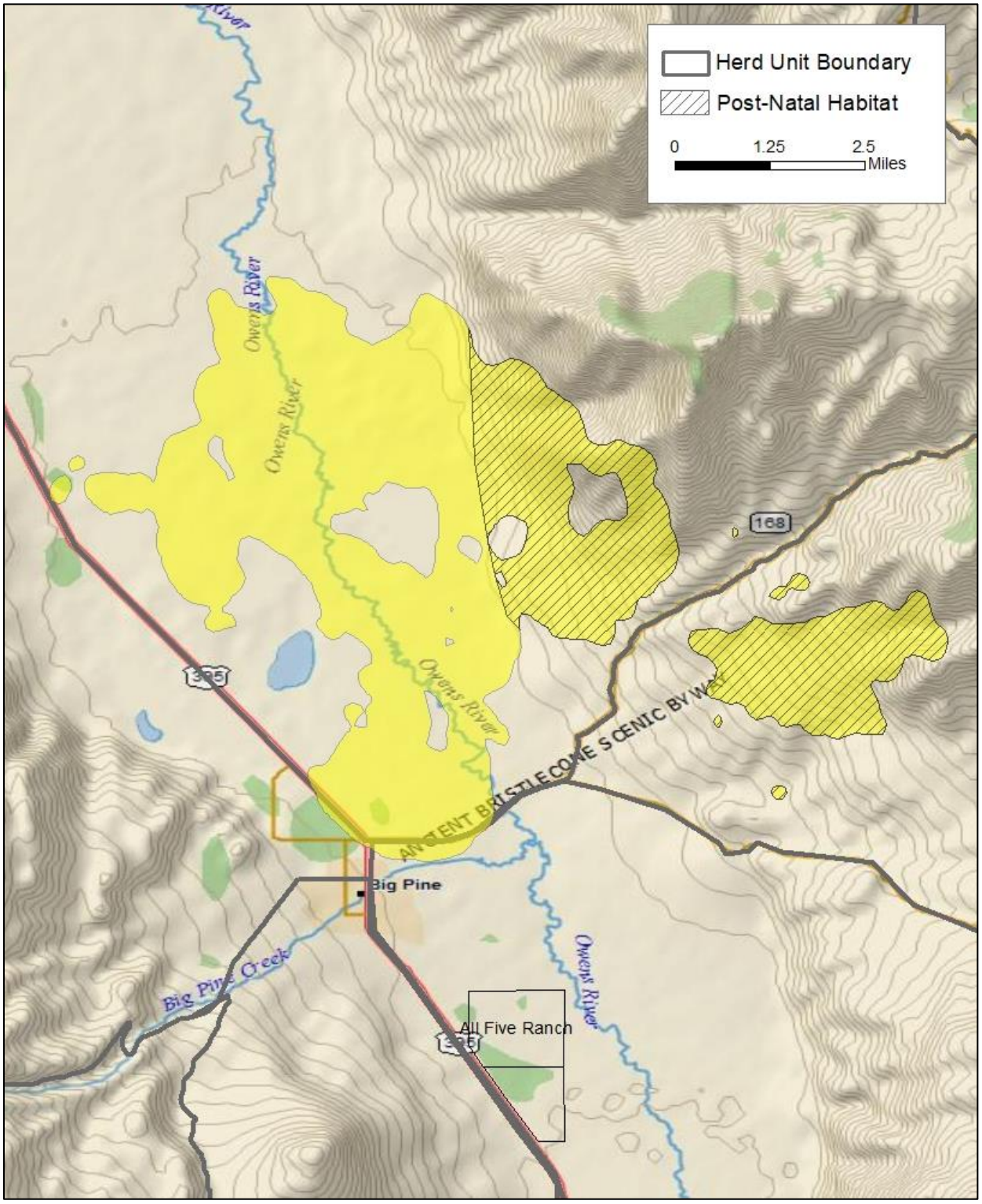
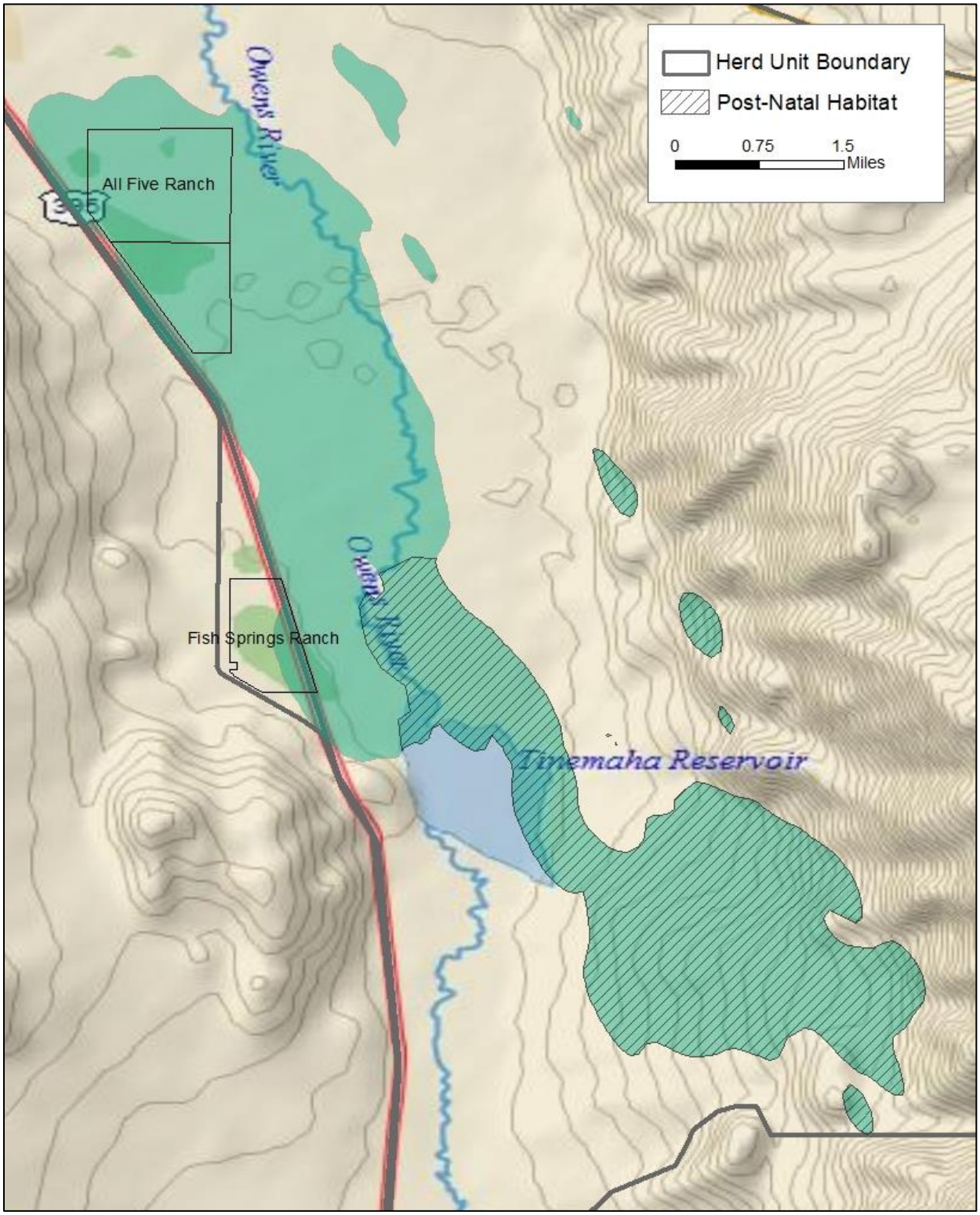
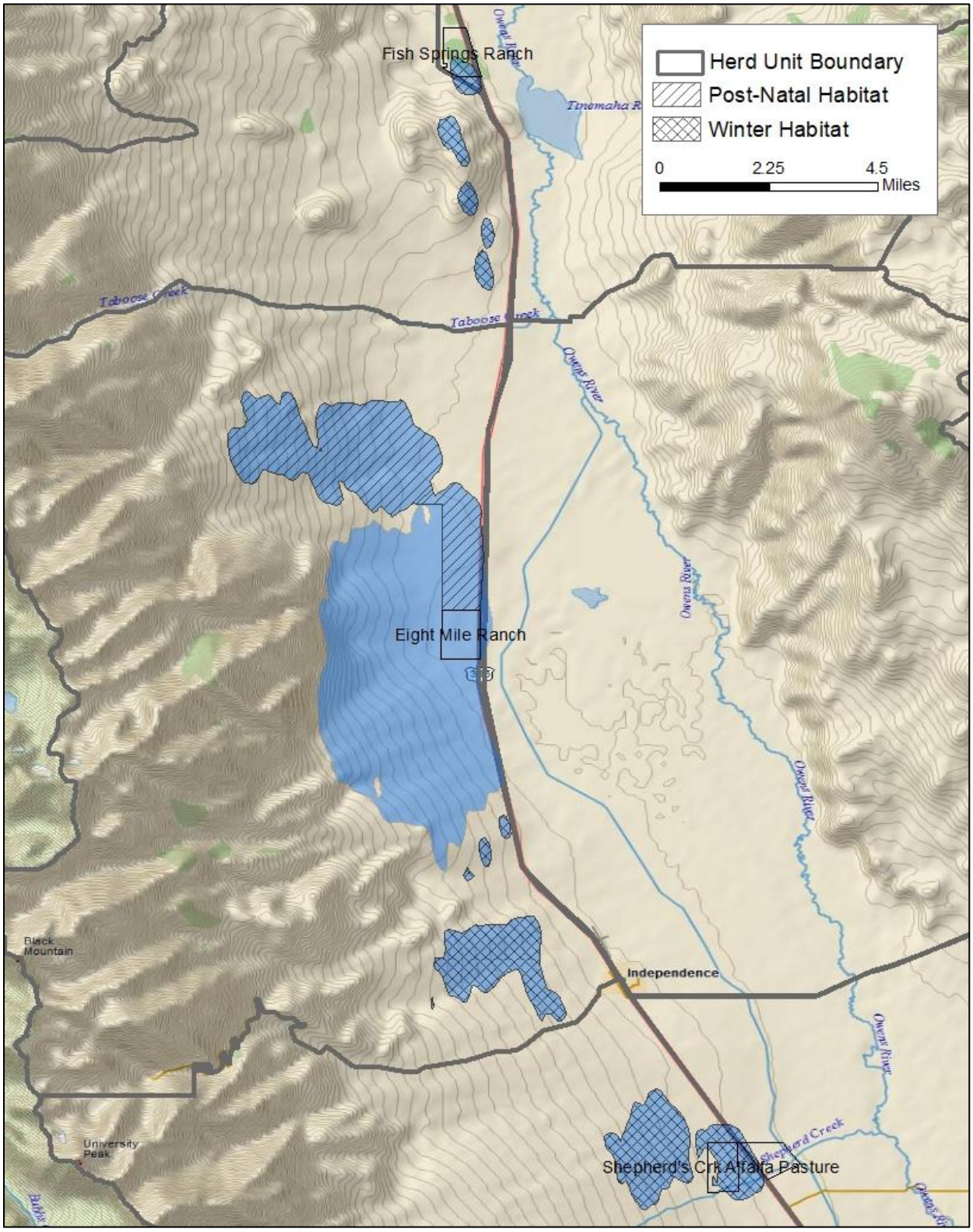
Appendix I. Bishop Cow Tule Elk Home Range, 2015-2018.



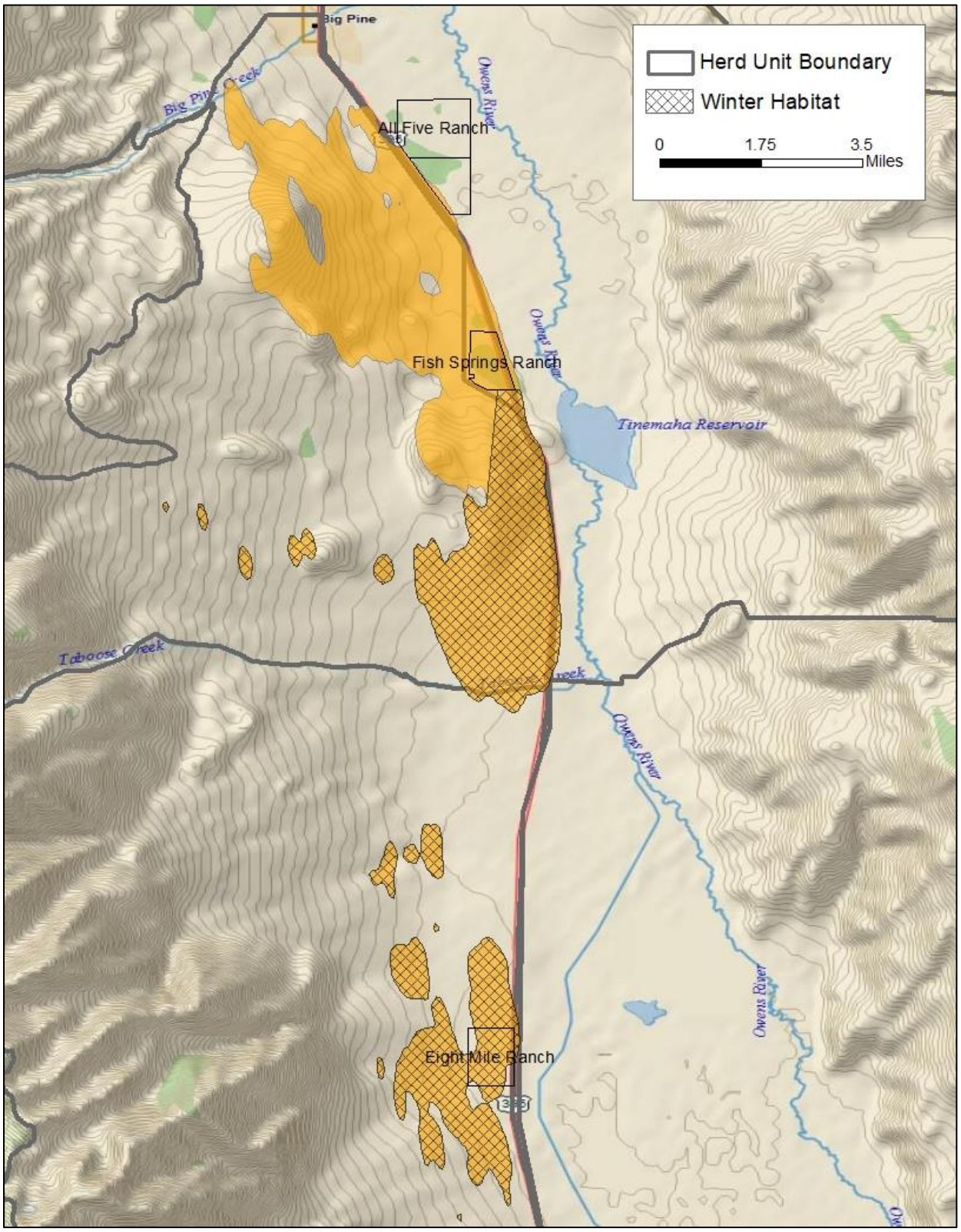
Appendix II. Tinemaha Cow Tule Elk Home Range, 2015-2018.



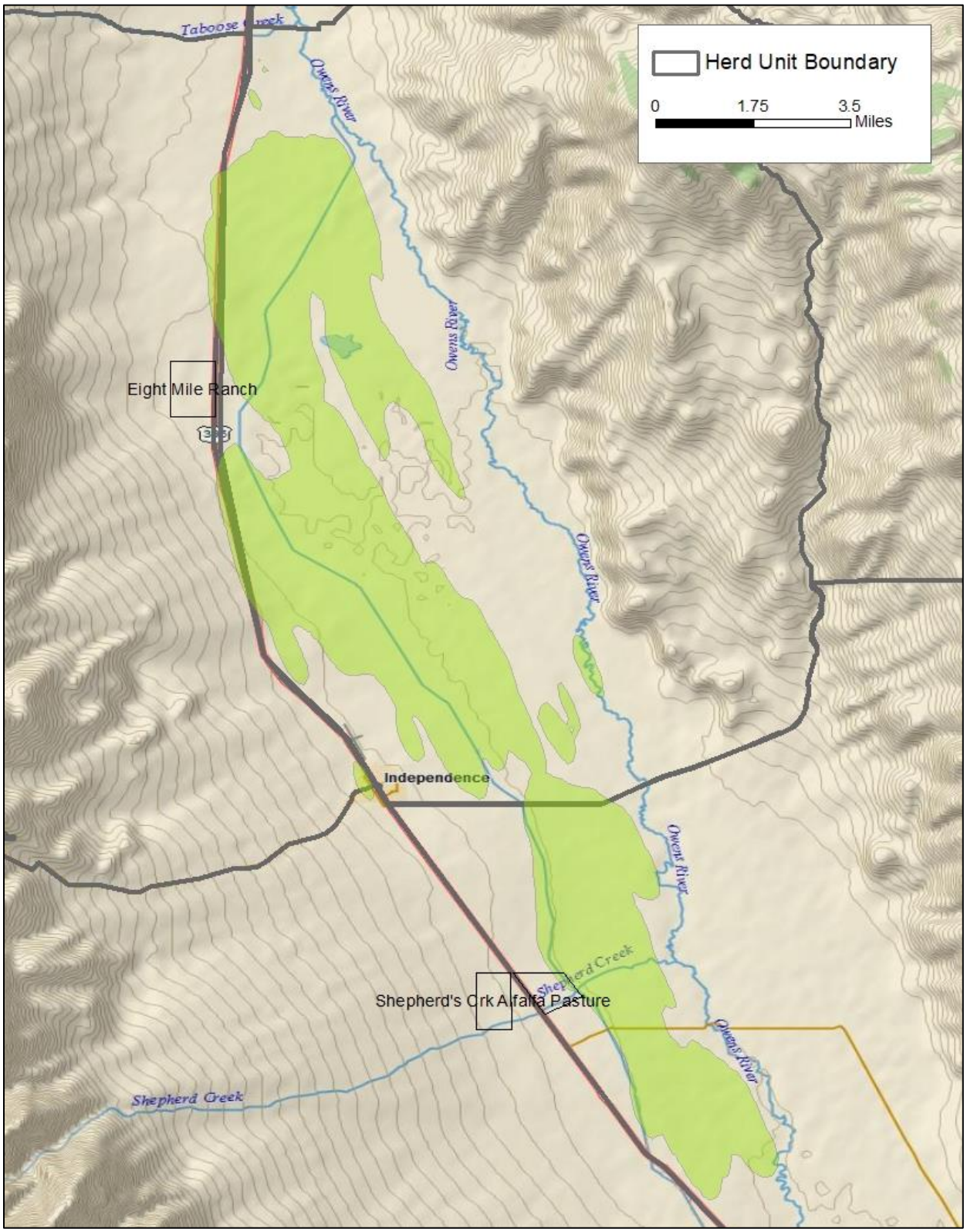
Appendix III. Goodale Cow Tule Elk Home Range, 2015-2018.



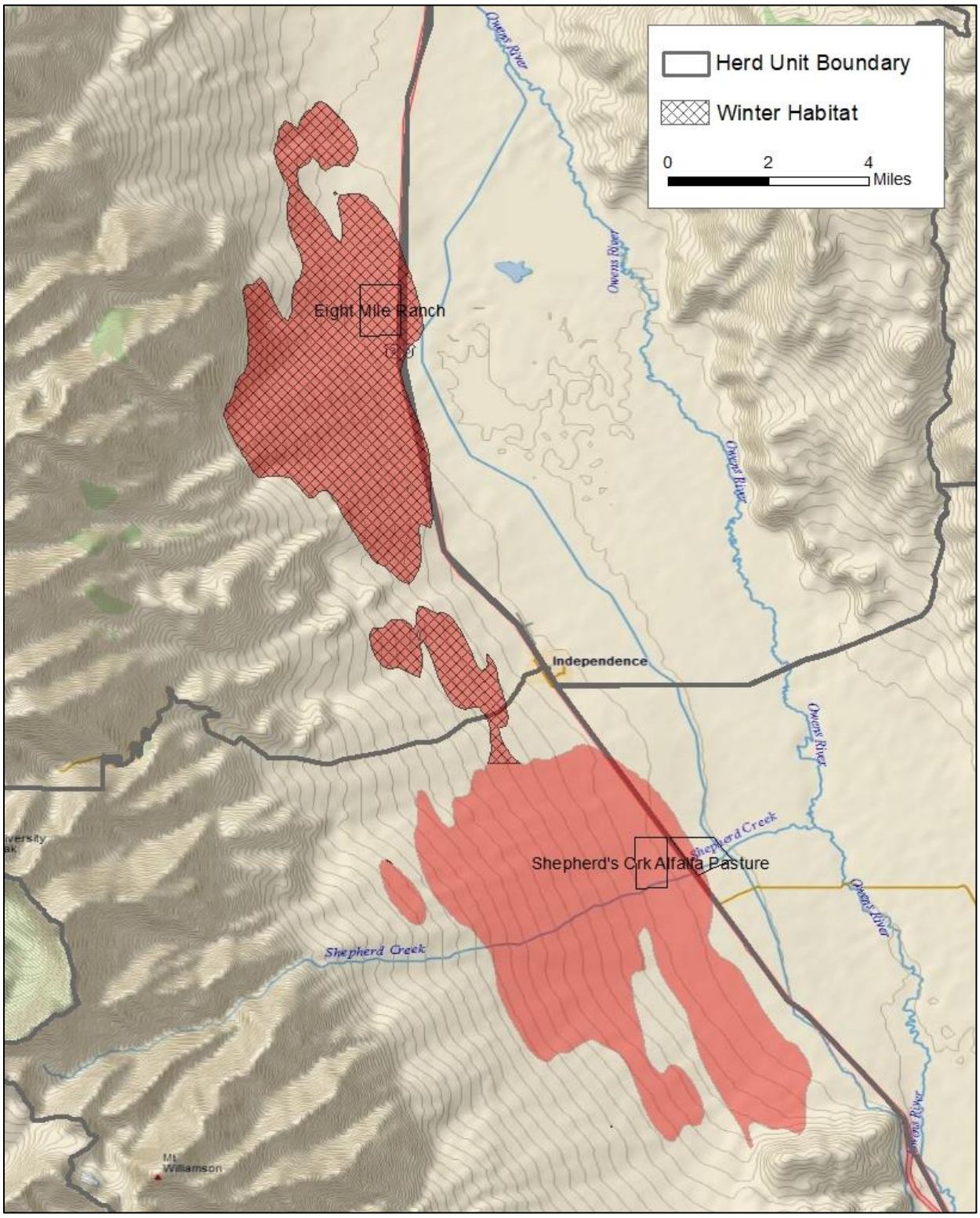
Appendix IV. Tinemaha West Cow Tule Elk Home Range, 2015-2018.



Appendix V. Independence Cow Tule Elk Home Range, 2015-2018.



Appendix VI. Whitney Cow Tule Elk Home Range, 2015-2018.



Appendix VII. Lone Pine Cow Tule Elk Home Range, 2015-2018.