# MORTALITY FACTORS AND HABITAT USE OF CALIFORNIA BIGHORNS IN THE DESCHUTES RIVER, OREGON

**JEREMY L. THOMPSON**[1]**,** Oregon Department of Fish and Wildlife, 4034 Fairview Industrial Dr.SE, Salem, OR 97302, USA

**DONALD G. WHITTAKER,** Oregon Department of Fish and Wildlife, 3406 Cherry Ave., NE, Salem, OR, 97303, USA

**KEITH L. KOHL,** Oregon Department of Fish and Wildlife, 4034 Fairview Industrial Dr.SE, Salem, OR 97302, USA

***Abstract:*** Previous California bighorn sheep (*Ovis canadensis californiana*) mortality research in Oregon has focused on declining populations within the Hart and Leslie Gulch herds. The Deschutes River herd has been expanding since reintroduction in 1993, and has served as a major source for translocation over the past ten years. Beginning in December 2007 we radio-marked and monitored 52 adult bighorn to determine cause of adult mortality, evaluate herd range and habitat use, monitor herd health, and measure sex and age-specific survival.

***Biennial Symposium of the Northern Wild Sheep and Goat Council 18:146–150; 2012***

***Key words*:** bighorn sheep, mortality, GPS, home range.

California bighorn sheep (*Ovis canadensis californiana)* within the state of Oregon were extirpated by 1915, likely from a combination of disease and overharvest. Restoration efforts within the state began in 1954 when 20 sheep from Williams Lake, British Columbia (BC) were released within an enclosure on Hart Mountain. As this original herd expanded, surplus animals were captured and transplanted into vacant habitats throughout the state.

The initial reintroduction into the Deschutes River canyon occurred in 1993. Thirty-five sheep captured from the upper portion of the Owyhee canyon in Idaho were released at approximately river mile 18 on the east side of the Deschutes. Subsequent releases were made into the west side of the canyon from the Steens Mountain (n = 18) and Lower John Day River (n = 12) in 1995 and 1999, respectively. There are currently an estimated 475 sheep in the Deschutes River population. Since 1999, 175 individuals have been captured for both intrastate and interstate relocation. In addition, 93 rams have been harvested during authorized seasons as of November 2011.

## STUDY AREA

The study area encompassed approximately 350 km$^2$ representing approximately 20 river miles within the Deschutes River canyon (Fig. 1). The Deschutes has an average discharge of 5,800 cubic feet per second. Flows varied little by season due to a dam at rivermile 100 that regulated water release. Elevations range from approximately 150 m along the river to 750 m on the rims surrounding the canyon. The canyon was characterized by generally open, grassy hillsides bisected by short side canyons and steep basalt cliffs. Vegetation was primarily open grassland, primarily bunchgrasses, with some shrub-steppe in areas less prone to fire disturbance. Canyon habitats were surrounded primarily by dryland agriculture. A train track runs through the study area along the west side of the Deschutes River.

## METHODS

Fifty-two radio collars (Sirtrack, Inc.) were deployed on bighorn sheep during December 2007 and December 2008. Collars were distributed in 4 unique ram groups and 5 unique ewe groups at the general ratio of 1 collar for every 10 bighorns in

[1] Email: jeremy.l.thompson@state.or.us

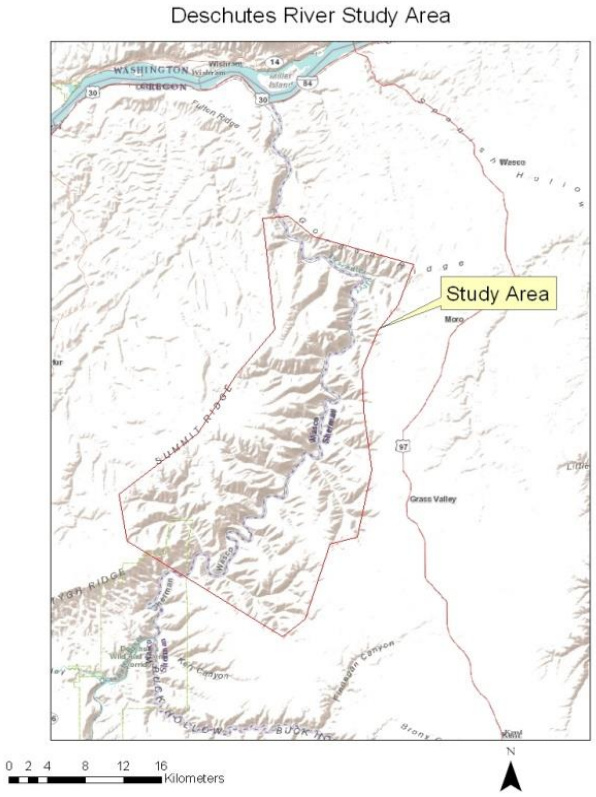


Fig. 1. Deschutes study area.

the group. Both rams and ewes were radio-collared. All sheep were captured using an aerial net gun fired from a helicopter, processed, and released on site by capture personnel.

Biological samples including blood, feces, and pharyngeal swabs were taken from each bighorn captured to monitor herd health. Analysis of samples was consistent with the testing protocol suggested by the Western Wildlife Health Committee (WWHC; Foster 2005). In addition to WWHC-suggested bacterial and viral analysis from serum, blood chemistry values were analyzed and compared to normal values (Whittaker et al. 2001) as an index of overall herd health. Fecal samples were analyzed for the presence of common bighorn parasites using flotation and the Baermann technique (Forrester and Lankester 1997) to estimate larval levels of *Protostrongylus* spp. Pharyngeal swabs were analyzed for presence of *Pasturella* spp. and *Mannhaemia* spp. bacteria.

Collars were monitored bi-weekly for mortality either from fixed-wing aircraft or by vehicle. Mortalities were investigated as soon as possible to determine cause of death. Cause of death was determined based on evidence collected at the site and visual inspection of the remains. If insufficient evidence existed, mortalities were classified as unknown.

We used the Kaplan–Meier product limit estimator (Kaplan and Meier 1958, White and Garrott 1990) to estimate survival probabilities ($S_{(t)}$) for each biological year. We used logistic regression to determine if sex, age class, or capture location predicted adult survival where the binary response variable was alive or dead (White and Garrott 1990).

All location data collected from GPS platforms were analyzed using ArcMap 10 (ESRI, Inc.) Home ranges were estimated for each distinct ram and ewe group using the 95% Kernel Density Estimator (KDE) and the Minimum Convex Polygon (MCP) estimators. Vegetative cover was also summarized for each ram group home range area.

## RESULTS

Twenty-three rams were collared with 15 ARGOS-enabled GPS collars and eight VHF collars. GPS collars were programmed to attempt a location every seven hours for a period of 25 months. Twenty-nine ewes were fitted with VHF transmitters. All collars were set with an eight hour mortality sensor switch. Average age at capture for rams was 5 years and average age of captured ewes was 3.5. Based on comparison of blood chemistry, parasitology, and bacteriology with historic and normal values, there was no indication of herd health issues (Table 1).

Seventeen mortalities occurred between 2007 and 2011 (Fig. 2). Predation was the leading cause (7 individuals, 42% of mortalities) of identified mortality, followed by hunter harvest (4, 24%) and one collision with a train. Exact cause of death could not be determined for 5 (29%) animals. Of the predation-related mortalities, 4 were documented as mountain lion, 2 were likely mountain lion, and one was unknown predation. Six of the 7 predation mortalities were rams.

Home range estimates were derived for the 4 distinct ram groups. Of the 15 GPS collars deployed on rams, 14 provided sufficient data for home range calculation. Acquisition success on collars averaged 57% and approximately 11,000 viable data points were used for home range

Table 1. Blood chemistry of captured bighorns from Deschutes River, OR. December 2005 through December 2009.

| Parameter | n | Mean | Median | Range |
|---|---|---|---|---|
| Selinium, serum | 55 | 107.36 | 84 | 30-349 (ng/ml) |
| Sodium | 43 | 155.21 | 154 | 149-171 (MQ/L) |
| Potassium | 43 | 5.15 | 5.2 | 3.9-6.4 (MEQ/L) |
| Chloride | 43 | 95.56 | 95 | 87-103 (MEQ/L) |
| Glucose | 43 | 156.95 | 160 | 66-223 (MG/DL) |
| BUN | 43 | 19.53 | 19 | 16-29(MG/DL) |
| Creatinine | 43 | 1.65 | 1.7 | 1.3-2.1(MG/DL) |
| T. Protein | 43 | 7.35 | 7.3 | 5.9-8.6(G/DL) |
| Albumin | 43 | 4.16 | 4.2 | 3.1-4.9(G/DL) |
| T. Bilirubin | 43 | 0.14 | 0.1 | .1-.3 (MG/DL) |
| GGT | 43 | 59.91 | 56 | 22-172(U/L) |
| AST | 41 | 211.54 | 189 | 130-370(U/L) |
| Calcium | 36 | 10.25 | 10.4 | 7.3-11.6(MG/DL) |
| I. Phos | 43 | 7.43 | 7.3 | 5.1-10.7(MG/DL) |
| CK | 42 | 1142.05 | 924.5 | 259-3862(U/L) |
| tCO2 | 43 | 5.19 | 4.8 | 1.5-14.1(MEQ/L) |
| SDH | 35 | 31.55 | 27.8 | 10-74.1(IU/L) |
| Anion Gap | 42 | 59.21 | 58.5 | 42-78 |
| Magnesium | 37 | 2.92 | 3.04 | .33-3.54(MG/DL) |

calculation. Home ranges were calculated using data from 3 GPS collared animals each in the Harris, Lockit, and Mack's Canyon ram groups, and 5 GPS collared animals in the Jones Canyon group. These were established using data from points derived from individuals within each herd range. Data for all individuals within a ram group were combined to estimate MCP and KDE.

Herd home range for the four ram groups averaged 43.8 km$^2$ when estimated using MCP (Table 2). Each home range was evaluated for areas of concentrated use via the KDE. We found that overall home range size was reduced by an average of 70% if analyzed with a 93% probability distribution. Mean for core area was 13.2 km$^2$.

Overall the bighorn population within the Deschutes River increased approximately 25% during the study period, with annual growth rates varying from 8% to 14%. The ratio of rams:100 ewes was high (88:100–125:100; $\bar{x}$ = 104). The ratio of lambs:100 ewes varied from 36:100–48:100 ($\bar{x}$ = 42). Over the same period, 51 sheep (42 ewes, 9 rams) were captured and removed for transplant and 47 rams were legally harvested.

Annual survival of ewes remained high throughout the study, never dropping below 95% (Table 3). Conversely, annual survival of rams dropped to 57% and 62% during the last two years of the study. As a result, survival differed between sex only for the last two years. Capture site was not a useful predictor of survival but comparisons may be limited by capture site sample size.

An initial assessment of habitat was conducted utilizing the existing vegetation cover layer through LANDFIRE (LANDFIRE 2006). This data provided an overlook of existing vegetation cover based on the percentage of cover of the live vegetative canopy for the dominant vegetation type (Table 4). For the study area, approximately 80% of the landscape fell into three main categories; herbaceous cover of between 50% and 60% canopy cover; herbaceous between 20% and 30%; and shrub cover between 10% and 20%.

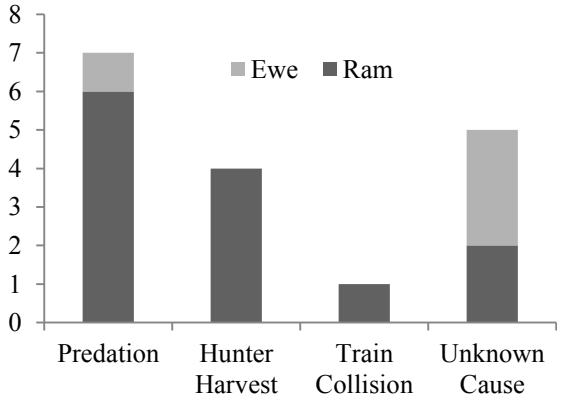


Fig. 2. Number of bighorn mortalities by type for each gender.

Table 2. Home range area ($km^2$) for ram groups in the Deschutes River bighorn population, Oregon.

| Ram Group | 95% KDE | MCP |
|---|---|---|
| Harris | 10.42 | 31.60 |
| Jones | 18.15 | 53.88 |
| Lockit | 10.25 | 46.80 |
| Mack's | 14.15 | 43.01 |
| Average | 13.20 | 43.80 |

Table 3. Annual survival of California bighorn sheep in the Deschutes River Canyon, Oregon, 2007 – 2011.

| Period | Rams | | | Ewes | | |
|---|---|---|---|---|---|---|
| | Lower 95% | $S_{(t)}$ | Upper 95% | Lower 95% | $S_{(t)}$ | Upper 95% |
| Dec '07 – June '08 | 0.76 | 0.92 | 1.0 | 0.87 | 0.95 | 1.00 |
| July '08 – June '09 | 0.74 | 0.91 | 1.0 | 0.90 | 0.96 | 1.00 |
| July '09 – June '10 | 0.36 | 0.57 | 0.78 | 0.89 | 0.96 | 1.00 |
| July '10 – June '11 | 0.36 | 0.62 | 0.88 | 1.00 | 1.00 | 1.00 |
| Dec '07 – June '11 | 0.21 | 0.42 | 0.62 | 0.67 | 0.82 | 0.96 |

Assessment of use based on calculated home ranges for the 4 ram groups show a similar pattern, suggesting that animals are using available habitat at a similar rate as is available within the landscape.

## DISCUSSION

High survival and recruitment characterized the Deschutes herd for the study period.

When compared to past mortality projects within the state, predation appeared not to be playing a major role in the overall demographics or health of the Deschutes sheep population.

While we recognize that this particular study period did not show evidence of any potential disease or predation issues within the herd, continued monitoring and surveys will still be maintained to capture any potential events in the future.

Marked rams within the study area showed strong affinity for their established home ranges. No rams were noted within the summer range of another ram group, and very little overlap of noted locations was found during the rut period. None of the marked sheep in the study were found to cross the river itself, and all data suggest that there is a strong affinity of both rams and ewes to their established home ranges.

With the home ranges estimated by the GPS platforms, one probable benefit of current habitat usage is the lack of movement by males outside of the canyon corridor. Although there are few domestic sheep adjacent to the Deschutes corridor,

Table 4. Top three vegetation cover types by ram home range.

| Herd Range | Vegetation Type | % Cover |
|---|---|---|
| Entire Study Area | Herbaceous 50>60 | 36.78 |
| | Shrub 10>20 | 31.61 |
| | Herbaceous 20>30 | 10.85 |
| Harris Herd Range | Herbaceous 50>60 | 73.81 |
| | Shrub 10>20 | 11.86 |
| | Herbaceous 20>30 | 10.35 |
| Jones Herd Range | Shrub 10>20 | 43.00 |
| | Herbaceous 50>60 | 23.75 |
| | Herbaceous 20>30 | 13.90 |
| Lockit Herd Range | Shrub 10>20 | 67.60 |
| | Herbaceous 30>40 | 18.62 |
| | Herbaceous 20>30 | 4.34 |
| Mack's Herd Range | Herbaceous 50>60 | 58.49 |
| | Shrub 10>20 | 18.03 |
| | Herbaceous 20>30 | 12.61 |

there is always potential for long-distance movements by juvenile males. There were no documented collar movements outside of the known occupied sheep habitat during the study period, and there have only been two documented sheep movements outside the corridor since the initial release. This low documented emigration rate will likely reduce the potential for introduction of pathogens from sheep within the herd.

The initial assessment of habitat use was done at a coarse scale, and a more refined summary will be looked at in the future utilizing the most recent data available.

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