these potential model parameters were compiled for analysis. Data that are available consisted of: (1) a fairly comprehensive inventory of water sources for Anza-Borrego Desert State Park, (2) a water source survey by the Bureau of Land Management for the northern parts of the range, (3) vegetation community maps, and (4) topographic relief.

In desert environments, water is a known limiting factor for many species of plants and wildlife. However, some populations of bighorn sheep are known to exist in areas without sources of perennial water (summarized in Broyles 1995), as is known to be the case in parts of the Peninsular Ranges for at least some parts of the year (refer to section I.B.1). In the Peninsular Ranges, the presence of perennial water is known to be a limiting factor only during prolonged droughts or summers without significant thunderstorm activity. However, given the numerous dependable water sources in the San Jacinto Mountains and other portions of the range (*e.g.* central Santa Rosa Mountains), water likely does not limit sheep distribution in these regions, even under drought conditions. The variable quality and lack of reliable water source data in some portions of the Peninsular Ranges, and the fact that water availability does not limit habitat use in much of these ranges, resulted in the decision to not use water sources to delineate bighorn sheep habitat. Available observational records (Figure 6) indicate that sheep range at least 16 kilometers (10 miles) from known perennial water sources. Given the existing distribution of water, sheep are capable of using, and therefore can be expected to use, all areas mapped as essential habitat.

Generalized plant community mapping has been completed within bighorn habitat throughout Riverside County, and detailed mapping has been completed in Anza-Borrego Desert State Park. However, bighorn sheep are generalist foragers and plants known to be eaten are broadly distributed across habitat types in the Peninsular Ranges. Extreme topographic relief provides a diversity of interdigitated habitats and plant communities across the mountainous slopes, canyons, washes, and alluvial fans within the home range of each ewe group. Consequently, the distribution of forage plants does not appear to limit sheep distribution, though it can influence seasonal habitat use patterns.

The primary habitat components that limit the distribution of bighorn sheep in the Peninsular Ranges may be those associated with predator evasion. Unobstructed visibility is recognized as an important habitat characteristic by many researchers (*e.g.*, Geist 1971, Risenhoover and Bailey 1985, Fairbanks *et al.* 1987, Etchberger *et al.* 1989). Bighorn sheep rely on their keen vision and climbing ability to detect and evade their predators (Geist 1971). The presence of escape terrain and an unobstructed view are, therefore, key habitat requirements (Geist 1971).

All bighorn sheep habitat models recognize escape terrain as a key habitat component. However, the definition of "escape terrain" varies widely (McCarty and Bailey 1994). Some researchers defined it by a minimum slope (*e.g.*, Andrew *et al.* 1999, Dunn 1996) or slope plus a qualitative measure of ruggedness (*e.g.*, Holl 1982, Risenhoover and Bailey 1985, Armentrout and Brigham 1988), while others have described escape terrain with word models that incorporate a qualitative description of slope and ruggedness (*e.g.*, Hansen 1980b, Elenowitz 1983, Gionfriddo and Krausman 1986, Fairbanks *et al.* 1987, Cunningham 1989). The difficulty in determining a universal definition may be because bighorn sheep in different mountain ranges have access to different habitat (in terms of slope and ruggedness), and/or because use of escape terrain varies with group size (Risenhoover and Bailey 1985), group composition, and season (Cunningham and Ohmart 1986, Bleich *et al.* 1997). Furthermore, escape terrain has been described as habitat used "for escape from perceived danger" (Van Dyke *et al.* 1983). This definition recognizes that escape terrain is based on a bighorn sheep's perception, something that apparently differs among individuals and populations. Desert bighorn sheep frequently have been found at slopes of 21 to 50 percent (Elenowitz 1983), slopes greater than or equal to 20 percent (Andrew *et al.* 1999), and slopes averaging 13 to 34 percent (Bleich *et al.* 1997). A minimum slope of 20 percent was used (in combination with canopy cover) to define bighorn sheep habitat in New Mexico (Dunn 1996). A slope of greater than or equal to 20 percent was adopted as the minimum required as escape terrain for bighorn sheep in the Peninsular Ranges. The first step of the habitat mapping process was, therefore, to identify all patches of land having a slope of greater than or equal to 20 percent (see following methods).

Bighorn sheep are closely associated with mountainous habitat and often are hesitant to venture far from escape terrain (Geist 1971). Although they have been documented to move great distances from escape terrain on rare occasions (Schwartz *et al.* 1986), it is not uncommon to observe animals moving a short distance from escape terrain in search of forage or water sources, or moving between neighboring mountain masses. Washes and alluvial fans often support a higher diversity, quality, and quantity of forage species than less productive rocky slopes (Leslie and Douglas 1979), seasonal and perennial water sources (Wilson *et al.* 1980, Holland and Keil 1989), bedding and thermal cover (Andrew 1994), alternative forage sources in times of drought, resource scarcity, and stress (Leslie and Douglas 1979, Bleich *et al.* 1997), and a source of forage with higher nutritional value during the lambing and rearing season (Hansen and Deming 1980). Also refer to section I.B.1. Since temperature varies inversely with elevation, the earliest winter forage growth occurs at lower elevations (Wehausen 1980, 1983), and sheep often seek this early source of nutrients. The critical importance to bighorn of access to a variety of feeding habitats was demonstrated in the Whipple Mountains when reintroduced sheep were confined to an enclosure containing what was considered ample forage. At lambing time, both ewes and their new lambs began dying of malnutrition (Berbach 1987), apparently because they were not free to seek out habitats containing more nutritious forage. Researchers have documented animals ranging at a variety of distances from mountainous terrain, *e.g.*, 1.6 kilometers (0.80 mile) (Denniston 1965), 0.8 kilometer (0.50 mile) (McQuivey 1978), 1.3 kilometers (0.70 mile) (Leslie and Douglas 1979), greater than 1 kilometer (1.6 miles) (Burger 1985), greater than 1.6 kilometers (1 mile) (Bleich *et al.* 1992), and greater than 2.5 kilometers (1.6 miles) (Andrew *et al.* 1997). Jones *et al.* (1957) reported bighorn sheep foraging as far as 2 kilometers (1.2 miles) from the base of the Santa Rosa Mountains. Elsewhere in the Peninsular Ranges, bighorn sheep were frequently observed within 0.8 kilometer (0.5 mile) from mountainous habitat feeding in or moving across washes and alluvial fans (DeForge and Scott 1982; E. Rubin and M. Jorgensen, pers. comm.). Accordingly, the second step of the mapping process was to include habitat within 0.8 kilometers (0.50 mile) of slopes greater than or equal to 20 percent.

To identify slopes of 20 percent or greater, 7.5' digital elevation models (DEMs) were merged together over the entire study area. These digital elevation models are 30-meter by 30-meter (98-foot by 98-foot) cell grids with a vertical accuracy of 7 meters (23 feet). All grid cells were then aggregated into slope classes. Next, the slope classes were analyzed to select habitat within 0.8 kilometer (0.5 mile) of slopes of greater than or equal to 20 percent. This selection was accomplished by first lumping slopes greater than or equal to 20 percent into one class in a derivative grid. A buffer of 0.8 kilometer (0.5 mile) was then applied to the perimeter of all areas of slope in the derivative grid.

In the Peninsular Ranges, bighorn sheep habitat is delimited at upper boundaries by dense vegetation associations (primarily chaparral) that reduce visibility and likely increase susceptibility to mountain lion predation. Measuring visibility (by actual field measurements) to delineate the upper boundary of habitat would require study because it is currently not known what visibility threshold is acceptable to bighorn sheep in the Peninsular Ranges. Fire frequency and its effect on plant succession changes visibility thresholds over time (refer to section I.D). Therefore, to determine the upper boundary of bighorn sheep habitat, the westernmost areas used by bighorn sheep within the past 25 to 30 years were identified and the vegetation associations in these areas were applied rangewide where detailed vegetation analyses were available. Because a detailed vegetation map was not available rangewide, a team of biologists experienced with Peninsular bighorn sheep flew the entire upper/western boundary line in a helicopter and visually assessed vegetation associations. The path of the flight was determined by consensus among the biologists and was recorded via a Global Positioning System (GPS). The antenna of a Trimble Navigation, LTD., Global Positioning System was mounted in the helicopter and position data were recorded every 10 seconds. A total of 228 kilometers (142 miles) were flown. A base station Global Positioning System, located in the Anza-Borrego Desert State Park, was run during the entire flight. Trimble Navigation Pathfinder Office software was used to post process the collected Global Positioning System data using base station information. Trimble Navigation Pathfinder Office (IM) was then used to export the data as an ESRI ARC/INFO Geographic Information Systems (GIS) readable file. Only corrected data were used to build the resulting Geographic Information System layer. Because this line is dynamic in response to fire frequency and likely has shifted to a lower elevation with the advent of fire suppression, a 0.8 kilometer (0.5 mile) extension was added to the west side of this line.

The resulting line in Anza-Borrego Desert State Park was checked against detailed Geographic Information System mapping of vegetation associations within the park (Keeler-Wolf *et al.* 1998). Vegetation associations not typically used by bighorn sheep in the Peninsular Ranges were excluded from essential habitat. These associations primarily included Muller's oak (*Quercus cornelius-mulleri*), sugarbush (*Rhus ovata*), chamise (*Adenostoma fasciculatum*), and manzanita (*Arctostaphylos* spp.) associations. Associations encompassed within bighorn sheep habitat included brittlebush (*Encelia farinosa*), desert lavender (*Hyptis emoryi*), cholla (*Opuntia* spp.), burro-weed (*Ambrosia dumosa*) and creosote (*Larrea tridentata*), and other creosote associations. The resulting line supported the habitat boundary that was derived during the helicopter flight along the western margin of current bighorn sheep habitat.

To validate the choice of greater than or equal to 20 percent slope and 0.8 kilometer (0.5 mile) distance from this slope as model parameters, Recovery Team members experienced with Peninsular bighorn sheep flew the easternmost line of bighorn sheep habitat in a northern portion of the range (San Jacinto Mountains and Santa Rosa Mountains). The path of this flight was determined by consensus among the team members, based on their observations of bighorn sheep in these ranges, and was believed to represent the low elevation (easternmost) boundary of habitat commonly used by Peninsular bighorn sheep. The path of this flight, which was recorded via Global Positioning System, supported the choice of the greater than or equal to 20 percent slope plus 0.8 kilometer (0.5 mile) distance from this slope as the eastern, lower elevation habitat boundary.

The resulting habitat boundaries were reviewed by Recovery Team members who have studied bighorn sheep in the Peninsular Ranges to verify whether those areas known to be used by sheep in the recent past (within the past 25 to 30 years) were included within the modeled habitat boundaries. This review included a comparison of bighorn sheep sighting locations against the map and verified that most areas used by sheep within the past 25 to 30 years were included within the modeled habitat boundaries (Figure 6).

Mapping Refinement

Upon further review by Recovery Team members, it was determined that the modeled habitat included a habitat type not likely to be used by Peninsular bighorn sheep. This habitat type, classified as mud hills (Augustine and Ward 1995) was found in the Borrego Badlands and Carrizo Badlands of Anza-Borrego Desert State Park. Much of this soil type was removed from the delineated map because it did not correspond with known bighorn sheep habitat use patterns. Conversely, the preliminary habitat boundaries excluded several small islands of "nonhabitat" (defined by the modeling of slope and distance from slope). Because Recovery Team members familiar with the areas considered these islands to be bighorn sheep habitat on the basis of known sightings in nearby or comparable areas, these islands were included in delineated habitat.

A small number of known observations fell outside the delineated boundaries at lower elevations on relatively flat terrain, such as Clark Dry Lake and Coyote Canyon. These observations support previously published reports of bighorn sheep occasionally moving away from mountainous areas. However, the relative rarity of records beyond the 0.8 kilometer (0.5 mile) distance from slope was judged to indicate that such habitat was not essential to population recovery if the habitat delineated within the 0.8 kilometer (0.5 mile) distance from slope were protected. In other areas, the opposite process was required to minimize the habitat edge to area ratio consistent with sound tenets of resource management and preserve design. Along some segments, the 0.8 kilometer (0.5 mile) distance from slope was expanded slightly to capture "nonhabitat" areas that would have represented deep but narrow intrusions into an otherwise stable and manageable essential habitat boundary.

Further modifications were deemed necessary along the urban interface in the Coachella Valley. The 0.8 kilometer (0.5 mile) distance from slope largely has been lost to urban development. Much of the remaining valley floor and alluvial habitat within the 0.8 kilometer (0.5 mile) distance is highly fragmented and degraded with marginal or detrimental value to bighorn conservation (*e.g.*, vacant lots along Highway 111, parcels bordered on three sides by urban development). A series of meetings with affected jurisdictions and major land owners was convened under the auspices of the Coachella Valley multiple-species planning effort to discuss and refine the delineation of essential habitat along the urban interface. Lands without long-term conservation value were excluded from essential habitat (Figures 7, 8, 9). The larger fragments that still remain were included within essential habitat where they were contiguous with mountain slope habitat and of a configuration amenable to effective management. Subject to implementation of required conservation measures, the essential habitat boundary does not include development projects previously reviewed and approved by us.

Finally, pursuant to Secretarial Order 3206 June 5, 1997, we have entered into government to government discussions with the various American Indian tribes that possess lands in bighorn sheep habitat. We coordinated with the tribes to encourage their participation in delineating essential habitat and developing the Peninsular bighorn sheep Recovery Plan in a way that promotes recovery of the species and minimizes the social, cultural, and economic impacts on tribal communities. We worked with and supported the efforts of the Torres-Martinez Desert Cahuilla Indians to obtain data on the value of Reservation lands to bighorn sheep conservation but the Tribe has not agreed that sufficient information is available to demonstrate that their lands are essential to recovery. Based on coordination with the Morongo Band of Mission Indians, tribal lands within the essential habitat boundary will be included for sheep conservation. The Agua Caliente Band of Cahuilla Indians has coordinated with us in the delineation and have agreed that a reservation-wide habitat conservation planning effort will determine appropriate land management issues at a finer scale within the essential habitat boundary.

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APPENDIX C. GUIDELINES FOR DEVELOPING A LONG-TERM STRATEGY FOR REINTRODUCTION, AUGMENTATION, AND CAPTIVE BREEDING OF BIGHORN SHEEP IN THE PENINSULAR RANGES

The purpose of this appendix is to provide guidelines for developing a long-term strategy for reintroduction, augmentation, and captive breeding of bighorn sheep in the Peninsular Ranges, as identified in the recovery plan (task 1.4). This appendix is organized into two sections. The first section outlines some of the preliminary steps needed to identify cases in which reintroductions, augmentations, and captive breeding may be appropriate, and highlights some important considerations in the development of a long-term strategy. The second section presents protocols for captive breeding and release of captive animals, and represents guidelines prepared by the Bighorn Institute for an existing captive breeding and release program. This section addresses many of the issues identified in our Policy Regarding the Controlled Propagation of Species Listed Under the Endangered Species Act (65 FR 56916; September 20, 2000).

I. Considerations in developing a long-term strategy for reintroductions and augmentations

A number of decisions must be made when developing a long-term strategy for augmentation and reintroduction of bighorn sheep in the Peninsular Ranges. Important preliminary steps are presented here in outline form:

1) Identify the general goals of the long-term strategy in relation to the overall recovery effort. These goals should consider the viability of the population with respect to population dynamics and genetics.

2) Determine if existing ewe groups should be augmented or new groups established. A population model, using estimated population parameters (*e.g.*, abundance, recruitment, survivorship, dispersal), should be used to evaluate the effectiveness of various options (including the option of no augmentation or reintroductions) on the viability of the metapopulation.

3) Identify and prioritize sites for augmentations and reintroductions. This assessment must evaluate not only the site's importance to the viability of the entire population, but also must address the following questions:
   a) What is/was the cause of extinction or endangerment in this location?
   b) Has this cause been minimized or removed?
   c) Is reintroduction or augmentation the best conservation option for this particular situation? Have other necessary measures, such as habitat restoration or protection, been taken?

4) Determine augmentation and reintroduction techniques. The success of previous bighorn sheep augmentation and reintroduction projects has been mixed, and a number of questions remain (Desert Bighorn Council 1996). In reintroducing or augmenting Peninsular bighorn sheep, the following issues need to be evaluated:

   a) Determine whether to use captive or free-ranging animals. For the following reasons, caution should be exercised when using captive animals:
      i) If multiple, consecutive generations of animals are bred in captivity, they may undergo "domestication selection"; that is, captive individuals may have behavioral or morphological phenotypes that perform well in captivity but not in the wild. In addition, captive animals may have been raised in an overly protective environment where selection against deleterious genes was relaxed (Brambell 1977, Campbell 1980, Elliott and Boyce 1992, Bush *et al.* 1993).
      ii) Captive animals may be disease vectors to wild populations if they have been exposed to novel diseases during *ex situ* (outside the original site, or captive) propagation (Campbell 1980, Woodford and Kock 1991, Bush *et al.* 1993), or if they have continued to harbor pathogens that have been "purged" from wild populations.
      iii) The use of captive animals during augmentations can reduce or increase the effective population size of the wild population (Ryman and Laikre 1990, Elliott and Boyce 1992).

      Part II of this appendix provides protocols by which these concerns may be minimized. Releases of free-ranging animals are typically more successful than are those of captive animals (Griffith *et al.* 1989, Gordon 1991, Stanley Price 1991); however, an advantage of using captive animals is that their genetic profiles typically are known. In addition, the potential effects on population (Stevens and Goodson 1993) and genetics of removing animals from the wild population must be considered. Currently the small size of ewe groups within the Peninsular Ranges limits the availability of free-ranging animals for translocation. Additional genetic studies may help identify sources within the Peninsular Ranges or elsewhere. Future projects could involve both captive and free-ranging bighorn sheep.

b) If captive animals are to be used in reintroductions and augmentations, determine the desired size of the captive herd, and optimum facilities and management techniques. One alternative is to establish a large captive herd that is housed in a larger enclosure and managed less intensely than the existing captive herd. An approach similar to this is used by the New Mexico Department of Game and Fish (1997) at their Red Rock Wildlife Area, where bighorn sheep are housed in a fenced area of over 500 hectares (1,235 acres). Potential advantages of such a facility are that released animals may have traits more characteristic of free-ranging animals (as opposed to animals raised in a more confined environment), and a larger captive population may lessen genetic concerns associated with small founder populations. As with any captive breeding program, however, the source of animals for this captive population would have to be considered, and both population and genetic management guidelines would have to be addressed (see part II of this appendix).

c) Determine the best population composition of released groups. This consideration applies whether captive or free-ranging animals are used. The number, age/sex composition, and experience of released animals are important considerations (Lenarz and Conley 1980, Wilson and Douglas 1982, Kleiman 1989). The gregarious behavior of bighorn sheep suggests that larger groups are desirable (Wilson and Douglas 1982). However, smaller group sizes more likely mimic natural re-colonization events. The sex ratio should maximize the reproductive potential of the released group or the wild population during reintroductions and augmentations respectively. For bighorn sheep, this typically means a low ram to ewe ratio (Lenarz and Conley 1980). Young animals have high reproductive value (Gotelli 1995) and have a strong tendency to integrate with existing herds when used as release stock (Ostermann *et al.* in press), and thus are desirable for augmentation programs. Lenarz and Conley (1980) suggested that the optimum age for released bighorn sheep is 3 years. However, inclusion of a small number of older or free-ranging, and presumably more experienced, individuals increases the likelihood of success of a reintroduction. The effect of these variables needs to be considered not only with respect to how they will influence success of the release, but also how the removal of these animals will affect the source stock from which they came (Stevens and Goodson 1993).

d) Identify appropriate release animals based on pedigree and proximity to the intended release area. Though based solely on genetic theory, this approach is conservatively designed to: (1) preserve the potential for genetic adaptations to local conditions, (2) prevent outbreeding depression, and (3) maintain the existing genetic structure currently found among Peninsular bighorn ewe groups (Brambell 1977, Boyce *et al.* 1999). However, other options are available to prevent loss of heterozygosity in the wild population (May 1991). In general, the preservation of the gene pool of the entire metapopulation (wild and captive populations included) should be the primary concern (Foose 1991). Therefore, when reintroducing or augmenting animals, care must be taken to avoid genetic swamping of native populations (Kleiman 1989, Ryman and Laikre 1991, Foose 1991, Elliott and Boyce 1992). Furthermore, during any reintroduction or augmentation, the number and sex ratio of released animals must be considered, as it will affect effective population size (Crow and Kimura 1970, FitzSimmons *et al.* 1997). The second section of this appendix discusses the genetic considerations of captive breeding and release of captive animals in detail.

e) Determine the most effective means of releasing animals. These considerations, which apply to both the release of captive and free-ranging animals, should include:

   i) Whether to use a 'soft' or 'hard' release (Berbach 1987, Moore and Smith 1991).
   ii) How far to move free-ranging animals during reintroductions and augmentations. The philopatric behavior of bighorn sheep may result in animals attempting to return to their natal home range. Research on dispersal and movement patterns may guide these decisions (refer to section II.D.2 of this recovery plan).
   iii) During which time of year to conduct releases.
   iv) What specific release site to use. For instance, how far should release sites be from other bighorn sheep (Bleich *et al.* 1996) or from human development? This question may be assessed by releasing and monitoring a small number of sentinel animals during a feasibility study (Kleiman 1989, Chivers 1991).

5) Determine methods for monitoring and assessing the success of reintroduction or augmentation programs, in relation to the goals of this recovery effort (Stanley Price 1991), and identify a specific schedule for future review and possible revision of the long-term strategy.

II. Captive breeding and release of captive bighorn sheep

While it is not a long-term solution (Snyder *et al.* 1996), captive breeding is a powerful tool for rescuing species threatened with extinction (Caughley 1994, Philippart 1995, Caughley and Gunn 1996). Captive breeding can also be used to delay extinction while the agents of a decline are investigated (Caughley and Gunn 1996). Other advantages of captive propagation include the ability to moderate environmental variance, manage genetic diversity, increase the effective population size, and expand animal numbers to provide stock for wild populations (Foose *et al.* 1995). Releasing captive-born animals into the wild to support weak populations is an increasingly common practice (Griffith *et al.* 1989, Kleiman 1989, Snyder *et al.* 1996).

Although there are benefits of captive propagation programs for releasing animals into the wild (Griffith *et al.* 1989, Kleiman 1989, Caughley 1994, Foose *et al.* 1995), these programs can be costly, labor intensive, and their effectiveness has been questioned (Campbell 1980, Philippart 1995, Caughley and Gunn 1996, Snyder *et al.* 1996). Additionally, there are a number of potential risks associated with captive breeding and release programs. Our Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act (65 FR 56916; September 20, 2000) identified the following risks that must be addressed when planning controlled propagation and reintroduction programs: (1) removal of natural parental stock that may result in an increased risk of extinction by reducing the abundance of wild individuals and reducing genetic variability within naturally occurring populations; (2) catastrophic events that can cause the loss of some or all of the captive population; (3) potential for inbreeding or other adverse genetic effects that may result from increasing only a portion of the gene pool; (4) potential erosion of genetic differences between populations; (5) exposure to new selection regimes in controlled environments that may diminish capacity to survive and reproduce in the wild; (6) genetic introgression; (7) increased predation or competition for food, space, and/or mates; and (8) disease transfer.

Adhering to established criteria and upholding standardized protocols will contribute to the success of reintroduction and augmentation programs and reduce the accompanying risks. In this appendix, generalized criteria and guidelines for reintroduction and augmentation programs are combined with knowledge of desert bighorn sheep ecology to create more specific guidelines for Peninsular bighorn sheep captive breeding and release programs.

In this appendix, reintroduction is defined as the movement of wild or captive animals into formerly occupied habitat, while the release of animals into currently occupied habitat is termed "augmentation" or "restocking." The ultimate objective of these guidelines is to establish wild, free-ranging herds that no longer rely on captive breeding. Separate guidelines should be developed for captive breeding programs with other primary goals.

Before commencing a captive breeding program, a feasibility study should be conducted to determine its necessity and potential for success. The following general criteria should be considered (Kleiman *et al.* 1994): the wild population's need for support with respect to genetic diversity and population structure, the availability of stock, removal of the original cause of decline, protection of sufficient habitat, local politics, governmental and nongovernmental agency support, reintroduction/augmentation technology, knowledge of species biology, and sufficient financial resources. A summary of these criteria, which are grouped into four categories, is provided below.

Need for population and/or genetic support

Because captive breeding and reintroduction/augmentation programs require large financial and logistical commitments, the need for population and/or genetic support must first be clearly established (Kleiman 1989, Phillipart 1995, Snyder *et al.* 1996). The International Union for the Conservation of Nature and Natural Resources (1995) guidelines for reintroduction and augmentations recommend conducting a population and habitat viability workshop before initiating a program. A population viability analysis may also facilitate the design and objectives of the program by providing direction on the number of animals needed, and hence the size of the facility needed, and whether restocking (augmenting populations) or reintroduction (establishing new groups) is preferred. Captive breeding is often expensive and not always the most cost-efficient conservation strategy (Kleiman 1989, Kleiman *et al.* 1991, Snyder *et al.* 1996). It must be conducted in conjunction with other conservation measures, and should be based on specific recommendations within a recovery or management plan so that it does not unjustly preempt other recovery techniques (Snyder *et al.* 1996).

Environmental conditions

Captive breeding should only be undertaken if suitable, unsaturated habitat is available (Brambell 1977, Kleiman 1989, Ounsted 1991) and release sites have sufficient carrying capacity to support the expansion of the reintroduced or augmented population. Ideally, release sites should be legally protected (Kleiman *et al.* 1994). Removing or controlling the original cause(s) of decline is an essential step, as failure to do so is a primary reason that reintroduction and augmentation efforts are unsuccessful (Brambell 1977, Ounsted 1991, Kleiman *et al.* 1994). However, in some situations, augmenting a population while investigating the cause of decline is an acceptable practice (Caughley and Gunn 1996). The philopatric behavior of bighorn sheep (Geist 1971) suggests there are advantages to augmenting a population to retain traditional herd knowledge, rather than reintroducing animals after extirpation, particularly if this would allow research into the cause of decline.

Biopolitical conditions and funding

Although no breeding program can be successful without knowledge of the species' biology or reintroduction/augmentation technology, non-biological factors such as long-term funding, project administration, and communication among participating organizations have been found to be important determinants for program success (Stanley Price 1991, Beck *et al.* 1994, Kleiman *et al.* 1994). Feasibility studies should include investigating prospects for long-term funding and obtaining the support of all relevant governmental and non-governmental agencies. Inadequate funding could severely limit the progress and success of the program. Therefore, programs should not be initiated until funding is secured to ensure that all phases (disease testing, research, post-release monitoring, etc.) will be accomplished. Because captive breeding programs are a multidisciplinary undertaking involving people drawn from a variety of backgrounds (International Union for the Conservation of Nature and Natural Resources 1995), the decision making structure, as well as the authority and responsibility of each group involved should be clearly delineated (Kleiman *et al.* 1994).

Knowledge of the species and reintroduction/augmentation technology

Knowing the ecological requirements of a species is necessary for a successful breeding and release program. For many species, the lack of basic information and release technology necessitates detailed studies examining the species behavior and biological needs before establishing a breeding program (Kleiman 1989, Stanley Price 1991). However, past and ongoing captive propagation programs for desert bighorn sheep (Calkins 1993, New Mexico Department of Game and Fish 1997, Ostermann *et al.* in press) have demonstrated the potential for establishing self-sustaining captive populations and the techniques developed for translocations (Rowland and Schmidt 1981, Wilson and Douglas 1982) provide information that can be applied to releasing captive-reared animals into the wild.

Husbandry

Large, predator-proof enclosures with native vegetation, natural habitat features, and adequate food, salt, mineral, and water resources are needed. Native vegetation should be retained in the enclosure, and supplemental feed may be required to prevent over-browsing. An enclosure that contains a variety of habitat types and topographic relief will allow captive animals to exhibit natural behavior, such as using escape terrain in response to disturbance. Presumably, housing captive animals in conditions as similar to the release site as possible will ease their transition to a wild environment. During the nonbreeding season, adult males and females should be separated or have ample room to naturally segregate. To reduce disease transmission risks, captive populations should be maintained within the natural range of the animal, in single-species facilities that do not regularly exchange stock (Snyder *et al.* 1996). The design of the enclosure should allow for the safe capture of animals for sampling and/or release. Enclosure fencing should be greater than or equal to 3 meters (10 feet) in height above ground and extend a minimum of 0.61 meter (2 feet) underground, or employ other options to exclude predators. Mountain lions have entered enclosures and killed captive bighorn sheep on several occasions (Blaisdell 1971, Sandovol 1979, Winkler 1977). Monitoring consisting of at least daily checks of the enclosure and animals is necessary for detecting health concerns, causes of mortalities, and disturbances.

Disease prevention and screening

Disease prevention is of primary importance for desert bighorn sheep captive breeding programs. Of all North American wild ungulate species, wild sheep are possibly the most sensitive to common livestock diseases and parasites (Jessup

1985). Disease outbreaks terminated reintroduction efforts at both the Lava Beds National Monument in California (Blaisdell 1982) and the Sierra Diablo pens in Texas (Brewer 1997), two initially successful desert bighorn sheep breeding operations. Disease in the captive animals and poor reintroduction success led to the release of all bighorn sheep from the Zion National Park captive propagation enclosure (McCutchen 1978). Outbreaks of blue-tongue reduced the Red Rock population by approximately 18 animals in 1985 and 25 animals 1991 (New Mexico Department of Game and Fish 1997). See section I.E.3 for information on the captive population at Bighorn Institute.

Disease considerations for augmentation programs include the potential of introducing disease to the wild population when releasing captive-reared stock and the impact of diseases endemic in the wild population on released animals (Viggers *et al.* 1993). The prevalence of disease in the wild and captive population will determine the need to eradicate pathogens in animals brought into or released from captivity and whether to release or breed certain animals. Elimination of all pathogens from captive animals is not expected or recommended (Bush *et al.* 1993, Viggers *et al.* 1993), as this may reduce their immunity to disease and place them at risk of diseases endemic in the wild population. Regular, standardized disease monitoring of both the wild and captive populations is strongly recommended.

Disease prevention measures

Captive breeding facilities should be closed to the public and the staff should practice rigorous disease prevention measures, including avoidance of potential disease transmission from other captive stocks as well as between wild and captive bighorn sheep. All potential routes for disease transmission from domestic livestock should be anticipated and avoided. For example, when purchasing hay, care should be taken to avoid dealers who rotate their crops with domestic livestock grazing.

Separate quarantine facilities should be available to house incoming stock; however, animals known to be sick should not be brought into captivity. It is important to determine the cause of death for all animals that die in captivity or soon after release into the wild. Fresh carcasses should be refrigerated and transported to a veterinary diagnostic laboratory for full necropsy.

Disease-free certification

Disease screening (hematology, serum chemistry, serology, virus isolation, ova and parasite tests, and bacterial culture) should be performed on greater than or equal to 25 percent of the captive animals at least annually, and on all pre-release animals within 30 days prior to their release into the wild. Health screening of pre-release bighorn sheep helps prevent the introduction of disease into the free-ranging population and optimize the released animal's chances for survival in the wild. Screening of wild-caught breedstock reduces the chance of introducing disease to the captive population. All bighorn sheep entering or leaving the captive breeding program should be certified as "disease-free." Disease-free certification requires that within 30 days prior to release: (1) the animals appear healthy and shows no signs of active infection upon visual examination by an U.S. Department of Agriculture accredited veterinarian familiar with bighorn sheep, (2) recent laboratory results (from testing described above) do not indicate active infection or other health concerns, (3) the animal tests negative for Ovine Progressive Pneumonia (AGID test), and (4) the animals have not been exposed to diseased animals in the captive breeding facility.

Treatment of sick animals in captivity

Animals showing signs of illness (*e.g.*, drooping ears, nasal discharge, coughing, lethargy, weight loss) should be closely observed and biologically sampled to attempt to determine the cause of illness. Bighorn sheep in poor condition, needing frequent treatment, or exhibiting signs of infectious or contagious disease should be placed in quarantine. Treatment should be provided under veterinary supervision if the condition is life threatening, unless research needs dictate otherwise.

Principles guiding genetic management

Genetic management strives to minimize the loss of naturally occurring genetic variability by preserving genes of founders who represent a gene pool of interest

(Ballou and Lacy 1995). Goals for the genetic management of captive populations usually include retaining genetic variation for future evolutionary potential, minimizing genetic changes that may occur while a species is in captivity, and avoiding inbreeding (Foose and Ballou 1988, Hedrick and Miller 1992, Foose 1991, Foose *et al.* 1995). Concerns about the fitness, evolutionary potential, and locally adapted gene pools of natural populations require that conservation efforts also consider intraspecific genetic variation (Soulé 1986, Millar and Libby 1991, Hedrick and Miller 1992, Cronin 1993). Molecular markers (allozymes, restriction fragment length polymorphisms, microsatellites, mitochondrial DNA) can aid in identifying current and historic levels of population subdivision, gene flow, and population characteristics (Milligan *et al.* 1994, Avise 1995). However, it is important to note that molecular markers identify only a small portion of the genome and are not specifically or necessarily tied to traits involved in either adaptation or fitness.

Identifying the genetic structure of the population being augmented is considered a first step towards assuring that appropriate subpopulations are targeted for propagation and release (Brambell 1977, Lyles and May 1987). Peninsular bighorn sheep are distributed in a metapopulation comprising approximately eight subpopulations, although the degree to which this structure reflects anthropogenic forces is unknown (Torres *et al.* 1994, Boyce *et al.* 1997, Rubin *et al.* 1998, Boyce *et al.* 1999).

The genetic effects of population subdivision are quantified by the fixation index (F_{ST}; Wright 1951), which describes the proportion of genetic variation within bighorn sheep subpopulations relative to the total variation in the population. The fixation index can also be used as an index of genetic differentiation among populations. A high fixation index value indicates significant genetic substructuring of the population. Moderate values (defined as F_{ST} of 0.05 to 0.15, Wright 1978) for mean F_{ST} were found for six populations within the Peninsular Ranges using nuclear DNA markers (micro-satellite loci [F_{ST} equals 0.113] and the major histocompatibility complex loci [F_{ST} equals 0.120]). They suggest there are relatively high levels of male-mediated gene flow among populations (Boyce *et al.* 1997). When managing a group of closely related subpopulations migration should be maintained while also allowing for genetic differentiation among demes in response to local selective pressure (Nelson and Soulé 1987, Ryman *et al.* 1995).

Other factors to consider in reintroduction or augmentation programs are effects to the native gene pool, including introgression, and an increase in the variance in family size or the number of offspring per individual (Ryman *et al.* 1995). Introgression occurs when populations with different genetic characteristics are mixed. It may cause the loss of locally adapted genes through interbreeding, loss of entire gene pools as a result of displacement, and/or homogenization of a previously genetically structured population through swamping with a common gene pool. Factors relating to introgression that should be considered include: the amount of genetic divergence between the captive and wild populations, the genetic population structure of the wild population, and the number of animals to be released relative to the size of the recipient population (Ryman *et al.* 1995). Without knowledge of the genetic characteristics of the natural population, it is nearly impossible to predict the occurrence or importance of changes in the genetic structure of the augmented population. Although problems with outbreeding depression usually involve populations that are distinct subspecies, the effects of genetic mixing are difficult to predict, ranging from no effect to outbreeding depression even within the same species under similar circumstances (Ryman *et al.* 1995). There are some circumstances when introgression can be beneficial, for example, when a natural population has been genetically depleted over an extended period due to small population size (Ryman *et al.* 1995).

A second problem with captive or supportive breeding programs is the potential to increase the variance in family size or number of offspring produced per individual (Ryman *et al.* 1995). Taking a fraction of the wild population into captivity for enhanced reproduction and survival may increase population numbers, but it can reduce genetic variation by inflating the variance in family size, a parameter that is inversely related to the genetically effective size of the population (Ryman and Laikre 1991). Pedigree analysis, rotation of breeding stock, and genetic management of the captive and wild populations can help lessen concerns associated with introgression and variance in family size. For example, in the northern Santa Rosa Mountains, the origin (captive or wild-born) of all animals in this herd is known and the sire and/or dam of most individuals is known (Ostermann and DeForge 1996). In this case, particular wild-born bighorn sheep native to the gene pool can be targeted for captive propagation if necessary. This situation presents a unique opportunity to use high intensity genetic management (Lacy *et al.* 1995) to improve or maintain the genetic variability in a free-ranging population.

Selection of breeding stock

Even when the main goal of an augmentation project is to provide population support, Kleiman (1989) recommended first considering the genetic characteristics of potential release animals. Animals released into the wild should be similar to the native animals of the region because over evolutionary time, successful populations are expected to become morphologically, physiologically, and behaviorally adapted to the local environment (Brambell 1977, Kleiman 1989, Lynch 1996). Obtaining locally adapted stock for captive breeding and release into the wild is proposed as a method to approximate the correct, locally adapted genotype, although this may add relatively little genetic variability to the wild population (Lyles and May 1987). However, given the habitat fragmentation and small size of several demes in the Peninsular Ranges, genetic exchange to avoid inbreeding depression should be considered.

Only bighorn sheep less than 1 year of age are recommended for capture for breeding stock if animals are to be placed in small enclosures (approximately less than 2 hectares [5 acres]) for quarantine. Young bighorn sheep adjust more readily to a captive environment than adult bighorn sheep (J. DeForge, pers. comm.), which have died from colliding with fences while in captivity (Montoya 1973, Sandoval 1981). Larger enclosures would reduce this risk.

Mating strategies

Appropriate level of genetic management of captive populations depends on the information available, intended intensity of management, and goals of the program (Lacy *et al.* 1995). Breeding programs for bighorn sheep vary from small populations receiving high-intensity genetic management to large herds where only low-intensity genetic management is possible. Several low-intensity mating strategies based on maximizing the effective population size and maximum avoidance of inbreeding have been developed (Princee 1995). This document focuses on concepts for intensive genetic management, which applies mainly to small captive populations.

The genetic importance of an animal is defined as a measure of the probability that it carries founder genes that are currently at risk of being lost (MacCluer *et al.* 1986, Ballou and Lacy 1995, Thompson 1995), though this value may be compromised by the presence of deleterious genes. Although animals with many living relatives in a population may be less genetically valuable than animals with few relatives, this larger group of relatives may be more successful due to superior fitness. "Mean kinship", one of several methods used to identify genetically important individuals, is defined as the average of the kinship coefficients between an individual and all living individuals including itself (Ballou and Lacy 1995). Animals with low mean kinship values are genetically important. Because mean kinship is insensitive to the age structure of a population, the concept of kinship value was introduced. "Kinship value" considers the age and reproductive value of animals when calculating mean kinship (Ballou and Lacy 1995). Kinship values will exceed mean kinship for animals whose relatives are of prime reproductive age.

Both theory and computer simulation studies suggest that mating strategies based on mean kinship (and therefore kinship value) retain the highest level of gene and allele diversity (Ballou and Lacy 1995, Miller 1995). To the extent possible, a strategy based on kinship value (Ballou and Lacy 1995) should be used to arrange matings in the captive population, precluding matings between relatives. Target founder representation and kinship value can be used to assess the genetic importance of animals and help direct rotation of breeding stock. Rams will generally contribute genes faster than ewes and will therefore need to be rotated more frequently than ewes.

Genetic evaluation

Captive breeding programs should include provisions for genetic testing, including mitochondrial DNA sequence analysis and microsatellite typing on all founders in the captive population. Genetic testing of captive-born offspring is particularly important in populations with low intensity genetic management or in cases where paternity is unknown. Molecular genetic analyses can be used to determine the genetic similarity between captive-reared and free-ranging sheep, as well as to construct pedigrees for captive or wild populations.

Population management

General objectives for population management of large captive populations with multiple generations in captivity are: (1) establishment of a self-sustaining captive population, (2) expansion of the population to a predetermined carrying capacity as quickly as possible within genetic management guidelines, (3) stabilization of the population at a given capacity, with an age and sex ratio that will achieve the goals of the program (such as production of surplus stock for release) (Foose and Ballou 1988). For small captive breeding programs, population management is most relevant to the behavioral stability of the captive population and minimizing the impact of stock rotation. In most cases bighorn sheep should be released into the wild by 10 years of age, to prevent an accumulation of old-age animals. Ewes that fail to recruit a lamb for 3 consecutive years should be considered for release because they are not contributing to the goal of producing stock for release into the wild.

Surplus or unfit animals

Healthy animals displaying abnormal behavioral or physiological characteristics should be evaluated. Preferably, if the characteristic has potential to be altered to allow release into the wild, the animal should be retained in captivity until suitable for release. If an animal's genetic characteristics cause it to be unfit for release into target populations, that animal can be released into a nontarget subpopulation so long as deleterious traits are not introduced to the wild. Because the primary goal of captive propagation is reintroduction or augmentation, bighorn sheep should be released into the wild whenever possible. As a last resort, animals may be transferred to a zoo facility in cooperation with the American Zoological and Aquarium Association.

Research and data collection on the captive population

Captive populations can provide an ideal control population for experimental or developmental studies. Data on the population characteristics, behavior, physiology, nutrition, and diseases of the captive population should be collected to the extent possible without risking the animals' survival or ability to be released into the wild. Handling or continuous observation at close range should be minimized to avoid habituation. The captive population at Bighorn Institute has been used in several studies (Castro *et al.* 1989, Jessup *et al.* 1990, Borjesson *et al.* 1996) that required little or no additional handling.

A SPARKS (Single Population Analysis and Records Keeping System; International Species Information System [ISIS] 1989) or similar format studbook should be maintained to record the identification, sex, parentage, date of birth, release date, release location, and date as well as cause of death for each individual born or brought into captivity. Marking of animals to facilitate data collection may be necessary in large captive populations. Locations of births within enclosures and individual ewe reproductive success should also be recorded. Notes recording the feeding rations, general health, and behavior of captive animals, and unusual environmental conditions should be collected at least once daily.

Research and data collection on released bighorn sheep

Each release should be designed as an experiment to test various techniques related to factors such as release site and time (May 1991). Monitoring post-release animals is one of the most critical components of a reintroduction or augmentation program because it allows for the assessment of methods, use of adaptive management, and can provide a framework for theoretical studies. All released bighorn sheep should be fitted with a radiocollar and eartag and monitored as frequently as possible (more than weekly) to record their integration process, habitat use, behavior, health, survivorship, and reproductive success. At a minimum, monitoring should be designed to document survival and reproductive rates, cause-specific mortality, habitat use of released bighorn sheep though their first year in the wild, and key biotic and abiotic factors, such as habitat quality and weather. Most importantly, post-release studies should provide data to evaluate the success of the program. Long-term (greater than or equal to 3 years) monitoring on at least a monthly basis of greater than or equal to 50 percent of released animals in a subpopulation should be included in all programs. Monitoring of post-release animals should include planned studies comparing captive-reared and wild-reared sheep (*e.g.*, reproductive success, survivorship, vigilance, maternal behavior, reactions to disturbance, etc.), and theoretical studies (May 1991, Sarrazin and Barbault 1996).

Peer-reviewed Program Assessment

Guidelines for reintroductions (Kleiman 1989, Stanley Price 1991, Chivers 1991) suggest an assessment phase in which the experiences, results, and conclusions of a reintroduction or augmentation program would be published at intervals or at the completion of the study. Short-term success of such programs can be evaluated by: 1) the survival and/or reproductive rates of released animals, or 2) the amount of genetic diversity retained and/or habitat preserved, or 3) public education and research interest generated, or 4) the time gained to allow continued research into the problems suppressing the population (Kleiman 1989; Caughley and Gunn 1996). The multi-faceted nature of captive breeding and release programs requires that assessments examine both the captive breeding and release phases, as well as the indirect benefits generated from the program. Reporting failures encountered in captive breeding and release programs is of equal or greater value than reporting successes, although it is done much less frequently.

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APPENDIX D. GUIDELINES FOR SAFELY CAPTURING, HANDLING, AND MONITORING BIGHORN SHEEP

Standard research methods, including surveys (foot, helicopter, and fixed wing aircraft), field capture, biological sampling, and radiotelemetry monitoring have been used for assessing abundance and abundance trends (DeForge *et al.* 1995, 1997; Rubin *et al.* 1998), recruitment patterns (Wehausen *et al.* 1987, DeForge *et al.* 1995, DeForge *et al.* 1997, Rubin *et al.* 2000, Ostermann *et al.* in press), adult survivorship and cause-specific mortality (Hayes *et al.* 2000, DeForge *et al.* 1997, DeForge and Ostermann 1998b, Ostermann *et al.* in press), health status and disease exposure (DeForge *et al.* 1982; Clark *et al.* 1985, 1993; Jessup and Boyce 1993; Elliott *et al.* 1994; Boyce 1995; Crosbie *et al.* 1997), genetic profiles (Boyce *et al.* 1997, Boyce *et al.* 1999), and spatial distribution of the population (Rubin *et al.* 1998) in specific subpopulations of bighorn sheep within the Peninsular Ranges. Adaptive management (Holling 1978) will require the continued use of these field research methods to achieve recovery of Peninsular bighorn sheep.

As with any human intervention, these research methods are not without risks and consequences for free ranging bighorn sheep. Low-level helicopter surveys provide an effective method for estimating population size and distribution. However, alterations in behavior, movement, and distribution of bighorn sheep resulting from helicopter disturbance (Bleich *et al.* 1990a) could potentially introduce bias into those estimates or adversely affect survivorship and reproduction in bighorn sheep populations (Bleich *et al.* 1994). Jessup *et al.* (1984) compared the relative risks and benefits of different capture methods, including drop-netting, drive-netting, darting from helicopters, stationary corral-trapping and the use of a hand-held net gun operated from a helicopter. Some methods were found to be inherently safer than others. All methods presented some risk to individual animals, and no single method of capture was best for all situations. Bleich *et al.* (1990b) documented chronic injuries to the mandibles and necks of bighorn rams from ill-fitting radiotelemetry collars and proposed potential adverse effects on foraging behavior and decreased fitness of these otherwise dominant males.

Through constant critical re-assessment of research activities, risks can be recognized and addressed to minimize the impact of these activities on bighorn sheep populations. In the past, epidemiological analysis of capture data documented the relative safety of drop net and helicopter net gun capture of bighorn sheep over other methods including drive-net, chemical immobilization, and corral trapping (Jessup *et al.* 1988). Recommendations on collar tightness (Bleich *et al.* 1990b) have reduced jaw and neck injuries in bighorn rams in recent years. Risks associated with future research activities can be minimized by requiring: (1) adequate justification for the activity, (2) thorough planning, (3) selection of appropriate survey and capture methods, experienced personnel, and proper equipment for the activity, and (4) constant critical re-assessment of research activities to recognize and address problems arising from these activities.

Guidelines for specific research activities

Surveys

Fixed-wing aerial surveys have a very low probability of affecting bighorn sheep because aircraft are typically flown at high altitude. During these flights, telemetry locations of radio-collared animals are obtained but visual observations are not usually attempted. The risk of disturbance to bighorn sheep is greater during helicopter and foot surveys.

Helicopter surveys may temporarily disrupt normal bighorn sheep behavior and may negatively affect bighorn sheep if not conducted properly. Helicopter surveys should be avoided during periods when bighorn sheep may be especially sensitive to disturbance. These periods include the late winter through early summer months, when the majority of ewes give birth, and the summer months, when bighorn sheep are dependent on scant water sources. During surveys, the helicopter should only remain above a group of animals long enough to determine group size and composition. If the group appears to be running excessively, if terrain conditions are potentially dangerous for the animals, or if young lambs are observed in a group, the safety of the animals should take priority over data collection, and the survey crew should continue moving to the next portion of the survey area. During surveys, the location of roads should be considered, and flight paths should proceed from roads into habitat, so as to avoid driving animals towards automobile traffic.

Foot surveys are not typically considered a risky research activity but the following considerations will further reduce any negative impact on bighorn sheep. Bighorn sheep appear to be more comfortable when they are able to remain higher than their human observers and watch them from a distance. Observers should approach bighorn sheep from below and avoid approaching too closely. Care should be taken to avoid startling bighorn sheep by appearing suddenly around a corner or over a ridge. Time near springs and guzzlers should be kept to a minimum to avoid displacement of animals from water sources, especially during the summer.

Capture

The active management of bighorn sheep may require: (1) marking or tagging to determine population numbers, range usage, movement patterns, behavior, reproduction, survival, and cause-specific mortality; (2) treating or sampling diseased individuals; (3) sampling of healthy bighorn sheep for research; and (4) relocation (Jessup *et al.* 1984). In skilled, experienced hands, the use of a net gun from a helicopter has been shown to be a safe method of capture, with fewer stress related complications and lower injury and mortality rates than other methods (Jessup *et al.* 1988). Due to the steep, rough terrain and the scattered distribution of bighorn sheep found in the Peninsular Ranges, net gun capture appears to be the most practical and cost-effective capture technique. The use of drop nets and tangle nets may also be necessary on the rare occasion when an animal has to be captured within or on the fringes of the urban environment. The safe use of these techniques requires careful planning and adequate numbers of experienced personnel trained in handling net-captured bighorn sheep. Thorough discussions of capture methods and veterinary medical concerns can be found in *The Wildlife Restraint Handbook* (California Department of Fish and Game 1996), and the *Wildlife Restraint Series* (International Wildlife Veterinary Services 1996).

The most common veterinary problems occurring during the helicopter net gun capture of bighorn sheep are physical injury, capture stress/capture myopathy (disorder of muscle tissue or muscles) and hyperthermia. Physical injury can occur when a netted animal tumbles on rough, rocky terrain, takes a fall down a steep slope, or when the net tangles around the animal's neck and compromises respiration. The risk of physical injury can be minimized by netting the animal as it runs uphill or capturing animals on relatively flat saddles or in flat sandy canyon bottoms. Capture stress/capture myopathy occurs when an animal severely overexerts itself, resulting in pathologic metabolic changes and cellular damage in muscle tissue and internal organs. Hyperthermia occurs when an animal's heat production from muscle activity exceeds its ability to dissipate that heat. Due to the physical exertion experienced during helicopter pursuit, the rectal temperature of most bighorn sheep at capture will be higher than 38.9 degrees Celsius (102 degrees Fahrenheit), considered normal for resting domestic sheep (California Department of Fish and Game 1996), and will often reach 39.4 to 40.6 degrees Celsius (103 to 105 degrees Fahrenheit) or greater. These animals are susceptible to hyperthermia regardless of the ambient temperature. Dousing with water around the flanks, inguinal region, thorax, head, and neck at capture to cool the animal should be routine during warm weather and anytime an animal shows an increasing trend in rectal temperature. Animals with heavy winter pelage also may have a problem dissipating heat even in cold weather and may require efforts to cool them. Keeping chase times within conservative limits will prevent most problems with capture stress/capture myopathy and hyperthermia. A "safe" chase time will vary with the condition of the animal, terrain, environmental conditions, and the intensity of pursuit. Most individual chase times during California Department of Fish and Game bighorn sheep captures are under 3 minutes. Pursuit of a running animal should not exceed 5 minutes. Attention must be paid to total chase time as animals in a group may be run repeatedly as individual herd members are captured. Pursuit should be called off if the animal appears disoriented, exhausted, or injured, or anytime a member of the capture crew determines that there is excessive risk in continuing the capture effort.

Prolonged restraint can also contribute to capture stress/capture myopathy and hyperthermia. Most bighorn sheep cease struggling when eye covers and hobbles are applied. Positioning the animal in a normal resting position with its head up will allow the sheep to belch ruminal gas and minimize bloat and regurgitation. Vital signs should be taken immediately and monitored continuously to monitor the need/effectiveness of cooling treatment or to determine if a severely distressed animal should be released. A severely compromised animal that is not ambulatory requires aggressive therapy. Jessup (1999) recommended that wild sheep with rectal temperatures greater than 41.7 degrees Celsius (107 degrees Fahrenheit), respiration rates of 75 per minute, and/or heart rates greater than 200 per minute receive intensive treatment for capture stress/myopathy including cooling baths, balanced intravenous fluids, anti-inflammatory drugs (fast acting corticosteroids), vitamin and mineral supplements, and possibly intraperitoneal bicarbonate. Medical treatment of a moderately compromised animal that is ambulatory involves the trade-off of continued stress during the treatment period with the benefits of medication. Some medications themselves may have adverse effects when administered. For example, pharmacologic doses of corticosteroids used in treating shock may induce parturition in ewes in late stages of pregnancy (Plumb 1995). In a field situation, the decision to treat or release is a judgement call made by capture personnel in consultation with an experienced wildlife veterinarian.

Air transport of bighorn sheep to base camps should be accomplished in "sheep bags" (heavy weave plastic mesh bags custom designed for this purpose), which support the animal in a sternal position. "Air transport of mountain sheep upside down suspended by their hobbled legs.....is inappropriate and unnecessary" (Jessup 1999). During captures using base camp processing, the capture crew should be prepared to process animals exhibiting capture stress at the capture site to reduce the handling time.

Processing (application of tags and collars, collection of biological specimens, administration of prophylactic medications) should be carried out in a quick, efficient manner with minimal disturbance to the animal. Prior to release, the animal should be positioned so that release occurs in the direction with the fewest physical hazards and that allows the animal to move toward the area from which it was captured.

Other issues to consider when capturing and handling bighorn sheep include:

> Pregnancy status - capture of ewes in the last two months of pregnancy should be avoided whenever possible (December through early summer).

Caution should be used when capturing ewes with very young lambs (spring through late summer) due to possible abandonment of the lamb or exposure of the lamb to predation in the absence of the mother. These ewes should be processed at the capture site, and should not be transported to a base camp.

Extreme caution should be used when capturing young lambs. Lambs should be processed and released at the capture site whenever possible.

Whenever possible, processing at the capture site is preferred to minimize stress on the animal, However, for adult animals, the choice of processing at the capture site or transport to a base camp will vary with local conditions. Very important for ewes and less so for rams, the location and distance of base camps from the capture site should allow direct access back into the area in which the animal was captured. A general guideline is that the release site should be within the home range of the ewe group and within 5 kilometers (3.1 miles) of the capture location with no insurmountable or dangerous obstacles separating the animal from its home range.

Capture personnel should be made aware of human safety and zoonotic disease concerns.

Key points to consider before capture of bighorn sheep:

A detailed capture plan must be prepared in advance of the capture that outlines goals, methods, potential problems, personnel and safety procedures (California Department of Fish and Game 1988).

A pre-capture meeting should be mandatory for all participating personnel.

All personnel must be trained in proper animal handling techniques.

Experienced veterinary assistance and emergency medical supplies and equipment should be readily available to treat a physically distressed or injured animal. Frequent post-capture monitoring of individual bighorn sheep is mandatory to determine effects of capture, tags, and collars on survivorship, reproduction, and well being.

A written report should be prepared after each capture that documents the activity, provides a critical assessment of the capture, and suggests improvements for future capture activities.

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APPENDIX E. PROTOCOLS FOR MONITORING POPULATION ABUNDANCE

This appendix presents protocols for two methods of monitoring the abundance and population trends of Peninsular bighorn sheep. These two methods are: (1) waterhole counts and (2) aerial helicopter surveys. For explanations of terminology (*e.g.*, ewe group) or reference to specific names of locations, please refer to the main body of the recovery plan and papers cited therein.

Waterhole counts have been conducted in selected parts of Anza-Borrego Desert State Park since 1971 (M. Jorgensen, pers. comm.) and have been used to assess abundance trends of Peninsular bighorn sheep (Rubin *et al.* 1998). Prior to 1993, no marked animals were present in the areas in which counts were conducted. Count data were, therefore, only appropriate for use as an index of abundance rather than for calculation of an absolute population estimate. Since 1993, however, collared animals have been present and waterhole count data can be used to generate population estimates for some ewe groups in Anza-Borrego Desert State Park.

Waterhole counts are organized and conducted by volunteers under the direction of Park staff. Although helicopter surveys provide a more comprehensive population estimation tool, waterhole counts should be continued. Continuation for at least 10 more years will allow investigators to determine the correlation between waterhole count and aerial survey population estimates, which may make it possible to generate historical population estimates using early waterhole count data. In addition, waterhole counts provide data that are difficult to determine from a helicopter (*e.g.*, reproductive status of individually marked ewes; refer to section II.D.2.1 of the recovery plan), and provide an opportunity for the community to participate in Peninsular bighorn sheep conservation projects (refer to section II.D.3).

Helicopter surveys have been conducted in the Santa Rosa Mountains annually since 1977 (Wehausen *et al.* 1987, DeForge *et al.* 1995), the San Jacinto Mountains in 1983, 1984, and annually since 1987 (DeForge *et al.* 1997), and in some parts of Anza-Borrego Desert State Park in the early 1980's (M. Jorgensen, pers. comm.). Radio-collared animals have been present in the northern Santa Rosa Mountains since the early 1980's (DeForge *et al.* 1995) and in the San Jacinto Mountains since 1992 (DeForge *et al.* 1997). In 1994, 1996, and 1998, radio-collared animals were present throughout the Peninsular Ranges and surveys covered all parts of the ranges for the first time, making it possible to generate population estimates for the entire range as well as for subregions (Rubin *et al.* 1998). Currently, helicopter surveys in the San Jacinto Mountains and the Santa Rosa Mountains are conducted by California Department of Fish and Game and the Bighorn Institute, while surveys of the remainder of the range are conducted by California Department of Fish and Game and Anza-Borrego Desert State Park. The following sections outline specific protocols for each monitoring technique.

Aerial Helicopter Surveys

Frequency of surveys

Helicopter surveys covering the entire range should be conducted at least every other year. Recently, the San Jacinto Mountains and Santa Rosa Mountains have been surveyed annually, while the remainder of the range has been surveyed every other year (1994, 1996, 1998).

Time of survey

Helicopter surveys should be conducted ideally between late September and early November. This method reduces the risk to bighorn sheep by avoiding periods when young lambs are present, periods when ewes reach late gestation, and months of high summer temperatures. In addition, this time period coincides with part of the rut, or breeding season. This approach allows the most accurate estimate of the sex ratio because bighorn tend to congregate during this time.

Areas to be surveyed

All bighorn sheep habitat in the Peninsular Ranges should be surveyed. For consistency among years, the same predetermined areas should be flown every year, with the same amount of time (effort) spent per area during each year. Flight areas and associated approximate survey times are included in this appendix (Tables E-1 and E-2). Maps are not included here because the geographic references in the Tables below accurately describe the survey areas and this plan is

Table E-1. Approximate polygons flown by Bighorn Institute in annual helicopter surveys of the San Jacinto and Santa Rosa Mountains. Topography and sheep sign influenced the amount of time spent per area. Flight polygons were developed while the population was at a low, and some areas where sheep sign (trailing, bed sites, etc.) has not been noted for several consecutive years are flown less intensely than areas with sign. If the population increases, more time may be needed to thoroughly survey areas that are only cursorily surveyed now. Flight times are actual time within the polygon.

Polygon Number	Area/Canyons	Approx. flight time (hours)	Notes
1	San Jacinto Mountains: west fork of Palm Canyon north to Blaisdell Canyon	2.25	Areas south of Andreas and north of Chino have been flown less intensely in recent years due to lack of bighorn sheep sign. It will be necessary to add survey time if distribution expands.
2	Santa Rosa Mountains: Calcite Mine west to Rattlesnake Canyon	2.25	
3	Santa Rosa Mountains: western Santa Rosa Mountains, west of Rattlesnake Canyon to Buck Ridge and Rockhouse Canyon	2.25	Buck Ridge flown cursorily.
4	Santa Rosa Mountains: Big Wash north, Wonderstone Wash, Travertine Palms, and Barton, Alamo, and southern Sheep Canyons.	1.75	Barton, Alamo, and Sheep Canyons flown cursorily due to lack of sign.
5	Santa Rosa Mountains: north Sheep Canyon, Martinez Canyon	1.25	
6	Santa Rosa Mountains: Agua Alta and Toro Canyons	2.00	
7	Santa Rosa Mountains: Guadalupe, Devil, and Bear Canyons	2.25	Polygon should include Indio and Eisenhower Mountains.
8	Santa Rosa Mountains: Coyote, Sheep, Deep, Carrizo, and Dead Indian Canyons.	2.25	
9	Santa Rosa Mountains: Magnesia, Bradley, and Cathedral Canyons.	2.00	Western Cathedral Canyon appears to have been abandoned recently – minimal flight time spent west of Cathedral Canyon. Surveys may need to intensify west of Cathedral Canyon proper if the population increases.

Table E-2. Survey polygons flown in bighorn sheep habitat outside of the Santa Rosa and San Jacinto Mountains. Flight times are actual time within the polygon.

Polygon Number	Area	Polygon Description	Approx. flight time (hours)
10	Coyote Canyon	Coyote Peak	1.25
11	" "	NE side of Coyote Canyon	3.00
12	" "	SW side of Coyote Canyon	2.25
13	N. San Ysidro Mts	N of County Rd 22 (Montezuma Grade)	2.75
14	S. San Ysidro Mts	S of County Rd 22 and Yaqui Ridge	2.00
15	" "	Pinyon Ridge and N side of Sentenac Canyon	1.00
16	Vallecito Mountains	Pinyon Mts to Pinyon Canyon	2.25
17	" "	Sunset Mtn, Harper Flats, to Harper Canyon	1.50
18	" "	Harper Canyon to Hapaha Flats to Alma Canyon	1.75
19	" "	Alma Canyon to Fish Creek Wash to Split Mtn	1.25
20	" "	Whale Peak (Fish Creek Wash to Smuggler Cyn)	1.25
21	Carrizo Canyon area	Tierra Blanca Mts to Rockhouse Canyon	2.00
22	" "	W side Carrizo Wash (to Blackwater Canyon)	1.25
23	" "	Carrizo Gorge to Tule Cyn, E. to Dos Cabezas	2.00
24	" "	E side of Carrizo Wash (N of railroad tracks)	1.25
25	Fish Creek Mountains	Fish Creek Mountains	1.75
26	Coyote Mountains	Coyote Mountains	1.75
27	S. of Interstate 8	Dos Cabezas to U.S.-Mexico border	2.00

not intended to represent a comprehensive compendium of information related to bighorn conservation activities.

Survey techniques

The survey crew consists of three observers in addition to the pilot. When possible, the same pilot and pool of experienced observers should be used each year. The doors of the helicopter should be removed for optimum visibility. Each polygon should be flown systematically at 40 to 60 kilometers per hour (25 to 35 miles per hour), following topographic contours of 100 to 150-meter (330 to 490-foot) intervals. The pilot and the observers should not be aware of the locations of radio-collared sheep, and telemetry should not be used to locate groups or individuals. The number of radio-collared animals in each survey polygon should be determined immediately before or during the helicopter survey, by additional personnel, using aerial fixed-wing or ground monitoring. These animals serve as "marked" animals in the calculation of abundance estimates using mark-recapture methods (see below). The Global Positioning System base station at Anza-Borrego Desert State Park headquarters should be run during the entire survey so that Global Positioning System location data can be corrected by staff at their General Plan office. All four individuals in the flight crew are considered observers, and each of the three passengers is assigned one of the following additional tasks: (1) to monitor the progress of the flight on a topographical map, advise the pilot of polygon boundaries, and record the location of each observed sheep on the map, (2) maintain a data sheet onto which the date, time, elevation, group size and composition, number of collared animals, and, possibly, identification of collared animal is recorded for each group of animals, or (3) record the flight of the survey and the location of each observed animal using a Global Positioning System unit. All observed animals should be classified as yearling ewe, adult ewe, yearling ram, Class II ram, Class III ram, Class IV ram, or lamb (classifications modified slightly from those used by Geist 1971). When possible, simultaneous double-counts should be conducted during each survey, following the methods of Graham and Bell (1989), to provide an additional abundance estimate. All sightings of feral animals and deer should be recorded during surveys. The location and condition of springs, tinajas, and other water sources also should be recorded.

Data Analyses

Population estimates should be generated using estimators such as Chapman's (1951) modification of the Peterson estimator (Seber 1982), or the joint hypergeometric estimator (*e.g.*, Neal *et al.* 1993). Estimates should be calculated separately for each sex and for the total population (rams and ewes combined). In the event that low numbers of collared rams prevent the estimation of ram numbers, the ram to ewe ratio and the estimated number of ewes can be used to generate an estimate of adult numbers. Confidence intervals (95 percent) should be calculated using methods such as those of Seber (1982). Simultaneous double-count data should be used to estimate the number of groups missed and to generate an additional estimate of the minimum number of animals present within the surveyed areas (Graham and Bell 1989). All reported results (*e.g.*, lamb to ewe or ram to ewe ratios) should clearly state whether or not yearlings are included.

Estimates should be generated for the entire range, as well as for individual ewe groups. It is important to note that ewe group distribution may change slowly over time. Monitoring of radio-collared ewes to determine ewe group structure will therefore, have to be continued, and stratification of survey data may have to be modified slightly. Furthermore, ewe group delineations in the Santa Rosa Mountains south of Highway 74 and in the Vallecito Mountains still need to be more clearly resolved.

Further considerations

Initially, a sufficient number of active radio-collared animals must be present in each portion of the range for use in mark-recapture estimate calculations. The number of collared animals should be sufficient to achieve an accuracy of plus or minus 25 percent with probability of 0.05, following the methods described in Krebs (1989) and Robson and Regier (1964), or approximately 30 percent of the estimated ewe population should be radio-collared. However, a "sightability" estimate may be generated after additional multiple surveys are conducted, thereby eliminating the need to maintain this percentage of radio-collared animals. This approach would be especially beneficial if/when population numbers become large.

As batteries expire, collars become non-functional and the actual number of marked animals present in the survey area becomes difficult to know. Only those bighorn sheep with functional collars should be used as marked animals. This approach will require that bighorn sheep with "functional" collars be distinguishable from those with "nonfunctional" collars at a glance, from the helicopter. Therefore, an accurate inventory of all collared animals must be maintained and the choice of collar and eartag color combinations must be considered during collaring efforts. No newly collared animal should match (in collar and eartag color combination) an animal that is possibly still present in the field.

Within a polygon, an attempt should be made to "sweep" across the survey area, rather than flying over an area more than once. This method will reduce the chance of double counting animals. Helicopter activity at times cause bighorn sheep to move (Bleich *et al.* 1994); therefore, adjacent polygons should, when possible, be flown consecutively so that groups can be recognized and possible double counts eliminated. The flight polygons delineated in this document were chosen, in part, so that natural breaks in topography or roadways coincided with polygon boundaries.

Data should be maintained in an electronic data set that can be used by investigators in the future. All raw data should be retained. That is, data should not be summarized before being entered into a data set.

Waterhole Counts

Frequency of Counts

Waterhole counts should be conducted annually.

Time of Counts

Counts should be conducted at the same time every year so that yearly comparisons of ram:ewe ratios, lamb:ewe ratios, group size, and number of sheep observed at water sources are most meaningful. In addition, counts should be conducted during the hottest and driest time of the year to maximize the number of animals coming to drink at water sources. Counts have typically been conducted during the July 4th weekend, and should continue to be held between mid June and the first week of July.

Areas to be Counted

Annual counts have been conducted in the southern part of the park (Carrizo Canyon area) during 1973 to 1982, and in the northern part of the park (San Ysidro Mountains, Coyote Canyon, and one site in the south Santa Rosa Mountains) since 1971. Counts in the southern portion of the park were discontinued after 1982 because of the large number of volunteers that were needed to conduct counts at both ends of the State park, and the complex logistics of organizing and getting teams set up in fairly remote count sites.

In the past, the number of sites counted in each area has varied slightly across years because of variation in the number of available volunteers or unexpected problems (for example, a fire near count sites). The number of sites did not significantly influence the number of sheep counted in each portion of the range (Rubin *et al.* 1998). However, an attempt should be made to keep the number and locations of count sites constant during future years. Priority sites should be those that have been counted most consistently in the past. Additional or "secondary" sites should be counted when additional volunteers are available. Data analyses can then focus on data collected at "priority" sites, while "secondary" sites can be used for more cursory monitoring of sheep presence.

Count Techniques

Teams of three to five observers should be assigned to each count site. Each team should include at least two individuals who are experienced at classifying bighorn sheep by age and sex. At each count site, the entire team should be stationed at a location that allows observation of animals coming to a water source, while minimizing disturbance of the animals or interference with their use of the water source. These locations have been identified by Anza-Borrego Desert State Park personnel. While at these sites, observers should minimize noise and movement. Observations should be made during 7 a.m. to 5 p.m. on 2 consecutive days and 7 a.m. to 2 p.m. on the third day. During these periods, observers should systematically scan all areas within view and record all sheep observations on the supplied data sheet. Data to be recorded include date, time, temperature, group size and composition, the presence of collared animals, and, if possible, the identification of collared animals. Additionally, interactions among individuals (*e.g.*, breeding behavior, lamb nursing bouts) and observations of other species (*e.g.*, deer, coyotes, birds) should be recorded. The location of each group of bighorn sheep should be noted on a topographic map.

Repeat sightings of individual sheep should be recorded as such, but they should not be counted. At the end of each day, each team should review and discuss their observations with neighboring teams so that repeat observations can be identified and eliminated from the final tally.

Data Analysis

The primary use of data collected during waterhole counts is to monitor abundance trends. Rubin *et al.* (1998) used count data to assess long-term trends. In this case, linear regression analysis was used to determine if the number of ewes observed per day showed an increasing or decreasing trend over a period of 10 to 26 years. If a sufficient number of collared animals are present in each ewe group area, abundance estimates can be generated for some ewe groups, using mark-recapture techniques. Lamb to ewe ratios can be calculated to monitor reproductive success of ewe groups. Most lambs are 3 to 5 months old during waterhole counts and these ratios will not be directly comparable to ratios generated from helicopter surveys, which represent lamb recruitment to an older (approximately 6 to 8 months) age. The reproductive status (lamb present versus not present) of individual radio-collared ewes can supplement observational data collected by biologists monitoring reproductive patterns of Peninsular bighorn sheep. Ram to ewe ratios should be generated for comparison among years. The rut typically peaks after July, so these ratios may underestimate the actual ram to ewe ratios since some rams may not have joined ewe groups yet.

Further Considerations

To make waterhole count data as useful as possible for future investigators, it is important for teams to determine the composition of each group as accurately as possible. Given the great distances sometimes involved, an effort should be made to equip each team with a spotting scope and at least one individual should be experienced at using it to observe and classify bighorn sheep.

All new observers must complete a one day orientation and training session led by Anza-Borrego Desert State Park personnel. In addition, all new observers must be paired with individuals experienced at classifying bighorn sheep in the Peninsular Ranges (Bleich 1998).

Data should be maintained in an electronic dataset for use in the future. All raw data should be retained. That is, data should not be summarized before being entered into a primary data set.

Reinitiation of waterhole counts in the Santa Rosa Mountains should be considered. This approach may enhance the probability of detecting relationships between aerial helicopter data and water hole count data, thereby facilitating a retrospective interpretation of numbers of sheep in the Santa Rosa Mountains in the past.

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APPENDIX F. RECOMMENDED CONSERVATION GUIDELINES

BACKGROUND

Bighorn sheep in the Peninsular Ranges are afforded protection pursuant to the California Fish and Game Code (sections 4700 as a fully protected species and 2050 as a threatened species). Section 4700 of the Fish and Game Code does not allow for issuance of permits or licenses to take fully protected mammals, except for scientific research, notwithstanding any other provision of law; therefore, a California Endangered Species Act section 2081 permit that would authorize incidental take of Peninsular bighorn sheep cannot be issued. This take prohibition in turn limits the type of mitigation that can be required pursuant to the California Environmental Quality Act. The sheep also is listed at 50 CFR § 17.11 by the U.S. Fish and Wildlife Service as an endangered species and protected against take at 50 CFR § 17.21. Regulations that authorize take under prescribed circumstances are found at 50 CFR Parts 17 and 402.

The California Environmental Quality Act requires that mitigation measures be identified and implemented for any significant impacts unless a finding of over-riding considerations is adopted. Section 15370 of the California Environmental Quality Act Guidelines provide five categories of mitigation measures: "...avoid, minimize, rectify, reduce or compensate." These forms of mitigation are appropriate for bighorn sheep only to the extent that they avoid take of the species, pursuant to Section 4700 of the Fish and Game Code, and avoid take under 50 CFR § 17.21, unless otherwise authorized by the U.S. Fish and Wildlife Service under 50 CFR § 17.22. Accordingly, the Fish and Wildlife Service and California Department of Fish and Game work with lead agencies and project proponents on a case by case basis to identify which forms of mitigation would be appropriate.

OBJECTIVES

The objective of these guidelines is to provide a set of consistent mitigation measures for project proposals that do not otherwise threaten sustainable bighorn sheep populations needed for recovery. These mitigation measures are not intended for projects proposed in locations that would fragment habitat or preclude effective reserve design and management of the species because those adverse effects cannot be offset. In such instances, the Fish and Wildlife Service and California Department of Fish and Game may recommend additional avoidance, minimization, and mitigation measures to ensure against the likelihood of significant adverse effects that would impinge on take and jeopardy thresholds. Through proper coordination, our agencies will assist local, State, and Federal governments in identifying whether the adverse effects of project proposals can be mitigated to a level of insignificance, based on project location, size, and potential for indirect effects, which typically are the primary criteria influencing the type and severity of impact. These guidelines may require future modification based on the availability of new information on threats, ecological requirements, species status, etc.

CONSERVATION MEASURES

I. HABITAT COMPENSATION: Acquisition of off-site habitat may be appropriate to offset any residual effects after application of appropriate avoidance and minimization measures. For projects adjacent to bighorn sheep habitat that provide infrastructure to support larger human populations, habitat compensation is generally appropriate because of the consequent increased levels of human-related disturbance in adjoining open space. The cumulative effects of human disturbance may be mitigated by acquisition of sheep habitat that would otherwise be vulnerable to future development. Projects adjacent to sheep habitat that do not result in indirect effects to adjoining sheep habitat generally lack a mitigation nexus.

To maintain sustainable subpopulations (ewe groups), compensation habitat should be acquired within the range of the affected ewe group and at an elevation comparable to the impact. Bighorn sheep in the Peninsular Ranges are mainly threatened by habitat loss at lower elevations that provide unique resources unavailable farther up the mountain slopes. Therefore, loss of unique or limiting resources at lower elevations can not be offset by conservation of different resources associated with habitats at higher elevations.

Habitat acquisition promotes survival and recovery by reducing the potential future loss of bighorn sheep habitat through permanent protection of land currently available for development. Amount of compensation will be determined on a case by case basis because the effects of individual projects are variable. A management endowment should accompany all acquired lands so that the responsible public agency has the ability to effectively manage conserved lands.

II. FENCING: Fencing along the urban interface provides a barrier that separates bighorn sheep from urbanization threats (e.g., disease and mortality associated with toxic plants, traffic, parasites, irrigated landscapes, pesticides, etc.). Fencing also can help mitigate the adverse effects of incompatible land uses adjoining sheep habitat. For example, fencing controls human access into habitat that may otherwise conflict with management objectives to minimize human disturbance, especially during sensitive time periods, such as lambing. Land uses along the habitat edge should be designed to not introduce additional human disturbance. Recreational access should be provided only where access is coordinated with natural resource agencies and is consistent with management objectives in the regional trails plan. Fencing does not offset the effects of habitat loss and should be located along the edge and not within sheep habitat.

A. Fencing should be mandatory for any new development in or adjacent to sheep habitat, where bighorn sheep have begun or may begin using urban sources of food and water.
B. Fences should be 2.4 meters (8 feet) high, chain-link or functional equivalent.
C. Fences should not contain gaps in which sheep can be entangled [gaps should not be larger than 11 centimeters (4.3 inches)].

III. TOXIC PLANTS: Landscape plants can cause sickness or death. Only local native plants should be used along the wildland interface. Known and potential toxic plants should not be used in areas accessible to bighorn sheep. Ornamental plants currently known to be toxic to sheep include oleander, *Prunus* species, and plants in the nightshade (Solanaceae) family.

IV. LAMBING SEASON AND HABITAT RESTRICTIONS: Seasonal restrictions during this period minimize impacts to bighorn sheep at a critical stage of their life cycle. Lambing habitat is often emphasized because of the sensitive nature and behavior of ewes and lambs. Lambing habitat comprises those areas used for breeding, sheltering, and nurturing of lambs up to the time of weaning, including those areas occupied by ewes 1 month before giving birth. Though the lambing season can span the majority of the calendar year--from late winter through summer, January 1 through June 30 encompasses the majority of the lambing season. Trails that traverse lambing habitat should be managed during this period or relocated outside of sensitive habitat areas.

V. SUMMER WATER SEASON: Available water sources during summer months are highly restricted and bighorn sheep are vulnerable to disturbance in these areas. If summer rains fail, water may remain scarce until the first winter rains. Accordingly, interagency cooperation will be needed to adapt trails management prescriptions to the water requirements of bighorn sheep. Public education, signage, rangers, and other forms of management should be provided at appropriate locations to control access during this period.

Title 14 of the Public Resources Code, Section 550(b)(1) and Sections 630(b)(11) and (30) restricts access to water holes on State lands in the Santa Rosa Mountains. Closure periods are from June 15 to September 15.

VI. WATER FEATURE DESIGN SPECIFICATIONS: Any artificial water features (*e.g.* ponds, lakes) in areas adjoining bighorn habitat should be designed to preclude shallow, vegetated edges that provide breeding habitat for *Culicoides* midges, an invertebrate disease vector for bluetongue virus. Water bodies should be designed with steep sides and depths at least 0.6 to 0.9 meters (2 to 3 feet) along the edge [see: Mullens, B. A. 1989. A quantitative survey of *Culicoides variipennis* (Diptera: Ceratopogonidae) in dairy wastewater ponds in southern California. J. of Medical Entomology 26(6):559-565; and Mullens, B. A. and J. L. Rodriquez. 1990. Cultural management of bluetongue virus vectors. Calif. Agriculture 44(1):30-32].

WILDLIFE AGENCY RECOVERY AND MANAGEMENT RESPONSIBILITIES

AUGMENTATION: Augmentation is a potential recovery tool that is addressed within the context of the recovery plan and would be used until a self-sustaining population is established. The release of captive reared or translocated wild animals to establish new populations or supplement small populations are not acceptable mitigation measures because they do not compensate for the permanent loss of habitat or ensure the continued viability of habitat to support self-sustaining, wild populations.

PREDATOR CONTROL: Predator control is a potential management tool available to the Fish and Wildlife Service and California Department of Fish and Game to address specific situations. Bighorn sheep are adapted to survive natural levels of predation, drought, disease, competition, etc., which do not pose problems in properly functioning ecosystems. Because predator control is a temporary solution to remedy a short-term problem, it does not constitute mitigation for the permanent loss of sheep habitat.

APPENDIX G. RESPONSE TO COMMENTS

The following issues are a compilation of all substantive comments received by the Fish and Wildlife Service from technical reviewers, agencies, and the public, which were not otherwise responded to by directly incorporating changes into the text of the final recovery plan. The issues are organized by general subject matter.

LEGAL ISSUES

Issue: Designation of essential habitat illegally usurps authority over local land use planning by imposing prohibitions on private property and mandating erection of fences. Identifying private lands for protection without committing Federal funding or conservation incentives exposes local government to property taking lawsuits because cities and counties lack the wherewithal to cooperate in implementation of the plan. To avoid representing a moratorium on future development, can some development in essential habitat go forward if adequately mitigated, and if so, what criteria or standards would be used?

Response: Essential habitat (in contrast to critical habitat, discussed below) is a nonregulatory indication of those areas we believe to be important to the conservation of bighorn sheep. The map is intended to provide information that can advance conservation efforts through the activities of other agencies and the public. By sharing biological information, we intend to promote public policy decisions that balance the conservation needs of bighorn sheep with other competing land uses. As such, the designation of essential habitat does not affect the discretion of local and State governments or private land owners over land use decisions. Given the biological importance of the habitat to recovery, limited development could occur in essential habitat if adequately mitigated and designed to be compatible with bighorn sheep recovery. Furthermore, the identification of areas with biological importance can provide a wider range of potential land uses that generate economic opportunity. For example, local governments and private landowners can structure economic incentives to conserve bighorn habitat by creating programs whereby developments in other areas can provide a source of income to land owners with habitat of higher conservation value. This mitigation bank concept has gained widespread acceptance in numerous other areas where local government has created a mitigation nexus that avoids property taking lawsuits and promotes regional habitat conservation planning.

Issue: Membership of the Recovery Team and peer review team consists of individuals whose livelihood depends on funding, permits, and recommendations from the State and Federal government. Therefore, these individuals are reluctant to voice criticisms with the recovery planning process for fear of retribution. In addition, authors of the draft recovery plan stand to gain financially by creating an open checkbook/cash cow with questionable research projects having no accountability.

Response: At our invitation, members agreed to participate on the Recovery Team for the purpose of providing scientific advice to the Fish and Wildlife Service and cooperating agencies, including assistance in developing and implementing the recovery plan. The draft recovery plan was largely written by team members who provided the information and opinions needed to complete a draft plan. Though consensus was achieved on most issues addressed by the team, we and cooperating agencies judged how best to incorporate various views where full agreement was not reached. Many of the research topics recommended in the recovery plan are a reflection of scientific questions that remain unresolved. Any funding to address these research needs will be directed on a competitive basis to the best qualified individuals available. Funding and permitting actions by us and cooperating agencies have and will follow applicable laws and regulations that ensure against preferential treatment and capricious behavior. Recovery Team members are not dependent upon the Fish and Wildlife Service or the listing of bighorn sheep for their continued livelihood. Members are under no obligation whatsoever and do not enjoy economic benefit for their voluntary participation on the Recovery Team.

Issue: Undue reliance on unpublished information fails to justify the spending of $16M every 5 years for several decades. The conclusions, recovery criteria, and habitat mapping lack credibility due to their reliance on over 100 unsupported citations and that underlying data were intentionally withheld from public review. The public has a right to inspect all the unpublished information cited in the draft plan as an aid to provide informed comments; therefore, the public comment *period should be extended until after these data have been made available. Following the response to all comments and correction of many deficiencies, the draft recovery plan should be circulated again for public review.*

Response: The draft recovery plan was based on the best available data, which includes personal experience of credible researchers. Unpublished information cited in the draft recovery plan was documented and compiled prior to completion of the final recovery plan and has been available along with published papers, for public inspection. Any facts or interpretations based on unpublished information cited in the draft recovery plan for which documentation could not be obtained have not been included in the final recovery plan. Justification for research recommended in the recovery plan was not based on cited unpublished information but on consensus recommendations of the Recovery Team and concurrence by the cooperating agencies. Upon reassessing the relative importance of the unpublished information cited in the draft recovery plan to the findings and conclusions in the recovery plan, we have determined that the unpublished information unavailable for review in the draft recovery plan did not materially affect any significant findings or recommendations in the final recovery plan. As a result, we elected to not reopen the public comment period. In response to any substantive comments received after review of the unpublished information, the recovery plan may be appended, revised or updated.

Issue: The recovery plan is too general to meet the specific criteria at 16 U.S.C. 1533(f). The unusable scale of the essential habitat map was intentionally vague and fails to meet the site specific standards for describing management actions necessary for recovery.

Response: Section 4(f) of the Act requires that recovery criteria be measurable and site specific, with estimates of associated time frames and costs. We believe that these requirements have been satisfied. The scale of the draft essential habitat map in the draft recovery plan was designed to portray a specific concept outside and along the urban interface based on bighorn habitat requirements and principles of conservation biology. The draft map was designed to elicit input from interested parties so that the final map could best reflect the concerns of local interests. We elected not to depict draft essential habitat in the draft recovery plan at a parcel specific scale because it would have engendered unnecessary and unproductive controversy and suggested a predetermined outcome. We scheduled numerous meetings with all local jurisdictions and major landowners to refine the boundaries along the urban interface. As described below under the Essential/Critical Habitat section, consensus among Federal, State, and local governments was achieved along the majority of the urban boundary.

Issue: A recovery plan is unnecessary if bighorn sheep in the Peninsular Ranges are synonymous with the Nelson's subspecies.

Response: Section 4(f) of the Act requires preparation of recovery plans for listed species whenever prudent. This comment implies that bighorn sheep in the Peninsular Ranges do not comprise an entity that can be listed under the Act. Please refer to the *Federal Register* Notice, dated March 18, 1998, as well as section I.A.1. of the recovery plan, for a discussion of the applicability of our policy on implementing the Act's provisions for listing distinct vertebrate population segments.

Issue: The Fish and Wildlife Service's authority and intended use of the "Recommended Conservation Guidelines" in Appendix F is not apparent. Furthermore, the guidelines appear intended to restrict the power and override the legislative authority of lead agencies.

Response: The Fish and Wildlife Service and Department of Fish and Game prepared these guidelines to assist local governments in their implementation of the California Environmental Quality Act and land use decision making, not to usurp the discretion of other governmental agencies. It is our intention to provide consistent guidance as early as possible in the decision making process so that (1) our recommendations do not come as a surprise later on in the planning process, and (2) projects can be designed to accommodate the habitat requirements of bighorn sheep.

PROCEDURAL ISSUES

Issue: The bibliography contains many blanks for the authors names, indicating that such information cannot be relied upon.

Response: The blank lines in place of the name of an author is a bibliographic convention that indicates the same author as for the preceding reference. In the final plan the bibliographic format has been revised to show full references.

Issue: The recovery plan should describe how the public will track agency implementation of recovery tasks, be involved in prioritizing lands to be acquired, be involved in future modifications to recovery criteria, comment on land exchanges, etc. Similarly, the draft recovery plan did not identify how entities, such as local government, were expected to fulfill assigned task responsibilities in the Implementation Schedule. The recovery tasks often lack site specificity and do not identify applicable mechanisms or responsible entities for implementing the tasks. For example, the habitat protection objective for task 1.1 does not describe who, how, or where the action would be completed. As a result, affected parties have been prevented from providing meaningful review of the recovery plan.

Response: The public can track implementation by communicating directly with the agencies assigned to implement specific tasks. Progress and updates should be incorporated into the public education and outreach programs recommended in the recovery plan. The public may also track the extent of appropriations allocated by legislative bodies as an indication of agency capability for implementing the recovery plan. Local governments should interpret the recovery plan as guidance for contributing to the recovery process. Many of the provisions in the recovery plan should be implemented through the regional habitat conservation plan sponsored by the Coachella Valley Association of Governments. This plan represents a stakeholders group that provides an opportunity for involvement by all interests. Any of the recovery tasks that apply to respective jurisdictions should be viewed as an opportunity to cooperatively participate with other agencies in the common goal of bighorn sheep recovery. We encourage local governments to use their applicable authorities for conservation/management of open space in the furtherance of bighorn recovery.

Participating agencies can provide more detailed guidance on the roles and responsibilities of local government as case specific questions arise. If the recovery plan is updated or revised in the future, the public will be given another opportunity to comment on the plan.

Issue: The recovery plan should contain an economic impact analysis to estimate the costs of recovery. The total estimated costs of recovery implementation should be determined and provided to the public for comment before the recovery plan is approved. Projected funding levels for monitoring appear inadequate; if a long-term monitoring program is needed, why are costs projected for only 5 years.

Response: Though an economic impact analysis is not required by law or regulation, section 4(f) of the Act requires an estimate of costs to achieve recovery. We have projected total costs based on a rough estimate of 25 years to recovery, with more detailed cost estimates for the first five years. Certain costs are difficult to estimate accurately without detailed scopes of work, real estate appraisals, etc. As a result, cost estimates in the Implementation Schedule should be viewed as approximations that inform the public and participating agencies about the resource estimates necessary to achieve the recovery objectives of the recovery plan.

Issue: *The recovery plan should describe the study areas for all research conducted in the Peninsular Ranges.*

Response: The reader should refer to the references cited to obtain more detailed information on the study methods of literature cited in the recovery plan. The purpose of this recovery plan is not to compile and summarize all research conducted in the area at issue.

Issue: Reliance upon forthcoming planning efforts, such as the Coachella Valley multispecies plan to address immediate bighorn sheep conservation needs, unnecessarily defers actions needed to avert the near-term risk of extinction.

Response: We are not aware of any such deferrals and intend to use our legal authorities under sections 4 (designation of critical habitat), 7 (interagency consultation), and 10 (habitat conservation planning) whenever appropriate during the interim period while the Coachella Valley plan is in preparation.

Issue: The recovery plan should critically examine past management mistakes so that they are not repeated in the future.

Response: Much of the recovery plan reflects on the past (*e.g.*, section I.D) and looks to the future (*e.g.*, section II.D). Many of the Recovery Team members have many years of experience in the Peninsular Ranges and, therefore, have a solid historical perspective. A focused, intensive historical inquiry likely would result in arguable conclusions of dubious merit that could adversely affect current interagency cooperation. The purpose of recovery plans is to assess the current situation with a view towards future feasibility of implementing needed conservation actions.

Issue: Many of the tables were not as descriptive as they could have been because (1) the tables excluded potentially available data, such as from years before or after those presented in the tables, and (2) statistical analyses were not conducted.

Response: In some instances, more recent data were not available; in other cases, data from earlier years were not comparable because of different data collection methodologies; and in other circumstances, available data have not yet been compiled and analyzed. In most instances, statistical analyses were not included because this information was provided in the references cited and because the purpose of recovery plans is more informative and prescriptive than analytical and quantitative.

Issue: The recovery plan should discuss the financial situation of the Bighorn Institute, along with a detailed critique of overall operations.

Response: Financial issues associated with the Bighorn Institute are not a concern of the Fish and Wildlife Service or cooperating agencies. Overall operations regarding research and captive rearing have been the subject of annual reviews by the California Department of Fish and Game prior to Federal listing and now fall under the purview of section 10(a)(1)(A), not section 4(f) of the Act.

Issue: A repository for all data collected on bighorn sheep should be created and made available to the public at large.

Response: Creation of such a repository would not be possible unless agencies and researchers donated proprietary information and personal property. The concept poses numerous legal, economic, and administrative issues that exceed our authorities and those of cooperating agencies.

Issue: Numerous comments requested the Fish and Wildlife Service and cooperating agencies to conduct additional research and further analyze data not in their possession before issuing a recovery plan.

Response: The Act's mandate to use the best available information does not require us to conduct additional research or obtain unavailable data as a prerequisite to preparing and completing recovery plans. A court stipulated settlement agreement required completion of the recovery plan under an established schedule.

Issue: The draft recovery plan focuses excessively on habitat conservation instead of population recovery; the various problems should be dealt with in order of importance.

Response: As described in the draft and final recovery plans, multiple, apparently cumulative factors are depressing population levels, with contributing causes differing among ewe groups. The relative importance of factors affecting reproduction, recruitment, and adult survival are poorly understood in some ewe groups, though intensively studied in others. These complexities make it difficult to determine relative importance and management priority. Therefore, we have and will address concurrently all probable factors affecting individual ewe groups to the extent possible. If the habitat base upon which bighorn sheep depend is not protected, sufficient space will not be available to support "recovered" population levels.

Issue: The Fish and Wildlife Service should list credentials of Recovery Team members.

Response: By practice and for consistency, we do not provide this information regarding team members. Members were selected for a variety of skills and experiences that may not be apparent from brief synopses.

Issue: The Fish and Wildlife Service rejected, without explanation, many comments provided by Recovery Team members themselves. Disagreements within the team should be discussed in the recovery plan.

Response: The various views held by members of the team were discussed openly at team meetings until a consensus emerged. Various iterations, including the final recovery plan, have been reviewed multiple times by team members, and all comments have been incorporated into the recovery plan directly or after group discussion where further consideration was warranted. We are unaware of any significant scientific disagreement within the team regarding the content of the recovery plan. Regardless, the Fish and Wildlife Service and cooperating agencies assume ultimate responsibility for the recovery plan, inasmuch as Recovery Teams function as expert advisors to the Fish and Wildlife Service.

Issue: The peer review process of the draft recovery plan was flawed, failed to address all the issues raised and to follow academic protocol, and therefore, should not be referred to as peer review. The draft recovery plan misleads the public into thinking that the peer reviewers endorse the draft plan.

Response: The peer review process referred to in the draft recovery plan represented separate technical and agency reviews prior to public release and was not intended to follow academic protocols. Though most of the comments received by the technical (peer) reviewers were addressed in the draft recovery plan, the draft recovery plan did not claim that the reviewers necessarily agreed with or endorsed the plan. The Recovery Team and Fish and Wildlife Service have included and addressed in this list of issues and responses all substantive comments submitted by technical reviewers not otherwise incorporated into the draft or final recovery plans.

Issue: Research tasks in the recovery plan should identify testable hypotheses.

Response: The Recovery Team is not a research team; therefore, this recovery plan represents a general strategy for recovery that identifies major research topics that should be pursued. It would not be appropriate to propose various experimental designs and hypotheses at this time because the additional level of analysis required should more properly occur when detailed research proposals by individual researchers are prepared.

Issue: The Recovery Team should include a trained land use planner to improve the effectiveness of coordinating conservation activities with local jurisdictions, such as the cities and counties.

Response: One of the current Recovery Team members has an extensive background in land use planning, having worked in that capacity for numerous jurisdictions for many years. In addition, several other members work routinely with local government in land use planning matters and have a thorough understanding of legal and procedural requirements needed to coordinate effective interagency conservation programs.

ESSENTIAL/CRITICAL HABITAT ISSUES

Issue: All local jurisdictions should be extended the same opportunity as the Indian tribes in determining essential habitat boundaries. Failure to do so will doom the recovery planning effort.

Response: Federally recognized Indian tribes enjoy a special relationship and trust privileges under numerous executive, legislative, and judicial mandates not extended to non-Tribal entities. Nonetheless, within the context of the Coachella Valley multispecies planning program, the Fish and Wildlife Service and California Department of Fish and Game convened numerous meetings with city and county governments to discuss and refine essential habitat boundaries in a process similar to that used with the tribes. The Fish and Wildlife Service, Department of Fish and Game, and local jurisdictions achieved agreement along virtually the entire urban boundary except for about six proposed project sites. The Fish and Wildlife Service and Department of Fish and Game will attempt to resolve residual differences for each of the proposed developments through individual regulatory actions.

Issue: The suggested 20 percent slope delimiting lower elevational boundaries in most cases lies below the 213-meter (700-foot) lower elevation limit described elsewhere in the recovery plan as the lower elevational limit of sheep distribution. The essential habitat line should be set along the 213-meter (700-foot) elevation contour from Palm Springs to La Quinta, which would avoid lambing and watering areas and provide opportunities for unrestricted hiking. Essential habitat should not extend onto the valley floor farther than existing wilderness or the proposed National Monument boundary. The map appears to represent a no growth effort that would extort extreme mitigation from developers.

Response: The 213-meter (700-foot) lower elevational limit of sheep distribution typically corresponds to the urban interface at the northern end of the Coachella Valley, whereas in the southern end of the valley, the urban interface occurs along lower elevational contours. As described elsewhere, sheep in the Peninsular Ranges are adapted to survive at lower elevations and depend on lower elevational slopes and alluvial habitats for important resources. The extent of suitable habitat is influenced by soils, aspect, and other topographic features that do not necessarily correspond with fixed elevation contour lines, or wilderness and proposed monument boundaries, which were established for a variety of reasons apart from the habitat needs of bighorn sheep.

Issue: Habitat compensation should not be required for development adjacent to sheep habitat because development of these fragmented areas would not affect sheep.

Response: Most of the proposed development along the urban interface occurs within, rather than adjacent to, sheep habitat. As discussed in the recovery plan, bighorn sheep in the Peninsular Ranges spend much of their time at lower elevations, where otherwise scarce resources, such as food and water, commonly occur. Flatter topography contains more productive alluvial soils that support more diverse and nutritional food sources than occurs on steeper, rockier slopes. Though alluvial habitats are more fragmented by urban development, these smaller patches still support habitat value, though much reduced from historical conditions. Development of habitat fragments also indirectly affects sheep by supporting a larger human population that increases the amount of disturbance in adjoining sheep habitat. As long as suitable habitat conditions exist within the historical range of the species and development results in indirect adverse effects to sheep in nearby habitat, local governments have a mitigation nexus under the California Environmental Quality Act. Mitigation measures can be designed to conserve larger patches of comparable value habitat by requiring offsite habitat replacement, thereby contributing to the conservation of sheep even if smaller habitat fragments are permitted for development. To contribute to recovery, we recommend that local governments consider offsite habitat replacement for permitted development of residual habitats between the essential habitat boundary and 800 meters (2,624 feet) from toe of 20 percent slope.

Issue: Proposed designation of essential habitat requires adequate legal notice to landowners in the vicinity of habitat proposed for conservation so that an opportunity to comment on the proposal is provided. The public comment period should be opened indefinitely until essential habitat is displayed on detailed aerial photography and has been made available for public comment. A more detailed map of essential habitat then should be provided for public comment before the recovery plan is completed.

Response: The Fish and Wildlife Service broadly announced a 45-day public comment period on the draft recovery plan (64 FR 73057; December 29, 1999), which was extended an additional week as a convenience to the public. This noticing process fulfilled all legal requirements. As described above, the Fish and Wildlife Service coordinated with affected interests in soliciting input and promoting discussion to achieve consensus on the essential habitat boundary.

Issue: The draft recovery plan does not adequately describe the importance of the Mount San Jacinto State Park to sheep recovery.

Response: The park is largely located above the elevation where bighorn sheep normally occur.

Issue: The essential habitat map should model food and water resources as was done for physiography.

Response: Food and water resources generally are too dynamic to quantify because their distribution is a function of unpredictably variable rainfall patterns. For example, randomly occurring thunderstorms do not provide uniformly distributed moisture regimens throughout sheep habitat but rather result in localized green-up following high intensity, short duration precipitation events. Sheep typically respond to these sporadic events by exploiting ephemeral sources of food and water. Patterns of sheep distribution relative to perennial water sources have been analyzed and discussed in Appendix B.

Issue: The draft recovery plan did not identify the specific projects previously approved by the Fish and Wildlife Service that would be excluded from areas mapped as essential habitat. Essential habitat should be designated on areas previously approved by the Fish and Wildlife Service for development if scientific data indicate these areas should be part of critical habitat for recovery. Essential habitat should include not yet constructed projects that have been previously approved by the Fish and Wildlife Service because these areas are needed for sheep recovery.

Response: The Fish and Wildlife Service completed section 7 consultation on the Ritz-Carlton Golf Course and Mirada development prior to release of the draft recovery plan, and completed section 7 conferences on the Jimenez Pit, Cahuilla Zone Reservoir, and Shadowrock projects prior to listing. The Fish and Wildlife Service and project proponents agreed to reconfiguration of project designs and other conservation measures on the former four projects. Agreement on the latter project has not been achieved and the affected area is considered essential habitat unless the project is reconfigured to be consistent with the section 7 conference opinion.

Issue: Critical habitat should be designated even if it divulges locations and consequently exposes sheep to harm.

Response: On July 5, 2000, the Fish and Wildlife Service published a proposed rule (65 FR 41405) to designate critical habitat under a separate process pursuant to a recent settlement agreement with the plaintiffs who challenged our not prudent finding that accompanied the listing. This topic was discussed in the proposed rule.

Issue: The recovery plan should describe the relationship of essential habitat and critical habitat from a regulatory and procedural perspective.

Response: Though the two designations are similar in their focus on defining future survival and recovery needs, they differ significantly from a regulatory perspective. For purposes of this plan, essential habitat is an informative designation intended to provide scientific guidance to cooperating agencies and the public, while critical habitat is statutorily defined with implementing regulations that govern Federal agency activity. Critical habitat receives protection under the Act through the prohibition against destruction or adverse modification of critical habitat as set forth under section 7 of the Act with regard to actions carried out, funded, or authorized by a Federal agency. Aside from the protection that may be provided under section 7, the Act does not provide other forms of protection to lands designated as critical habitat. Critical habitat designation does not impose any restrictions to activities on private or other non-Federal lands that do not involve a Federal permit, authorization, or funding. The process for designating critical habitat is distinct from the process for completing the recovery plan. A proposal to designate critical habitat for the Peninsular bighorn sheep was published in the Federal Register on July 5, 2000 (65 FR 41405). The essential habitat mapped in the recovery plan has the same boundary as the proposed critical habitat, with slight discrepancies introduced by a legal description for critical habitat along boundaries imposed by a township/range/section coordinate grid.

Issue: Undeveloped but fenced property should not be mapped as essential habitat.

Response: Areas that can be enhanced or restored are included as essential habitat if they are necessary for recovery. Fencing often does not establish an effective movement barrier to sheep, though it can cause entanglement, injury, and death. The Fish and Wildlife Service advises that fences constructed to exclude bighorn sheep could result in take if built at the wrong location or improperly designed.

Issue: The recovery plan should provide more specific guidelines to local jurisdictions for conserving habitat and reducing the effects of urbanization. For essential habitat to be effective, the recovery plan should provide guidance on future regulation of take under sections 7 and 10 of the Act, which should specifically prohibit authorization of future take if ewe group population levels drop below predetermined thresholds and/or populations increase to a point suggesting progress towards recovery. For example, the threshold approach used for predator management also could be applied to habitat loss.

Response: Appendix F was designed to provide general guidelines that would fit most projects in or adjacent to sheep habitat. More specific guidelines would be difficult without a case by case analysis of individual projects. The Fish and Wildlife Service can not use recovery plans to predetermine future regulatory decisions under sections 7 and 10 because the Act did not envision recovery plans as a regulatory mechanism.

Issue: The draft recovery plan places inordinate importance on land use controls and too little emphasis on reducing predation pressure. By failing to manage threats under its control, such as predation, the Fish and Wildlife Service unfairly shifts onerous regulatory impositions onto private property owners. Another commenter claimed that the acknowledged lack of understanding concerning factors limiting population viability undermines the credibility of the proposed land use controls, and that the uncertainty over adverse effects of urban development eliminates any nexus for governmental regulation.

Response: The Fish and Wildlife Service intends on concurrent implementation of numerous recovery tasks commensurate with available funding. Completion of the recovery plan provides a basis for increased funding allocations to cooperating agencies. Because numerous factors are depressing population growth, it would not be appropriate for the Fish and Wildlife Service and cooperating agencies to attempt to prioritize threats and address only one at a time. Focusing solely on predator control and allowing continued loss of valuable habitat would be based on a theory that habitat loss does not adversely affect bighorn sheep. The available evidence suggests the opposite. The ewe groups adjoining metropolitan areas historically have declined to a greater degree and currently are more severely threatened with extirpation than more southerly and remote ewe groups that have not sustained substantial loss of habitat in the past.

Issue: The draft recovery plan does not adequately identify the specific lands mapped as essential habitat and targets all available habitat without scientifically analyzing whether portions of the area support any suitable habitat at all.

Response: Appendix B presents a habitat model that analyzed a variety of habitat characteristics based on information in the scientific literature and distributional data throughout the Peninsular Ranges. Areas with unsuitable soils and topography were excluded, as were areas greater than 800 meters (2,624 feet) from toe of 20 percent slope, though sheep are known to use these areas. Based on the wide-ranging movements of sheep in the Peninsular and other ranges throughout the desert southwest, sheep are known to use a broad range of habitats in desert environments. None of the areas mapped as essential habitat contains soils, vegetation, or topography that is unsuitable for use by sheep. Though sheep may not use or occur in certain areas as frequently when population sizes are small and distribution is more constrained, it is sometimes difficult to track sheep movements, especially when only a small percentage of certain subpopulations have radio collars. Thus, the known distribution is always an underestimate of actual distribution.

Issue: The designation of "essential habitat" is an illegal subterfuge for avoiding the statutory requirement for designating critical habitat and analyzing consequent economic effects.

Response: A proposal to designate critical habitat for the Peninsular bighorn sheep was published in the Federal Register on July 5, 2000 (65 FR 41405), under terms of the settlement agreement referenced above. A notice of availability for the draft economic analysis on proposed critical habitat designation was published in the Federal Register on October 19, 2000 (65 FR 62691).

Issue: Numerous land owners requested that their lands be specifically removed from areas designated as essential habitat because of the significant social and economic impacts that should be minimized per existing Fish and Wildlife Service policy on recovery planning.

Response: As discussed above, the Fish and Wildlife Service has met with many landowners and agencies in an effort to refine the essential habitat boundary so that social and economic impacts are minimized to the extent that the potential for recovery is not compromised. These discussions resulted in substantial agreement with all parties involved over the vast majority of the urban interface. The resulting essential habitat boundary was designed to minimize economic conflict to the extent consistent with maintaining the likelihood of future recovery. Essential habitat differs significantly from critical habitat. Under critical habitat, exclusions are a procedural outcome of applying section 4(b)(2) and/or "special management" under the Endangered Species Act. Under 4(b)(2), economic and social impacts are evaluated. However, there is no such process identified for exclusions for essential habitat because recovery plans are nonregulatory documents designed to guide, not dictate, recovery of the species.

Issue: *The draft recovery plan was deficient because it did not quantify the acreage of different landownerships, historical distribution, and extent of proposed essential habitat.*

Response: Acreages were not calculated in the draft recovery plan because an updated landownership map was not available and a precise boundary along the urban interface was not delineated. In the final recovery plan, land ownership is delineated with respect to essential habitat in Figure 4; however, the land ownership map is somewhat outdated and any acreage figures would be approximate. Approximate land ownership percentages are summarized in

Section I.E. of the plan. Historical trends along the urban interfaces are summarized in Section D.1.

Issue: Lands that historically never were used by sheep should be identified. The term "unoccupied habitat" is scientifically undefined and inappropriately used to describe unsuitable habitat from which bighorn sheep are absent.

Response: Historical information prior to the use of aerial surveys and radio telemetry is of limited utility because the rugged topography and lack of roads throughout the Peninsular Ranges greatly restricted the extent of access on the ground. Therefore, it is not possible to reliably conclude that certain areas were not used historically. Similarly, given the relatively small sample size of radio-collared sheep at present, especially rams (which are far more wide ranging than ewes), more recent data cannot be properly interpreted to conclude that sheep are absent from certain areas. Therefore, the remaining undeveloped portions of historical range constitute the current distribution of bighorn sheep in the Peninsular Ranges. Use of the terms "occupied", "unoccupied", "suitable", and "unsuitable", are more conceptual than empirical. Thus, these terms add little to our understanding of sheep biology, and as a result, the final recovery plan avoids use of this terminology.

Issue: *Given the tendency of sheep to not venture far from escape terrain, justification in the recovery plan is not adequate to support the need for habitat up to 0.8 kilometer (0.5 mile) from toe of 20 percent slope. Twenty percent slope does not represent effective escape terrain; therefore, a steeper slope should be used for identifying habitat in need of conservation. The recovery plan does not adequately describe what constitutes a movement corridor on the desert floor. If sheep avoid human disturbance, the fragmented habitat patches on the desert floor within the urban matrix would appear to have low habitat value for sheep.*

Response: Though sheep typically are found in steeper terrain, numerous records exist in the Peninsular Ranges and elsewhere of occurrences over 0.8 kilometer (0.5 mile) from escape terrain. The 0.8 kilometer (0.5-mile) distance was selected to capture the more typical movements onto the alluvial slopes. The 20 percent slope for escape terrain was taken from the published literature. As discussed in

Appendix B, a range of slopes have been recognized by various authors as escape habitat. Flatter topography encompasses more productive soils that support more diverse and nutritious forage that is seasonally critical to sheep. Flatter topography also can be important for dispersal and for sources of seasonal water. Sheep in other areas of the desert southwest have been known to move many kilometers across the desert floor to reach neighboring mountain ranges. Given the limited number of documented movements of this kind, not enough is known to delimit linkage dimensions. Rams are especially prone to use flatter areas farther removed from escape terrain. Ruggedness on flatter topography can function as escape habitat but has been difficult to measure and account for in studies published to date. The essential habitat map excludes the less frequently used and lower value habitats characterized by small patch size and proximity to human disturbance.

Issue: Designation of essential habitat as proposed would restrict access for construction and maintenance of infrastructural facilities like flood control and water supply. Flood control facilities should not be included in essential habitat because any use by sheep is incidental to the primary purpose of these lands.

Response: Case by case project reviews under the regulatory provisions of sections 7 and 10 of the Act will determine whether construction of infrastructural facilities are compatible with sheep survival and recovery. Based on discussions with Riverside County Flood Control and Water Conservation District and Coachella Valley Water District, normal operations and maintenance of existing facilities would not conflict with the management objectives for essential habitat. Flood control facilities typically occur in washes and alluvial habitat that have been most affected by historical habitat losses and often still support the same important habitat values as the surrounding areas. As such, these facilities are not *de facto* unsuitable or detrimental to sheep use. If reasonably managed, these areas can fulfill their intended function while at the same time not conflicting with sheep use in the area.

Issue: The recovery plan does not discuss the possibility that past habitat loss from urbanization in the San Jacinto and northern Santa Rosa Mountains may *have resulted in irreversible population declines, rendering essential habitat designation in this area potentially useless.*

Response: The recovery plan strives to intensify management efforts to offset the loss of historic habitat, and thereby maintain functional population levels in the future. If populations become extirpated and the Recovery Team and cooperating agencies determine that habitat areas are no longer capable of supporting self-sustaining populations, future revisions of the recovery plan may delete essential habitat and management objectives for those areas.

BIOLOGICAL ISSUES

Issue: One commenter thought that the eyesight of bighorn equaling that of humans aided by 8-power binoculars should be emphasized.

Response: According to Geist (1971), scientific evidence is not available to support this popular myth, which probably originated with the experiences of hunters with the species.

Issue: The regular sightings of bighorn sheep in Chino Canyon and Tachevah Canyon alleged by Fish and Wildlife Service biologists appear inconsistent with portions of the draft recovery plan that state bighorn sheep vanished from the northern San Jacinto Mountains after construction of the Palm Springs Aerial Tramway.

Response: Though rams still range north of Chino Canyon, ewes have not been documented in the northern San Jacintos (north of Chino Canyon) since the late 1980's. The tramway was constructed in the early to mid-1960's.

Issue: *The high number of undetermined causes of death indicates that a better explanation is needed of how the deaths were discovered and how the causes were diagnosed.*

Response: Most deaths were discovered from radiocollared animals because the fate of uncollared animals is far more difficult to ascertain. When dead animals are found, the cause of death is sometimes difficult to determine because in many cases, coyotes and other scavengers have consumed the carcass so thoroughly that the original cause of death (whether predation or not) can not be determined.

Issue: Some commenters thought the recovery criteria of 25 ewes per 9 identified regions and an average of 750 adults for delisting is too low to assure survival and recovery, and that the estimated rangewide carrying capacity of 1,000 sheep appears low. Another commenter thought the criteria requiring a minimum of 25 ewes in each ewe group would be too difficult to achieve.

Response: The team and agencies decided that it would be difficult to justify a higher population level than was known historically, especially given the extensive habitat loss and fragmentation, and other factors that likely have reduced carrying capacity over time. Team members most familiar with the Peninsular Ranges assessed current and historic habitat quality, and made regional comparisons with other bighorn sheep habitats in estimating current conditions and carrying capacity. The 9 regions were deemed capable of supporting in excess of 25 ewes, with the carrying capacity in most of the regions substantially exceeding the minimum. Because 750 is an average figure, it would be necessary for the population to rise above that level for some period of time, likely in response to changing carrying capacity. The averaging criterion was selected because it allows natural population fluctuations and management flexibility. If the long-term carrying capacity exceeds 750 animals, the population likely would exceed the 750 minimum established in the recovery plan.

Issue: The operations by the Bighorn Institute are contributing to the decline instead of the recovery of bighorn sheep. Alternative methods, such as on-the-ground surveys, should be used for estimating population size and distribution, instead of more highly disruptive helicopter flights. Helicopter censuses and captures are far more stressful to sheep than researchers, hikers, and riders quietly moving through sheep habitat.

Response: The Bighorn Institute conducts hundreds of days of on-the-ground work and only about 6 days of helicopter work each year. Conducting on-the-ground studies is often not feasible on private property and could result in significant disruption to sheep if implemented at a level needed to estimate population distribution and abundance at precision levels comparable to aerial techniques. Even at current levels, on-the-ground disturbance associated with research activities could be detrimental if not for rigorous safeguards. For example, Bighorn Institute biologists regularly document through radio telemetry that their presence "bumps" or "pushes" sheep in flight away from them, at which point the field methodology requires backing off, which often prevents the recording of field data.

Issue: Why is agricultural use adjoining bighorn sheep habitat considered a more compatible use, whereas residential and resort developments are not?

Response: Agricultural activities do not generate the high levels of secondary impacts, such as human recreation in adjoining habitat, as is typically associated with urban land uses. In addition, agricultural lands can be restored to sheep habitat, whereas urban land uses can not. Though agricultural lands were excluded from delineated essential habitat, several Recovery Team members recommended they be included because of their restoration potential.

Issue: Numerous commenters inquired whether studies have been conducted and evidence exists for the presence of bighorn sheep on their lands.

Response: We have included a map with known locality records to provide a better indication of bighorn sheep distribution. References cited throughout the recovery plan should be perused to determine study areas and methods. The lack of records for certain areas does not necessarily indicate that sheep are absent, only that their presence has not been documented.

Issue: The slow reproductive rate and long-term estimates for recovery should be accelerated by importing sheep to increase population levels.

Response: Unless the factors that limit population growth in the Peninsular Ranges are addressed, it is unlikely that a program to introduce animals from outside areas would be successful. However, alleviating *in situ* decimating factors would allow the resident population to expand on its own, which would forego the