Status of bighorn sheep in California

Clinton W. Epps,[1] Vernon C. Bleich,[2] John D. Wehausen,[3] and Steven G. Torres[1]

[1] Resources Assessment Program, California Department of Fish and Game, 1416 Ninth Street, Sacramento, CA 95814, USA
[2] Sierra Nevada Bighorn Sheep Recovery Program, California Department of Fish and Game, 407 West Line Street, Bishop, CA 93514, USA
[3] University of California, White Mountain Research Station, 3000 East Line St., Bishop, CA 93514, USA

Desert Bighorn Council Transactions 47:20–35

Successful management of bighorn sheep requires detailed and timely knowledge of the status and distribution of populations of those unique ungulates. This inventory of bighorn sheep in California is intended to update previous population inventories published by Wehausen et al. (1987), Weaver (1989), and Torres et al. (1994; 1996). For the 1994 population inventory, the California Department of Fish and Game (CDFG) established a Geographic Information System database showing the historical and then-current distribution of bighorn sheep populations in the state. The 1996 inventory summarized changes known to have occurred during the preceding two years. Here, we present updates to the sizes, distributions, and identities of these populations (Table 1), organized by "metapopulation" management units (Figure 1) as defined by Torres et al. (1994). These updates reflect demographic changes in bighorn sheep populations over nine years, including extirpations and reestablishments through translocation or natural recolonization, as well as new data on the distribution and size of those populations. Because of the varying precision of the population estimates, we again present them categorically as size classes. The estimates are derived from helicopter surveys by CDFG, counts and camera monitoring at waterholes, minimum counts derived from non-invasive genetic sampling (Epps 2004, 2005), mark-resight estimates, and minimum ground counts. Because some estimates are based on few data and may not have been updated since previous inventories, we also present information on the source of each estimate, and indicate those areas where new information is needed. This approach will help establish priorities for future efforts and provide opportunities to better assess data uncertainties.

During 1995–2004, a number of legislative and taxonomic revisions concerning bighorn sheep in California occurred. Although the Peninsular bighorn sheep (*Ovis canadensis cremnobates*) is no longer considered a valid subspecies (Ramey II 1995; Wehausen and Ramey II 1993), the populations in the Peninsular Ranges were listed as endangered under the distinct vertebrate population provision of

Table 1. Extant and extirpated populations of bighorn sheep in California as of the end of 2004. Population size class estimates typically include all sex and age classes. Size class estimates of 0 do not necessarily indicate lack of use by bighorn sheep, as some of these areas are known to be used by transient rams. "Population Status" indicate which populations have changed status due to extinction or recolonization, or redefinition since 1993 (Torres et al. 1994) and 1995 (Torres et al. 1996). "Data Source" indicates the most recent year of data collection, as well as the source and type of data.

Metapopulation	Population	[1]Population Status	Population Size Class	Data Source-Year of Most Recent Data
Peninsular Ranges	Carrizo Canyon	N[3]	101–150	CDFG 2004[5,6]
	Vallecito	N	101–150	CDFG 2004[5,6]
	South San Ysidro	N[3]	25–50	CDFG 2004[5,6]
	North San Ysidro	N[3]	25–50	CDFG 2004[5,6]
	Coyote Cyn.	N[3]	25–50	CDFG 2004[5,6]
	Santa Rosa, E. of Hwy 74	N[3]	201–300	CDFG 2004[5,6]
	Santa Rosa, W. of Hwy 74	N[3]	51–100	J. DeForge[7]
	San Jacinto	N	25–50	S. Ostermann[7]
San Gabriel	San Gabriel	N	201–300	CDFG 2004[5]
Western Transverse Range	San Rafael	R	25–50	CDFG 2002[5]
	Caliente Peak	E	0	No new data
Sonoran	W. Chocolate (Gunnery)	N	101–150	CDFG 2004[5]
	E. Chocolate (Colorado R.)	N	51–100	CDFG 2004[5]
	Orocopia-Mecca Hills	N	51–100	CDFG 2004[5]
	Chuckwalla	A	25–50	No new data
	Cargo Muchacho	E	0	No new data
	Palo Verde	E	0	No new data
South Mojave	Newberry-Ord	N[3]	25–50	C. Epps 2001–2003[8,9]
	Rodman	E	0	C. Gallinger 2003[9]
	Bullion	R	<25	No new data
	Sheephole	A	51–100	CDFG 2004[5]
	San Gorgonio	N	51–100	CDFG 2004[5]; T. Anderson[9]
	N. San Bernardino (Cushenbury)	N	25–50	CDFG 2002[5,6]
	Little San Bernardino	N	151–200	CDFG 2001[5]
	Queen	N	51–100	CDFG 2003[5]; C. Epps 2002[8,9]
	Pinto	E	0	No new data
	Eagle	N	51–100	C. Epps 2002–2003[8,9]
	Coxcomb	N	<25	C. Epps 2002–2003[8,9]
	Granite-Palen	N	<25	C. Epps 2002–2003[8,9]
	McCoy	E	0	No new data
	Little Maria	E	0	No new data
	Big Maria	E	0	No new data
	Riverside	E	0	No new data
	Iron	N[2]	<25	C. Epps 2001–2003[8,9]
	Turtle	N	51–100	C. Epps 2001–2003[8,9]; CDFG 2000[5]

Table 1 (continued).

Metapopulation	Population	[1]Population Status	Population Size Class	Data Source-Year of Most Recent Data
South Mojave (cont)	Whipple	R	25–50	CDFG 1999[5]
	Old Woman	N	51–100	C. Epps 2001–2003[8,9]
	Chemehuevi	N	25–50	C. Epps 2002–2003[8,9]
	Sacramento	E[2]	0	C. Epps 2001–2003[8,9]
	Clipper	N	25–50	C. Epps 2001–2003[8,9]; CDFG 2004[5]
	South Bristol	N[2]	51–100	CDFG 2004[5]
	Marble	N	101–150	CDFG 2004[5,6]
Central Mojave	Cady	N	25–50	C. Epps 2001–2003[8,9]
	North Bristol	E[2]	0	C. Epps 2003[8,9]
	Old Dad- Kelso-Marl	N	201–300	CDFG 2004[5,6]
	Club Peak	N[3]	25–50	C. Epps 2002[8,9]
	Granite	N	25–50	C. Epps 2001–2003[8,9]
	Providence	N	51–100	C. Epps 2001–2003[8,9]
	Wood-Hackberry	N	25–50	C. Epps 2001–2003[8,9]
	Castle-Hart-Piute	N	51–100	C. Epps 2001–2003[8,9]; Viceroy Mine 2003[7]
	Dead	N	25–50	No new data
Central North Mojave	Clark	N	25–50	CDFG 2004[5]
	Kingston-Mesquite	N	51–100	CDFG 2004[5]
	Nopah	N	51–100	CDFG 1999[5]
	Soda	E	0	G. Sudmeier 2004[9]
	Avawatz	A	51–100	CDFG 1995[5]
North Mojave	Granite-Quail	E	0	No new data
	Owlshead	N[2]	<25	G. Sudmeier 2004[9]
	Eagle Crags	R	<25	CDFG 2002[5]
	Argus-Slate	R	51–100	R. Osgood 2003[9]; CDFG 1993[5]
	Coso	E	0	No new data
	South Panamint	N	51–100	CDFG 1996[5]; (Oehler 1999)
	Tucki	N	25–50	No new data
	Panamint Butte-Hunter	N	51–100	No new data
	Tin	N	51–100	No new data
	Dry Mtn-Last Chance	N	51–100	J. Wehausen 2003[8,9]
	Inyo	N	101–150	J. Wehausen 2003[8,9]
	Deep Springs	N[2]	<25	S. Hetzler 2000[9]
	North White	N	201–300	CDFG 2004[7]
	South White	R	25–50	CDFG 2004[7]
Very Southern Sierra Nevada	Cache Peak	E	0	No new data
	Chimney Peak	E	0	No new data
Southern Sierra Nevada	Great Western Divide	E	0	No new data
	Olancha Peak	E	0	No new data
	Mt. Langley	R	51–100	CDFG 2004[7]
	Mt. Williamson	N	25–50	CDFG 2004[7]
	Bubbs Creek	N[4]	<25	CDFG 2004[7]
	Mt. Baxter	N	51–100	CDFG 2004[7]
	Sawmill Cyn.	N[3]	<25	CDFG 2004[7]
	Taboose	E	0	No new data
	Mt. Tom	E	0	No new data

Table 1 (continued).

Metapopulation	Population	[1]Population Status	Population Size Class	Data Source-Year of Most Recent Data
Southern Sierra Nevada (continued)	Wheeler Ridge	R	51–100	CDFG 2004[7]
Central Sierra Nevada	Convict-McGee Cr.	E	0	No new data
	Lee Vining-Bloody-Lundy Cyn.	R	25–50	CDFG 2004[7]
	Sonora Pass	E	0	No new data
	Sweetwater	E	0	No new data
Northeastern California	Truckee River	E	0	No new data
	Skedaddle-Smoke Cr.	E	0	No new data
	Warner	E	0	No new data
	Lava Beds/ Mt. Dome	E	0	No new data
	Mt. Shasta	E	0	No new data
	Goosenest	E	0	No new data
	Bogus Mt.	E	0	No new data

[1] N = native; A = augmented; R = reintroduced; E = extirpated
[2] Population status has changed since 1995 (Torres et al. 1994, 1996)
[3] Population has been redefined since 1995 (Torres et al. 1994, 1996)
[4] Newly-discovered population
[5] Helicopter survey-capture
[6] Mark-resight population estimates
[7] Direct counts from ground observations
[8] Partially based on minimum genotypic counts from non-invasive genetic data
[9] Field observations of animals or sign

Table 2. Bighorn sheep population size class profile and summary by metapopulation for the 2004 population inventory, with comparison to total population numbers from the 1995 inventory (Torres et al. 1996).

Metapopulation	0	<25	25–50	51–100	101–150	151–200	201–300	>300
Peninsular Ranges	0	0	4	1	2	0	1	0
San Gabriel	0	0	0	0	0	0	1	0
Western Transverse Range	1	0	1	0	0	0	0	0
Sonoran	2	0	1	2	1	0	0	0
South Mojave	7	4	5	7	1	1	0	0
Central Mojave	1	0	5	2	0	0	1	0
Central North Mojave	1	0	1	3	0	0	0	0
North Mojave	2	3	2	5	1	0	1	0
Very Southern Sierra	2	0	0	0	0	0	0	0
Southern Sierra Nevada	3	2	1	3	0	0	0	0
Central Sierra Nevada	4	0	1	0	0	0	0	0
Northeastern California	7	0	0	0	0	0	0	0
Total	30	9	21	23	5	1	4	0
1995 Total	36	13	20	17	10	10	0	0
Net Change Since 1995	-6	-4	+1	+6	-5	-9	+4	0

the Endangered Species Act in 1998. Meanwhile, the uniqueness of Sierra Nevada bighorn sheep was established on the basis of genetic and morphometric evaluations (Ramey II 1995; Wehausen and Ramey II 2000). Formerly *O. c. californiana*, now classified as *O. c. sierrae* (Wehausen et al. 2005), Sierra Nevada bighorn sheep also were listed as endangered by the federal government in 2000.

Populations

Five apparent natural recolonizations and 2 apparent population extirpations are suspected to have occurred since the 1993 population inventory (Table 1); 2 of those recolonizations (Deep Springs Range and South Bristol Mountains) were noted but not described in the 1995 inventory. In the Mojave Desert, radiocollared ewes were first documented traveling to the nearby South Bristol Mountains in 1993 and subsequently were found to bear lambs. At least 2 ewes permanently emigrated to that range, and that small founding population has since increased considerably. Similarly, in 2000, fresh sheep sign was observed in the Iron Mountains, and during subsequent field investigations a small, reproducing population was found to be resident, with occasional movement of radiocollared rams to and from the nearby Old Woman Mountains. Bighorn sheep were also reported again in the Deep Springs region where they likely had been extirpated. Recent evidence of recolonization of the Owlshead Mountains by bighorn sheep has also been reported. Investigations at all known water sources in the Sacramento Mountains, formerly the site of a viable population of bighorn, suggested that no population remains in that area. Only 6 fecal samples were recovered at one location in 3 trips during 2001–2002, and genetic analyses indicated that they all were derived from 2 rams (C. Epps, unpublished data). Finally, anecdotal evidence suggests that the Resting Spring Range near Death Valley and the Calumet Mountains in the South Mojave may support populations of bighorn sheep, but further investigation is needed before they can be added to the population inventory.

More information has been obtained on several of the populations where reestablishment by translocation previously had been attempted. The reintroduced San Rafael population, thought to be non-viable (Torres et al. 1994), is now known to be extant. Recent surveys of the Eagle Crags during 2002 detected few ewes and numerous rams, and additional research is needed to determine if that population remains viable. In the North Bristol Mountains, genetic analyses of fecal samples obtained during summer at known water sources demonstrated that all samples were from rams (C. Epps, unpublished data), suggesting that a viable population no longer exists.

Recent research resulted in the redefinition of several populations. In the Peninsular Ranges Metapopulation; the Pinto-Inkopah, Jacumba-Inkopah, Laguna, and Tierra Blanca populations (Torres et al. 1994) are now combined under the Carrizo Canyon population. The population in the Fish Creek Mountains has been included with the Vallecito Mountain population. Further, the North Anza Borrego population has been subdivided into 3 populations (South San Ysidro Mountains, North San Ysidro Mountains, and Coyote Canyon). Finally, the Santa Rosa Mountains

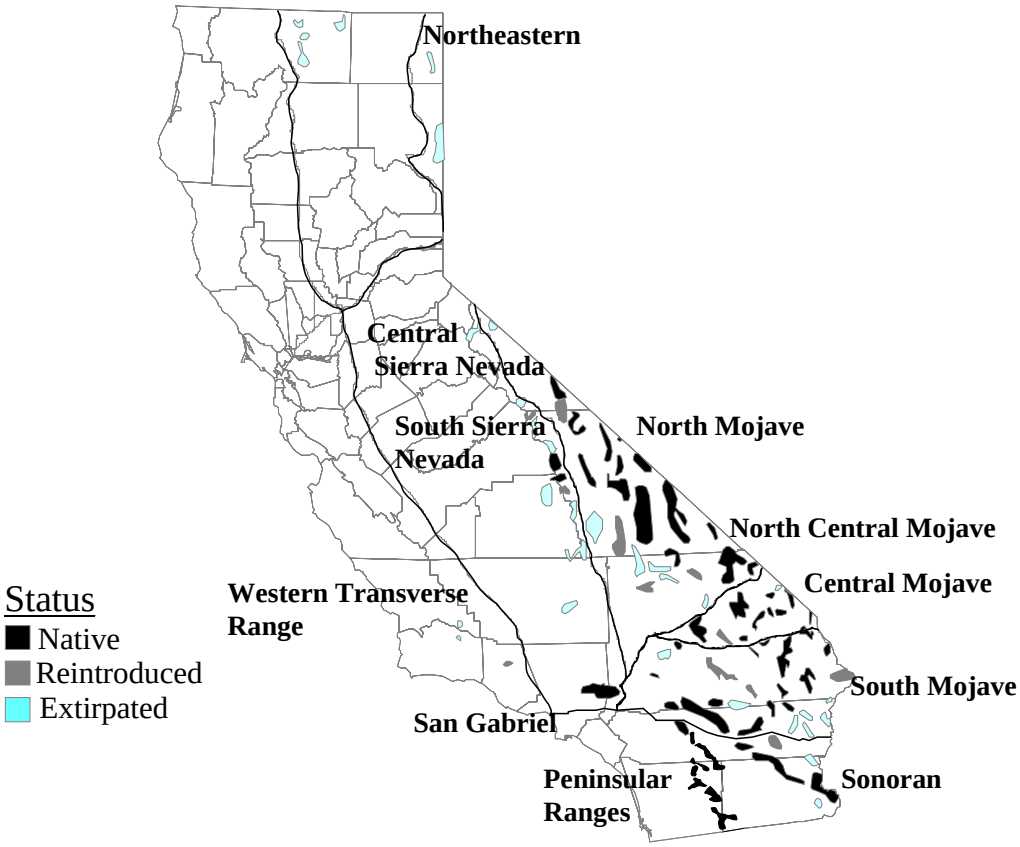

Figure 1. Metapopulations of bighorn sheep, with updated population polygons. Redefined Peninsular population polygons are loosely depicted; an updated GIS map is under preparation.

population has been split into 2 populations occurring on the east and west sides of Highway 74.

In the South Mojave Metapopulation, we have combined the Newberry and Ord populations into a single population. In the Central Mojave Metapopulation, the New York Mountains have been removed from the inventory; although important as a transitional range, the New York Mountains are poor habitat and may never have supported a viable population. We have also designated Club Peak as a population separate from Old Dad Peak; although movement by males and females with resultant gene flow occurs between these 2 areas, enough geographic and genetic separation exists (Epps 2005) that they probably have independent demographic trajectories.

In the Sierra Nevada, a small population of bighorn sheep recently was discovered at Bubbs Creek on the west side of the range (SNBSRP 2004), and may be a recent recolonization. We have also reclassified the Sawmill Canyon population as distinct from the Mount Baxter population, a demographic separation known since the 1970s (Wehausen 1979, 1996). Anecdotal accounts have suggested that bighorn sheep may be appearing again in northeastern California, although this population is not yet regarded as reestablished; at least 1 young male was

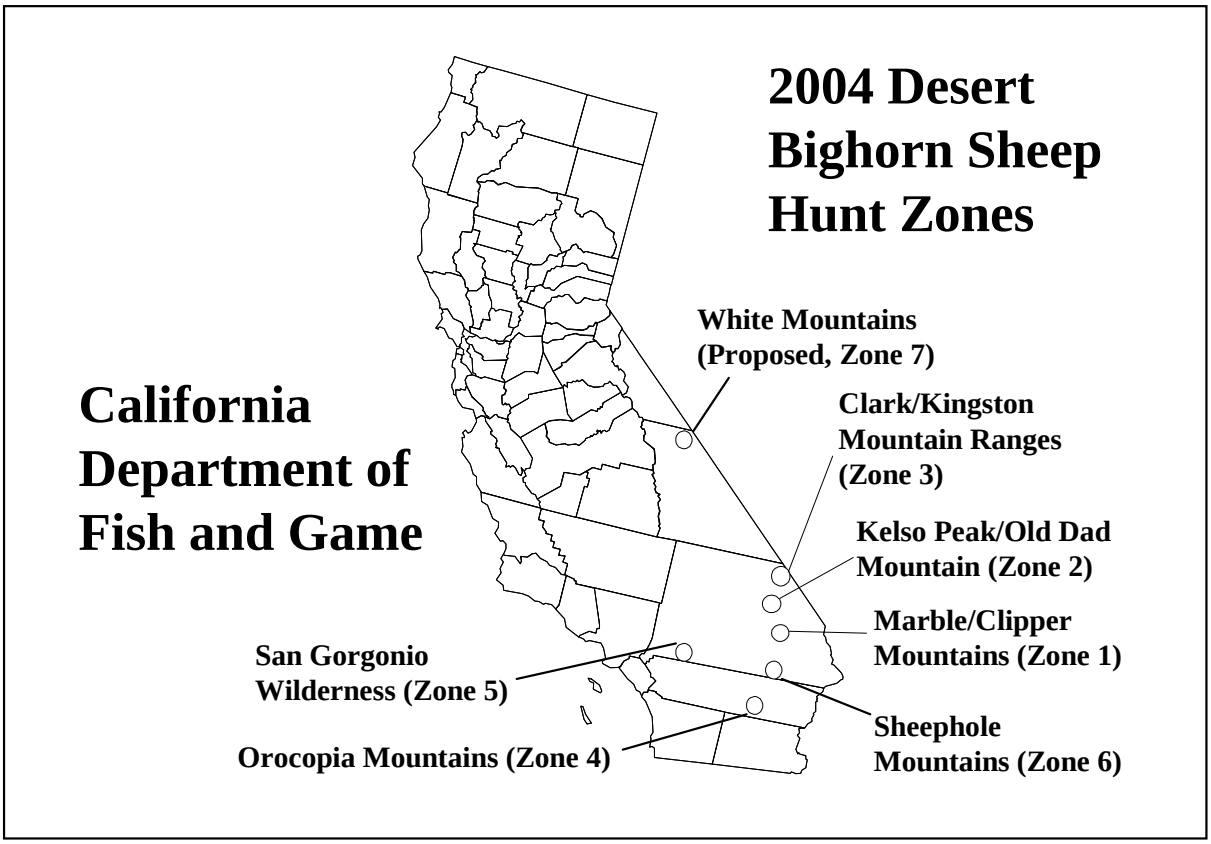

Figure 2. Locations of 2004 desert bighorn sheep hunt zones in California.

removed from the Warner Mountains after it was observed with a band of domestic sheep.

We used this population inventory to examine major population trends since 1995. Although the range of population estimates between 1995 and 2004 overlap in all categories and make definitive conclusions difficult, bighorn sheep numbers in California appear to show an upward trend. The distribution of populations by metapopulation and size class (Table 2) showed an increase in the number of populations in the 25–50 and 51–100 size classes, as well as a strong increase in the number of large populations of 201–300; all other size categories declined in number. As a result, the median total population estimate has increased by 844 animals since 1995 (Table 3).

Regional totals (Table 4) suggest a strong upward trend for bighorn sheep in the Peninsular Ranges. Estimated numbers of bighorn sheep in the Sierra Nevada (SNBSRP 2004) also suggest a strong increase since 1995; this reflects the recovery of Sierra Nevada bighorn from a low of about 100 individuals that occurred in 1995 (Wehausen 1996). Overall numbers of desert bighorn sheep (excluding Peninsular populations) likewise appear to have increased slightly, and the total number of viable populations (excluding reclassifications) has increased during this time period. Many areas of current or former use by populations of bighorn sheep have not been investigated in more than a

decade (Table 1). Those areas should be re-visited to determine whether changes in status have occurred.

Table 3. Bighorn sheep population estimates by metapopulation (2004). Low, median, and high totals result from summing the low, mid, and high values of each size class.

Metapopulation	Low	Median	High
Peninsular Ranges	554	731	900
San Gabriel	201	251	300
Western Transverse Range	25	38	50
Sonoran	228	316	400
South Mojave	738	1076	1396
Central Mojave	428	593	750
Central North Mojave	178	266	350
North Mojave	610	872	1122
Very Southern Sierra	0	0	0
Southern Sierra Nevada	180	292	398
Central Sierra Nevada	25	38	50
Northeastern California	0	0	0
Total	3167	4473	5716
1995 Total (Torres et al. 1996)	2541	3629	4712
Net Change Since 1995	+626	+844	+1004

Table 4. Bighorn sheep population estimates by geographical region (2004). 1995 estimates (calculated from or reported in Torres et al. 1996) are indicated in parentheses.

Region	Low	Median	High
Peninsula	554 (303)	731 (404)	900 (500)
Sierra	205 (101)	330 (163)	448 (224)
Other	2408 (2137)	3412 (3061)	4368 (3988)
Total	3167 (2541)	4473 (3628)	5716 (4712)

Research

The past 10 years have been marked by numerous and extensive research projects by CDFG, universities, and other agencies that have further advanced our understanding of bighorn sheep taxonomy, demography, distribution, ecology, behavior, and metapopulation dynamics in California. CDFG has continued to conduct annual surveys in the hunt zones (Figure 2) and occasionally other populations, and has captured and radiocollared bighorn in the Cushenbury, Old Dad Peak, Old Woman Mountains, Iron Mountains, Queen Mountains, East Chocolate Mountains, Orocopia Mountains, South Bristol Mountains, Marble Mountains, Panamint Mountains, Eagle Crags, White Mountains, San Gabriel Mountains, Vallecito Mountains, Carrizo Mountains, South San Ysidro Mountains, North San Ysidro Mountains, Coyote Canyon, East Santa Rosa Mountains, West Santa Rosa Mountains, San Jacinto Mountains, Lee Vining, Wheeler Ridge, Sawmill Canyon, Mount Baxter, and Mount Langley populations during 1995–2004.

A substantial number of publications concerning bighorn sheep in California was produced during 1995–2005. While not an exhaustive list, we present here a brief bibliography, organized loosely by topic (some papers are included in more than one topic area); we include material in the professional literature in this list, as well as unpublished theses and dissertations. Papers on habitat management, use or selection for bighorn sheep in California include Andrew et al. (1997*a*; 1999; 2001), Bleich et al. (1997), Divine (1998), Divine et al. (2000), Lesicka and Hervert (1995), Longshore and Douglas (1995), Oehler (1999), Oehler et al. (2003), Rubin et al. (2002*b*), Turner et al. (2004), and Rechel (2003). Contributions relevant to metapopulation processes include Bleich et al. (1996), Epps (2004; 2005), Epps et al. (2004), and Wehausen (1999).

The topic of predation and bighorn sheep was examined by Bleich (1996; 1999*a*), Bleich et al. (2004), Boyce et al. (1996*b*), Ernest et al. (2002), Hayes et al. (2000), Schaefer et al. (2000), and Wehausen (1996). Bighorn sheep demography was also an important area of research (Andrew et al. 1997*b*; Coonan 1995; DeForge et al. 1995; DeForge et al. 1997; Douglas and Longshore 1995; Holl et al. 2004; Ostermann et al. 2001; Rubin et al. 1998; Rubin et al. 2002*a*; Schaefer et al. 2000; Wehausen 2005). Considerable research was published on morphometrics, taxonomy, and the rapidly-growing field of genetics (Boyce et al. 1996a; Boyce et al. 1999; Epps 2004, 2005; Gutierrez-Espeleta et al. 1998; Jessup and Ramey II 1995; Ramey II 1995, 1999; Wehausen and Ramey II 2000; Wehausen et al. 2004; Wehausen et al. 2005). Research on life history and behavior (Rubin 2000; Rubin et al. 2000; Wehausen 2005) as well as disease and physiology (Drew et al. 2001; Jessup et al. 1995; Singer et al. 1997; Swift et al. 2000) also was published, as was information evaluating translocation techniques (Thompson et al. 2001) and evaluations (Ostermann et al. 2001).

Habitat Improvements

Water development and maintenance projects long have been part of the CDFG strategy for maintaining and enhancing populations of bighorn sheep (Bleich et al. 2005). During the last decade, however, the pace of development projects slowed considerably, largely as a result of passage of the California Desert Protection Act. This act created numerous wilderness areas and established the Mojave National Preserve and, thereby, complicated efforts to continue water development projects (Bleich 1999*b*). Despite the near absence of habitat improvement projects during the last decade, maintenance of existing development has continued, largely by volunteer organizations such as the Society for the Conservation of Bighorn Sheep and Desert Wildlife Unlimited. Over the past decade, an average of about five major volunteer projects have occurred each year, and have included activities such as replacement of water storage tanks, tamarisk removal, and otherwise routine maintenance including replacement of damaged or corroded fittings. Additionally, volunteers have established seven stations that monitor availability of water at anthropogenic catchments and transmit information via satellite link (Hill and Bleich 1999); those stations have provided invaluable information that has been useful in scheduling inspections or needed repairs.

Harvest (1996–2004)

Hunting of bighorn sheep in California began in 1987; hence, it is a relatively new phenomenon after >100 years of total protection (Wehausen et al. 1987). Since the onset of the hunting program, 7 hunt zones have been established and, pending final approval by the California Fish and Game Commission, an eighth zone is proposed to open in 2005 (Figure 2). Since 1996, several changes have affected hunting of bighorn sheep in California. Because of severe drought, numbers of sheep in the Orocopia Mountains have declined substantially, necessitating that harvests in that area be restricted severely. A similar downward trend in the East Chocolate Mountains resulted in the closure of that zone, and harvest proposals for the Clark and Kingston mountains have been modified downward during recent seasons. Regulations in

California restrict the harvest of bighorn sheep to adult males having approximately a ¾ horn curl.

Since 1996, hunter opportunity has been approximately constant, and hunter success in California remains in excess of 90% (Table 5); slight changes in hunter opportunity on an annual basis reflect the conservative nature of the harvest program, as well as annual adjustments based on current survey results. In general, revenue from fund-raising auction tags has fallen off slightly since 1996 (Table 5).

Problems-Opportunities

Listing of bighorn sheep in the Sierra Nevada and in the Peninsular Ranges as endangered by the federal government resulted in some unanticipated opportunities. In the Sierra Nevada, the California Legislature made funding available to support a substantial recovery program that includes 3 full-time CDFG personnel and 3 full-time contract personnel; the U. S. Fish and Wildlife Service (USFWS) delegated responsibility for implementing the recovery program to CDFG (Bleich 2001*a*). To date, results have been encouraging, and the population of bighorn sheep in that range has increased from about 100 individuals to about 300 animals since 1999 (Table 4, SNBSRP 2004). Currently, the biggest obstacle with which the recovery effort is faced is the potential for disease transmission from domestic sheep, which are grazed on allotments proximate to ranges occupied by Sierra Nevada bighorn sheep. A draft recovery plan was circulated for public review during 2003; efforts to update the plan with new information and to finalize it are continuing. In the Peninsular Ranges, recent population surveys indicate a continuing upward population trend (Table 4). New information from ongoing telemetry investigations has resulted in the redefinition of subpopulations of bighorn sheep inhabiting the Peninsular Ranges. Recovery efforts are being carried out cooperatively by the USFWS, CDFG, University of California, and several nongovernmental organizations.

Bighorn sheep inhabiting the San Gabriel Mountains once represented the largest population of that species in California (Torres et al. 1994). A substantial population decline, attributed in part to changes in habitat associated with fire suppression and predation by mountain lions (Holl et al. 2004) continued during the late 1990s. As a result of that continuing decline, CDFG, the United States Forest Service, and Los Angeles County Fish and Game Commission initiated a cooperative effort to halt the decline and, eventually, restore bighorn sheep to higher population levels in the San Gabriel Mountains. Lack of funds continues to plague the project, but federal monies made available as the result of the devastating fires that burned throughout that range in 2003 offer some promise that the restoration effort will be successful.

During 2003, CDFG initiated an effort to complete plans for bighorn sheep conservation that were based on the premise that bighorn sheep existed in a metapopulation structure. Recent research (Epps 2004, 2005) has evaluated metapopulation structure and dynamics for bighorn sheep in California, and a CDFG project is underway to update the GIS map of bighorn sheep habitat in California. A draft plan for the Sonoran Desert Metapopulation was completed on schedule, but has not yet been finalized. The budgetary crisis with which the State of California has been faced for the last several years has resulted in the loss of numerous

Table 5. Summary of Nelson (desert bighorn) sheep tag allocations, harvest, applications, and revenue from 1987–2004 in California.

Year	Tags Allocated	Tags Filled	Total Applicants	Fundraising Tag Revenue	Drawing Tag License Fees	Totals
1987	9	9	4,066	$70,000.00	$21,930.00	$91,930.00
1988	9	7	3,385	$59,000.00	$18,525.00	$77,525.00
1989	9	9	3,185	$40,000.00	$17,525.00	$57,525.00
1990	6	6	2,591	$37,000.00	$13,955.00	$50,955.00
1991	8	7	2,834	$42,000.00	$15,570.00	$57,570.00
1992	12	12	3,798	$61,000.00	$22,464.50	$83,464.50
1993	11	9	4,318	$100,000.00	$25,082.00	$125,082.00
1994	14	10	4,692	$162,000.00	$28,422.00	$190,422.00
1995	16	14	4,217	$187,000.00	$26,312.00	$213,312.00
1996	14	10	4,493	$193,500.00	$28,702.75	$222,202.75
1997	11	11	3,925	$84,000.00	$26,836.25	$110,836.25
1998	10	9	4,853	$150,000.00	$32,588.00	$182,588.00
1999	11	11	5,058	$95,000.00	$34,120.00	$129,120.00
2000	10	10	5,445	$76,000.00	$36,288.00	$112,288.00
2001	14	12	5,754	$148,000.00	$40,539.00	$188,539.00
2002	14	12	7,147	$138,000.00	$51,485.25	$189,485.25
2003	10	10	7,697	$51,691.00	$54,679.75	$106,370.50
2004	13	12[2]	7,285	$58,884.50[1]	$40,536.00[1]	$99,420.50[1]
Total[1]	201	180	84,743	$1,753,075.50	$535,550.50	$2,288,635.75

[1] 2004 totals have not been finalized
[2] As of January 31, 2004; 2004–2005 season has not ended

personnel in CDFG, and the reassignment of others to unanticipated tasks. Although the long-term benefits of conservation planning on a metapopulation basis are clear (Bleich et al. 1996), timely completion of that effort will be a function of the priority in which it is viewed by the CDFG administration.

In 1994, Congress passed the California Desert Protection Act (CDPA), which established numerous wilderness areas throughout the deserts of California, and transferred management authority for much of the eastern Mojave Desert from the Bureau of Land Management (BLM) to the National Park Service (NPS, Bleich and Pauli 1999). That legislation has been especially problematic for issues of bighorn sheep conservation because the majority of ranges occupied by bighorn sheep were designated as wilderness; further, differing agency management policies and philosophical differences have complicated conservation activities within areas recently transferred to NPS (Bleich 1999*b*). A Memorandum of Agreement between CDFG and BLM has facilitated access to wilderness areas by CDFG for conservation activities; such an agreement has not yet been achieved with NPS despite the specific acknowledgment of CDFG management

authority in the newly designated Mojave National Preserve (MNP, Bleich 2001*b*). As a result, wildlife conservation activities proposed by CDFG to occur in the MNP remain contentious.

During 1999, the California Legislature passed a bill that provided CDFG the authority to remove mountain lions if it was determined that those predators were "…an imminent threat to the survival of any threatened, endangered, candidate, or fully protected sheep species." That legislation provided CDFG with management options that had been usurped with the passage of a ballot initiative in 1990, which designated mountain lions as a specially protected mammal. With the exception of individual animals subject to hunter harvest, all bighorn sheep in California are fully protected and, thereby, subject to the initiative passed in 1999.

As noted previously, passage of the CDPA complicated many conservation activities proposed by CDFG throughout the majority of the range of bighorn sheep in California. Further, large-scale plans, such as those prepared by BLM for the Northern and Eastern Colorado Desert that provided authority for implementation of habitat improvement and maintenance projects, have been successfully challenged in court. In the absence of regular maintenance activities, past efforts to enhance conditions for bighorn sheep will be negated. Efforts to enhance habitat and to translocate bighorn sheep have been compromised by court challenges, thereby affecting well-intended proposals to benefit that species. Without recognition that well-intentioned but conflicting legislation is problematic for wildlife conservation, management on behalf of bighorn sheep and wildlife in general will become even more difficult (Bleich 1999*b*, 2005).

Several apparent outbreaks of disease occurred in California in the past decade. Those events occurred in the Old Woman Mountains (San Bernardino County) and in the northern Panamint Range (Inyo County), and subsequently were investigated by CDFG. Mortality rates, as determined from animals that were captured for sampling and then telemetered, were not remarkable; hence, the demographic consequences of those events appeared to be minimal, but warrant further investigation. In 1995, in excess of 40 bighorn sheep died as a result of probable botulism poisoning at Old Dad Peak (San Bernardino County) (Swift et al. 2000). The immediate demographic consequences of that event were substantial, but the population has since compensated for those losses and remains among the largest in California (Table 1).

The majority of funding for conservation activities affecting bighorn sheep in California originates with the sale of fund-raising auction tags. Individual tags have brought as much as $150,000 during previous years (Table 5, Pauli 2002) but, in general, revenues from the sale of fund-raising tags have been declining. This may be a function, in part, of poor economic times over the past several years, but it also reflects the availability of only a single fund-raising tag since 2002. In the absence of additional financial support, CDFG bighorn sheep management activities likely will remain constrained by funds generated through the sale of bighorn sheep hunting permits. During 2005, a new hunt has been proposed for the White Mountains; if that proposal is approved by the California Fish and Game Commission, a second fund-raising tag may yield a substantial increase in funds available for bighorn sheep management in the coming year.

Acknowledgments: We thank Terry Anderson, Randy Botta, Kevin Brennan, Bob Campbell, Jim Davis, Jim DeForge, Carlos Gallinger, Scott Hetzler, Gerald Mulcahy, Ray Osgood, S. P. Parker, Andy Pauli, Esther Rubin, Tom Stephenson, Glenn Sudmeier, Doug Updike, and the employees of the Viceroy Mine at Hart Peak, for their observations on bighorn sheep populations in California or assistance with this report. We thank the many members of The Society for the Conservation of Bighorn Sheep and Desert Wildlife Unlimited for their continuing efforts on behalf of bighorn sheep conservation in California. This is a contribution from the CDFG Bighorn Sheep Conservation Program, the CDFG Resource Assessment Program, and is Professional Paper 047 from the Eastern Sierra Center for Applied Population Ecology.

Literature Cited

ANDREW, N., L. LESICKA, AND V. C. BLEICH. 1997*a*. An improved fence design to protect water sources for native ungulates. Wildlife Society Bulletin 25:823–825.

ANDREW, N. G., V. C. BLEICH, P. V. AUGUST, AND S. G. TORRES. 1997*b*. Demography of mountain sheep in the East Chocolate Mountains, California. California Fish and Game 83:68–77.

ANDREW, N. G., V. C. BLEICH, AND P. V. AUGUST. 1999. Habitat selection by mountain sheep in the Sonoran desert: implications for conservation in the Unites States and Mexico. California Wildlife Conservation Bulletin 12:1-30.

ANDREW, N. G., V. C. BLEICH, A. D. MORRISON, L. M. LESICKA, AND P. COOLEY. 2001. Wildlife mortalities associated with artificial water sources in the Sonoran Desert. Wildlife Society Bulletin 29:275–280.

BLEICH, V. C. 1996. Interactions between coyotes (*Canis latrans*) and mountain sheep (*Ovis canadensis*). Southwestern Naturalist 41:81–82.

BLEICH, V. C., J. D. WEHAUSEN, R. R. RAMEY, AND J. L. RECHEL. 1996. Metapopulation theory and mountain sheep: implications for conservation. Pages 353–373 in D. R. McCullough, editor. Metapopulations and Wildlife Conservation. Island Press, Covelo.

BLEICH, V. C., R. T. BOWYER, AND J. D. WEHAUSEN. 1997. Sexual segregation in mountain sheep: Resources or predation? Wildlife Monographs:134:1–50.

BLEICH, V. C. 1999*a*. Mountain sheep and coyotes: Patterns of predator evasion in a mountain ungulate. Journal of Mammalogy 80:283–289.

BLEICH, V. C. 1999*b*. Wildlife conservation and wilderness management: uncommon objectives and conflicting philosophies. North American Wild Sheep Conference Proceedings 2:195–205.

BLEICH, V. C., AND A. M. PAULI. 1999. Distribution and intensity of hunting and trapping activity in the East Mojave National Scenic Area, California. California Fish and Game 85:148–160.

BLEICH, V. C. 2001*a*. Restoring bighorn sheep to the Sierra Nevada: a new challenge for wildlife biologists. Wild Sheep 24:47–50, 52.

BLEICH, V. C. 2001*b*. On wildlife management in national monuments. The Wildlifer 306:59.

BLEICH, V. C., E. F. CASSIRER, L. E. OLDENBURG, V. L. COGGINS, AND D. L. HUNTER. 2004. Predation by a golden eagle, *Aquila chrysaetos*, on a juvenile mountain sheep, *Ovis canadensis*. California Fish and Game 90:91–93.

BLEICH, V. C. 2005. In my opinion: politics, promises, and illogical legislation confound wildlife conservation. Wildlife Society Bulletin 33:in press.

BLEICH, V. C., J. G. KIE, T. R. STEPHENSON, M. W. OEHLER SR., AND A. L. MEDINA. 2005. Managing rangelands for wildlife. Pages 873–897 *in* C. E. Braun, editor. The wildlife techniques manual. The Wildlife Society, Bethesda, Maryland.

BOYCE, W. M., P. W. HEDRICK, N. E. MUGGLI-COCKETT, S. KALINOWSKI, M. C. T. PENEDO, AND R. R. RAMEY II. 1996*a*. Genetic variation of major histocompatibility complex and microsatellite loci: a comparison for bighorn sheep. Genetics 145:421–433.

BOYCE, W. M., E. S. RUBIN, C. HAYES, S. G. TORRES, AND M. C. JORGENSEN. 1996*b*. Mountain lion predation on bighorn sheep in the

Peninsular Ranges of California. Biennial Symposium of the Northern Wild Sheep and Goat Council 10:12.

BOYCE, W. M., R. R. RAMEY II, T. C. RODWELL, E. S. RUBIN, AND R. S. SINGER. 1999. Population subdivision among desert bighorn sheep (*Ovis canadensis*) revealed by mitochondrial DNA analysis. Molecular Ecology 8:99–106.

COONAN, T. J. 1995. Weather, nutritional status, and recruitment of desert bighorn sheep in Death Valley, California. Desert Bighorn Council Transactions 39:68–76.

DEFORGE, J. R., E. M. BARRETT, S. D. OSTERMANN, M. C. JORGENSEN, AND S. G. TORRES. 1995. Population dynamics of peninsular bighorn sheep in the Santa Rosa Mountains, California, 1983–1994. Desert Bighorn Council Transactions 39:50–67.

DEFORGE, J. R., S. D. OSTERMANN, C. W. WILLMOTT, K. B. BRENNAN, AND S. G. TORRES. 1997. The ecology of peninsular bighorn sheep in the San Jacinto Mountains, California. Desert Bighorn Council Transactions 41:8–25.

DIVINE, D. D. 1998. Habitat patch dynamics of desert bighorn sheep *Ovis canadensis nelsoni* in the eastern Mojave Desert. University of Nevada, Las Vegas, Nevada. Ph.D dissertation.

DIVINE, D. D., D. W. EBERT, AND C. L. DOUGLAS. 2000. Examining desert bighorn habitat using 30-m and 100-m elevation data. Wildlife Society Bulletin 28:986–992.

DOUGLAS, C. L., AND K. LONGSHORE. 1995. Costs and effectiveness of methods used for population estimates of bighorn sheep in Death Valley National Park. Desert Bighorn Council Transactions 39:1–9.

DREW, M. L., V. C. BLEICH, S. G. TORRES, AND R. G. SASSER. 2001. Early pregnancy detection in mountain sheep using a pregnancy-specific protein B assay. Wildlife Society Bulletin 29:1182–1185.

EPPS, C. W. 2004. Population processes in a changing climate: extinction, dispersal, and metapopulation dynamics of desert bighorn sheep in California. University of California, Berkeley, California. Ph.D. dissertation.

EPPS, C. W., D. R. MCCULLOUGH, J. D. WEHAUSEN, V. C. BLEICH, AND J. L. RECHEL. 2004. Effects of climate change on population persistence of desert-dwelling mountain sheep in California. Conservation Biology 18:102–113.

EPPS, C. W. 2005. Using genetic analyses to describe and infer recent colonizations by desert bighorn sheep. Proceedings of the Sweeney Granite Mountains 25th Anniversary Symposium:in press.

ERNEST, H. B., E. S. RUBIN, AND W. M. BOYCE. 2002. Fecal DNA analysis and risk assessment of mountain lion predation of bighorn sheep. Journal of Wildlife Management 66:75–85.

GUTIERREZ-ESPELETA, G. A., S. T. KALINOWSKI, W. M. BOYCE, AND P. W. HEDRICK. 1998. Genetic variation in desert bighorn sheep. Desert Bighorn Council Transactions 42:1–10.

HAYES, C. L., E. S. RUBIN, M. C. JORGENSEN, R. A. BOTTA, AND W. M. BOYCE. 2000. Mountain lion predation of bighorn sheep in the Peninsular Ranges, California. Journal of Wildlife Management 64:954–959.

HILL, S. D., AND V. C. BLEICH. 1999. Monitoring wildlife water sources using low Earth orbiting satellites (LEOS). Wildlife Society Bulletin 27:25–27.

HOLL, S. A., V. C. BLEICH, AND S. G. TORRES. 2004. Population dynamics of bighorn sheep in the San Gabriel Mountains, California, 1967–2002. Wildlife Society Bulletin 32:412–426.

JESSUP, D. A., W. M. BOYCE, AND S. G. TORRES. 1995. Bighorn sheep health management in California: a fifteen year retrospective. Proc. Joint Conference AAZV/WDA/AAWV 1995:56–67.

JESSUP, D. A., AND R. R. RAMEY II. 1995. Genetic variation of bighorn sheep as measured by blood protein electrophoresis. Desert Bighorn Council Transactions 39:17–25.

LESICKA, L. M., AND J. J. HERVERT. 1995. Low maintenance water development for arid environments: concepts, material and techniques. Pages 52–57 *in* D. P. Young, R. Vinzant, and M. D. Strickland, editors. Wildlife water development. Water for Wildlife Foundation, Lander, Wyoming.

LONGSHORE, K., AND C. L. DOUGLAS. 1995. Home ranges of desert bighorn sheep inhabiting the Black Mountains, Death Valley National Park, California. Desert Bighorn Council Transactions 39:26–35.

OEHLER, M. W. 1999. Ecology of mountain sheep: effects of mining and precipitation.

University of Alaska, Fairbanks, Alaska. M.S. thesis.

OEHLER, M. W., R. T. BOWYER, AND V. C. BLEICH. 2003. Home ranges of female mountain sheep, Ovis canadensis nelsoni: effects of precipitation in a desert ecosystem. Mammalia 67:385–401.

OSTERMANN, S. D., J. R. DEFORGE, AND W. D. EDGE. 2001. Captive breeding and reintroduction evaluation criteria: a case study of Peninsular bighorn sheep. Conservation Biology 15:749–760.

PAULI, A. M. 2002. Bighorn sheep hunting: win-win for hunters, species. Tracks Summer 2002:17.

RAMEY II, R. R. 1995. Mitochondrial DNA variation, population structure, and evolution of mountain sheep in the southwestern United States and Mexico. Molecular Ecology 4:429–439.

RAMEY II, R. R. 1999. New perspectives on the evolutionary origins, historic phylogeography, and population structure of North American mountain sheep. Transactions of the North American Wild Sheep Conference 2:9–20.

RECHEL, J. L. 2003. Using neighborhood effects and friction surfaces to model spatial distributions and movement areas: applications to desert-dwelling mountain sheep (Ovis canadensis). University of California, Riverside, Riverside, California. Ph.D dissertation.

RUBIN, E. S., W. M. BOYCE, M. C. JORGENSEN, S. G. TORRES, C. L. HAYES, C. S. O'BRIEN, AND D. A. JESSUP. 1998. Distribution and abundance of bighorn sheep in the Peninsular Ranges, California. Wildlife Society Bulletin 26:539–551.

RUBIN, E. S. 2000. The ecology of desert bighorn sheep (*Ovis canadensis*) in the peninsular ranges of California. University of California-Davis, Davis, California. Ph.D. Dissertation.

RUBIN, E. S., W. M. BOYCE, AND V. C. BLEICH. 2000. Reproductive strategies of desert bighorn sheep. Journal of Mammalogy 81:769–786.

RUBIN, E. S., W. M. BOYCE, AND E. P. CASWELL-CHEN. 2002*a*. Modeling demographic processes in an endangered population of bighorn sheep. Journal of Wildlife Management 66:796–810.

RUBIN, E. S., W. M. BOYCE, C. J. STERMER, AND S. G. TORRES. 2002*b*. Bighorn habitat use and selection near an urban environment. Biological Conservation 104:251–263.

SCHAEFER, R. J., S. G. TORRES, AND V. C. BLEICH. 2000. Survivorship and cause-specific mortality in sympatric populations of mountain sheep and mule deer. California Fish and Game 86:127–135.

SINGER, R. S., D. A. JESSUP, I. A. GARDNER, AND W. M. BOYCE. 1997. Pathogen exposure patterns among sympatric populations of bighorn sheep, mule deer, and cattle. Journal of Wildlife Diseases 33:377–382.

SNBSRP. 2004. Sierra Nevada bighorn sheep progress report 2003. Outdoor California 65:4–17.

SWIFT, P., J. D. WEHAUSEN, H. B. ERNEST, R. S. SINGER, A. PAULI, H. KINDE, T. E. ROCKE, AND V. C. BLEICH. 2000. Desert bighorn sheep mortality due to presumptive type C botulism in California. Journal of Wildlife Diseases 36:184–189.

THOMPSON, J. R., V. C. BLEICH, S. G. TORRES, AND G. P. MULCAHY. 2001. Translocation techniques for mountain sheep: does the method matter? Southwestern Naturalist 46:87–93.

TORRES, S. G., V. C. BLEICH, AND J. D. WEHAUSEN. 1994. Status of bighorn sheep in California, 1993. Desert Bighorn Council Transactions 38:17–28.

TORRES, S. G., V. C. BLEICH, AND J. D. WEHAUSEN. 1996. Status of bighorn sheep in California-1995. Desert Bighorn Council Transactions 40:27–34.

TURNER, J. C., C. L. DOUGLAS, C. R. HALLAM, P. R. KRAUSMAN, AND R. R. RAMEY. 2004. Determination of critical habitat for the endangered Nelson's bighorn sheep in southern California. Wildlife Society Bulletin 32:427–448.

WEAVER, R. A. 1989. Status of bighorn sheep in California – 1989. The Sheepherder January 1989:20–23.

WEHAUSEN, J. D. 1979. Sierra Nevada bighorn sheep: an analysis of management alternatives. Cooperative Administrative Report, Inyo National Forest and Sequoia, Kings Canyon and Yosemite National Parks.

WEHAUSEN, J. D., V. C. BLEICH, AND R. A. WEAVER. 1987. Mountain sheep in California: a historical perspective on 108 years of full

protection. Western Section Wildlife Society Transactions 23:65–74.

WEHAUSEN, J. D., AND R. R. RAMEY II. 1993. A morphometric reevaluation of the Peninsular bighorn subspecies. Desert Bighorn Council Transactions 37:1–10.

WEHAUSEN, J. D. 1996. Effects of mountain lion predation on bighorn sheep in the Sierra Nevada and Granite Mountains of California. Wildlife Society Bulletin 24:471–479.

WEHAUSEN, J. D. 1999. Rapid extinction of mountain sheep populations revisited. Conservation Biology 13:378–384.

WEHAUSEN, J. D., AND R. R. RAMEY II. 2000. Cranial morphometric and evolutionary relationships in the northern range of *Ovis canadensis*. Journal of Mammalogy 81:145–161.

WEHAUSEN, J. D., R. R. RAMEY, AND C. W. EPPS. 2004. Experiments in DNA extraction and PCR amplification from bighorn sheep feces: the importance of DNA extraction method. Journal of Heredity 95:503–509.

WEHAUSEN, J. D. 2005. Nutrient predictability, birthing seasons, and lamb recruitment for desert bighorn sheep. Proceedings of the Sweeney Granite Mountains 25th Anniversary Symposium.

WEHAUSEN, J. D., V. C. BLEICH, AND R. R. RAMEY II. 2005. Correct nomenclature for Sierra Nevada bighorn sheep. California Fish and Game 91: In press.