APPENDIX C

Revised
Santa Rosa and San Jacinto Mountains Trails Plan
Technical Appendix
November 15, 2005

Superseded
Santa Rosa and San Jacinto Mountains Trails Plan
Technical Appendix
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Prepared by

U.S. Department of the Interior
Bureau of Land Management
690 W. Garnet Avenue
N. Palm Springs, CA 92258

NOTICE ON APPENDIX REDUCTION

This technical appendix has been reduced by 50% and printed double-sided to conserve paper and to allow the technical appendices to be incorporated into the EIR/EIS. If you wish to have a full-sized copy of this appendix, please contact the CVAG at 760-346-1127.

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Appendix C
Santa Rosa and San Jacinto Mountains Trails Plan

1.0 Background

The proposed Santa Rosa and San Jacinto Mountains Trails Plan (Trails Plan) comprises a recreation network for access and use within the National Monument. Trails cross lands owned by the local, state, federal, and tribal governments, as well as privately owned land. The proposed Trails Plan includes existing trails, the proposed perimeter Trail system, and the Palm Desert to La Quinta Connector Trail.

The Trails Plan has four alternatives, one of which is the No Action/No Project Alternative. In the Draft EIR/EIS, the Proposed Action/Preferred Alternative is Alternative B. In the Final MSHCP the Proposed Trails Plan (Revised Alternative B) includes previously analyzed aspects of the other alternatives. In response to this further consideration, the approach to trails management has been revised in the Final Plan to one of adaptive management, where research and monitoring are elevated in importance. The Revised Trails Plan emphasizes research on the effects of recreational trails use on bighorn sheep, and monitoring of human trail use and bighorn sheep populations.

Currently, trails and trail use restrictions are imposed through a variety of permits and agreements entered into by the agency managing these lands. Conditions these agencies have imposed include: restricting~~on of~~ motorized vehicles; requiring dogs be on leashes and prohibiting them from certain areas; restricting~~ons on~~ certain types of uses; and limiting access during sensitive periods or seasons.

The primary biological concern regarding trail use is the potential impacts to the federally and state listed Peninsular b~~B~~ighorn s~~S~~heep within designated critical habitat within the MSHCP. The discussion below is of the primary information and concepts that resulted in the formulation of the Trails Plan Proposed Action/Preferred Alternative.

2.0 Methods and Data Sources for Peninsular Bighorn Sheep and Trails Analysis

Interagency Wildlife Biologist Working Group. The process for compiling data and criteria used to formulate trails' alternatives and evaluate trails and recreational activities relative to Peninsular bighorn sheep was agreed upon by the California Department of Fish and Game (CDFG), Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), and Coachella Valley Association of Governments (CVAG) in March 2002. At this time, an interagency Wildlife Biologist Working Group was convened, consisting of wildlife biologists from CDFG, USFWS, and BLM. This group met eight times.

The focus of the Interagency Wildlife Biologist Working Group was to (1) compile and evaluate the scientific literature relative to recreation use and Peninsular bighorn sheep, (2) compile and review biological information regarding distribution and habitat use by Peninsular bighorn sheep in the Peninsular Ranges, and (3) assemble the data and other information relative to habitat selection by rams, habitat selection by ewes and lambs, trail locations, and locations of water sources used by bighorn sheep. This process involved a critical evaluation of trails and areas listed in Table 10 of the *Recovery*

Plan for Bighorn Sheep in the Peninsular Ranges, California as having "potential conflicts that should be addressed in an interagency trails management plan" (USFWS 2000:88). The Interagency Wildlife Biologist Working Group examined past and present bighorn sheep habitat use patterns, location of trails with respect to presently and historically occupied bighorn sheep habitat, and location and use of water sources in relation to trails in the Santa Rosa and San Jacinto Mountains. A subsequent literature review was conducted by BLM staff in December of 2003, focused on available knowledge of the effects of trail use on bighorn sheep, including captive sheep.

Information Sources. The information used in this analysis comes from a variety of sources, each having different levels of reliability. The best available information has been used as the biological foundation for the Trails Plan. The following is a short description of the major information sources used in the development of this Trails Plan.

Weaver and Mensch's Administrative Report (CDFG, 1970). The Weaver and Mensch 1970 Administrative Report to the California Department of Fish and Game provides a historical picture of Peninsular bighorn sheep population estimates and distribution across the Santa Rosa and San Jacinto Mountains from 1953 to 1969. Those population estimates were based on waterhole surveys, helicopter surveys and ground surveys conducted by various researchers throughout the years covered by the report. Waterhole count data were used as an index of abundance rather than for calculation of an absolute population estimate (USFWS 2000). In addition to population estimates, Weaver and Mensch (1970) provided information regarding lambing areas in the Santa Rosa and San Jacinto Mountains.

Santa Rosa Mountains Wildlife Habitat Management Plan – A Sikes Act Project (BLM and CDFG 1980). The Sikes Act Plan provided management guidance for the CDFG and BLM, the two government agencies responsible for Peninsular bighorn sheep management and habitat management respectively, in the Santa Rosa Mountains. The Sikes Act Plan was based on the best habitat evaluation techniques and information available at the time. Water source locations were included on an 8.5 inch by 17 inch map but without corresponding coordinates. Thus, the Sikes Act Plan provided a general idea of where water was located in the Santa Rosa Mountains, but was not specific regarding location. In the Sikes Act Plan, Peninsular bighorn sheep habitat was modeled after Hansen's habitat classification system that recognized different areas within sheep range have differing significance relative to the maintenance of sheep populations.

Draft Bighorn Sheep Metapopulations Plan. Additional information was gleaned from: the *Draft Bighorn Sheep Metapopulation Plan*, dated 20 May 1994 (CDFG); a draft sheep distribution map, dated 9 September 1997, from the USFWS; sheep sightings from the Bighorn Institute from 1983 to 1985; and a map of all known sheep sightings.

Hansen System. In the Hansen system, habitat classification was based on bighorn sheep utilization and preference, terrain characteristics, vegetation, proximity to urban areas, sensitivity to disturbance, and importance to bighorn sheep sex and age classes. Habitat was placed into one of four categories based on this classification system: (1) *vital to bighorn sheep* – areas where sheep concentrate during the hot months and during lambing; (2) *primary importance* – areas used by bighorn sheep primarily outside the hot, dry season, including movement corridors, canyon bottoms, benches, and flats; (3) *secondary importance* – areas receiving periodic use and considered necessary to maintain viable populations, including terrain not characteristically associated with high use but providing important habitat for rams or periodic use by ewes and young; and (4) *zones of deficiency* – areas that receive irregular use by Peninsular bighorn sheep, including lands most prone to human impacts and areas lacking habitat components considered necessary for bighorn sheep; these lands may be improved through habitat manipulation (water development) or change in human use patterns. Although this information was state-of-the-art in 1980, the Hansen Model is based on a subjective assessment of bighorn sheep habitat that is no longer used by sheep biologists and managers.

Peninsular bighorn sheep Telemetry Data. In the mid-1970s the Department of Fish and Game began conducting annual helicopter surveys of Peninsular bighorn sheep in the Santa Rosa and San Jacinto Mountains in an effort to better estimate bighorn sheep populations. In addition to these efforts, radio-collaring and intensive on the ground monitoring via radio telemetry were initiated in the 1980s in the Santa Rosa Mountains, thus greatly increasing the amount of data and knowledge available for managing Peninsular bighorn sheep. Early telemetry collars required on the ground tracking or aerial tracking of the collared sheep. Most collars used in recent years were GPS collars that automatically recorded coordinates which were downloaded into data bases either remotely or when the collars were recovered. Since the application of radio telemetry technology in the Santa Rosa and San Jacinto Mountains in the 1980s, approximately 26,000 observations and locations have been recorded many of them using GPS collars which are generally more accurate and which provide more locations per animal over the same length of sampling period

Limitations of radio telemetry data can include researcher bias related to how the locations are collected and areas where ewes are collared (ewes generally occupy a specific area and do not move long distances). This research has been focused primarily in the northern Santa Rosa Mountains (there have been only a couple of studies south of Dead Indian Canyon using radio collars) and the majority of the animals collared have been ewes. This further biases the data. However, these data do represent the best available information of habitat and areas used by Peninsular bighorn sheep, and were used in the development of Seasonal Trail Areas described in the trails management plan.

The Seasonal Trail Areas were derived using Peninsular bighorn sheep location data and a geographic information system (GIS). Bighorn locations were plotted on a map of the Santa Rosa and San Jacinto Mountains. Designated Essential Habitat was overlaid on the map along with the existing trails network. Next, the pattern of Peninsular bighorn sheep data points was examined and a line was drawn that encompassed the majority of bighorn sheep data points. Peripheral trails along the urban interface and trails above 4600 feet elevation were excluded. The intent of delineating Seasonal Trail Areas was to encompass identified and unidentified trails within bighorn sheep habitat that are subject to the Seasonal Trail Program. The concept of Seasonal Trail Areas has been removed from the Proposed Trails Plan.

3.0 Peninsular bighorn sheep Literature Review

There is a considerable body of information on desert bighorn sheep in the Peninsular Ranges (e.g., Grinnell and Swarth 1913, Tevis 1957, Blong 1967, Weaver and Mensch 1970, Wehausen et al. 1987, DeForge et al. 1997, Rubin et al. 1998). This information provides an understanding of how this population utilizes its habitat during different seasons of the year. This information, coupled with knowledge of bighorn sheep ecology, behavior, and habitat requirements, provides some understanding of the pattern of bighorn sheep movements and habitat use on the landscape.

~~Three~~ K~~k~~ey elements have been identified in the development of a logical and biologically meaningful trails management plan for Peninsular bighorn sheep in any area. They are: 1) demographic data on the bighorn sheep populations in the area, ~~1~~2) knowledge of the habitat requirements of Peninsular bighorn sheep in general, ~~2~~3) knowledge of the habitat and its use as it relates to the requirements of individual male and female Peninsular bighorn sheep, and ~~3~~4) knowledge of how sheep react or interact with trail users. With these understandings, it is possible to begin to determine how human activity may influence, or at times, disrupt an individual bighorn sheep's use of its habitat and to what degree that disruption may impact the life cycle of an individual or threaten its existence.

Bighorn Habitat Requirements. Peninsular bighorn sheep habitat requirements, when broken down to the most basic elements, include water, forage, escape terrain, and visibility (Risenhoover and Bailey 1985, Geist 1971, McCarty and Bailey 1994). All models of bighorn sheep habitat consider free water (streams, perennial water, and tenajas) as a necessary component of their habitat (McCarty and Bailey 1994). Ewes are generally found within 3.2 km of water (Blong and Pollard 1968, Hansen and Deming 1980, Halloran and Deming 1958), although Turner (1970) reported sheep in the Santa Rosa Mountains utilizing habitat up to 5 miles from water. Lack of forage is generally not considered to be a factor in bighorn sheep declines (Welles and Welles 1961, Browning and Monson 1980). Bighorn sheep are forage generalists, meaning that they forage on many plant species including grasses, shrubs, and forbs (Leslie and Douglas 1979, Bighorn Institute 1986, Rominger et al. 1988, Krausman et al. 1989, Cunningham 1989, Miller and Gaud 1989).

Escape terrain is a loosely defined term that generally describes steep, rocky, broken terrain. There are many different descriptions of escape terrain for Peninsular bighorn sheep (McCarty and Bailey 1994). Size of topographic features is critical to the type of use by bighorn sheep (Armentrout and Brigham 1988) as is the connectivity to the various other habitat components (Ough and DeVos 1982). Bedding cover can be unstable talus slopes, steep broken escarpments at least 0.4 acres in size, with traversable terraces. Lambing cover requires steep broken escarpments or rock outcrops at least 5.0 acres in size with traversable terraces (Armentrout and Brigham 1988). Visibility is an important component of desert bighorn sheep habitat. The predator evasion strategy of bighorn sheep involves visual detection of danger at a distance, visual communication of danger among individuals, and escape to terrain on which a bighorn sheep can outmaneuver and escape potential predators (Geist 1971, Risenhoover and Bailey 1980).

It is not enough that these habitat elements are present; they must be available in sufficient quantity, quality, and juxtaposition to one another (Dunn 1996, Risenhoover et al. 1988) to benefit the population. When any of these factors is lacking, the overall suitability of the habitat is diminished. For example, water may be available with escape terrain nearby but if visibility around the water source is compromised by vegetation, bighorn sheep may avoid using it due to increased risk of predation (Waklyn et al. 1987, Risenhoover and Bailey 1985, Risenhoover et al. 1988). Bighorn sheep habitat is generally not continuous (Geist 1971, Bleich et al. 1990). It is patchy and suitable patches may be separated by miles of terrain unsuitable for bighorn sheep such as flat, open terrain, brush-covered terrain, or wooded areas (Geist 1971, Risenhoover et al. 1988, Bleich et al., 1990).

Anti-Predator Behavior. In addition to basic habitat components, ewes and rams select habitat differently (Bleich 1993) based on seasonal forage and water requirements (Smith and Krausman 1987, Krausman et al. 1989, Hanley 1982), body size (Bleich 1993, McCarty and Bailey 1994), and anti-predator behavior (Bleich 1993, Berger 1978, Ruckstuhl 1998). Because of their smaller body size and resulting increased vulnerability to predation (Ross et al., 1997), ewes tend to occupy the steepest and most rugged terrain available. Bleich (1993) found that indices of predator abundance were substantially lower in areas use by females and young than those used by mature males in the Mojave Desert of southern California.

In addition, Bleich (1993) found that groups of females with lambs occurred on steeper slopes and in more rugged and open habitats during seasons when males and females were segregated. Ewes groups will forage away from escape terrain but generally remain within a couple hundred meters of escape terrain in order to evade predators (Bleich 1993, Rominger et al., 1988, Terry Russi (personal communication 4-24-03). However, although they do so less than rams, ewes will cross flats between or adjacent to mountain ranges on a regular basis (J. Wehausen, pers. comm.)

Conversely, rams, in groups or alone, will cross broad flat plains and valleys between mountain ranges (Bleich 1993) and will forage up to a mile away from escape terrain (McCarty and Bailey 1994). Ross et al. (1997) studied cougar predation on bighorn sheep in British Columbia and found that of twenty-nine sheep kills in three years, thirteen (45%) of those kills were lambs and sixteen were ewes that were at least one year old. Six mature rams were documented killed by lions in the same study; however, three of the six rams were observed limping or otherwise injured within a few days of being killed. A similar study is being conducted by researchers from University California at Davis in Anza-Borrego Desert State Park and Cuyamaca Rancho State Park. One of the specific objectives of this study is to determine prey selection particularly relative to bighorn sheep. The July 1, 2002 Progress Report reported that 14 bighorn sheep had been killed by mountain lions since fall 2001. Of these, 7 were females, 6 were males (2 over the age of 10 and in poor condition, 1 was 9 months old) and 1 additional lamb. These findings support the sexual segregation theory presented by Bleich (1993) and Ruckstuhl (1998), that sexual segregation in bighorn sheep is driven by body size and anti-predator behavior as well as foraging opportunities.

Habitat Selection. In the Santa Rosa and San Jacinto Mountains, habitat selection by ewes with lambs has been well documented since the 1950s (Weaver and Mensch 1970, DeForge and Scott 1982, Rubin and Boyce 1996). High use areas include Magnesia, Bradley, Dead Indian, ~~and~~Carrizo, Deep, Bear Creek, and Martinez Canyons (Weaver and Mensch 1970, DeForge and Scott 1982, DeForge et al. 1995, Rubin et al. 1998). These canyons contain steep, broken terrain that provides excellent escape opportunities, have good visibility so that sheep can detect predators, have a history of reliable water (Tevis 1959, Blong and Pollard 1968, Weaver and Mensch 1970, DeForge and Scott 1982, DeForge et al. 1995), and in general meet the needs of bighorn ewes during the spring lambing season. Rams have been documented in many of these areas as well but are less tied to escape terrain than ewes because of their larger body size. In other areas, such as the Murray Hill area east of Palm Canyon, there is past evidence that ~~large numbers of~~ bighorn sheep have ~~ever~~ used the area.~~with any predictability.~~ Grinnell and Swarth (1913) reported "…east of Palm Canyon [bighorn] sign was widespread over the hills below the 3500 foot contour." There is no direct mention of where east of Palm Canyon, whether in Eagle Canyon or Cathedral Canyon this sign was observed. There is no mention of observations of individual sheep in this area. The Murray Hill area, while having steep terrain with some rugged canyon habitat in Eagle Canyon to the north, does ~~not offer much to~~ provide potential bighorn sheep Habitat, including for ~~other than perhaps~~ ram movements through the area en route to the San Jacinto Mountains (DeForge et al. 1997, Rubin et al. 1998).~~, Russi personal communication 4-24-03).~~ Terry Russi (pers. comm.) recounts substantial sheep numbers observed around Murray Hill. James W. Cornett reviews written evidence and reports by at least a half dozen individuals about observations of bighorn sheep in or near Eagle Canyon from the late 1970s to the late 1980s (Cornett 1999). From the 1980s until recently, declines in sheep numbers in the northern Santa Rosa would explain the lack of observations of bighorn sheep in Eagle Canyon. Murray Hill and more rugged adjoining areas would be expected to support lambing in the future if properly managed and if sheep populations continue to grow or redistribute themselves into historically used areas. According to Cahuilla traditions (Bean et al. 1991), bighorn sheep formerly used Murray Hill as a lambing area.

Trail Use, Human Disturbance and Bighorn Sheep. The third element in this analysis is the relationship between human disturbance and bighorn sheep habitat selection and use. Researchers have found that human disturbance can alter habitat use and activity patterns of bighorn sheep (e.g., Van Dyke et al. 1983, Miller and Smith 1985, King and Workman 1986, Etchberger et al. 1989, Papouchis et al. 2000) as well as cause short-term physiological changes (MacArthur et al. 1979 and 1982, Martucci et al. 1992).

Population declines (Van Dyke et al. 1983, Etchberger et al. 1989, Harris 1992, Krausman et al. (2000), shifts in habitat use (Hamilton et al. 1982, Van Dyke et al. 1983, Papouchis et al. 2000), and interruption of seasonal migration (Ough and DeVos 1984) have been evaluated with respect to human disturbance with varying degrees of reliability. Timing and location of recreation in bighorn sheep habitat, the distance between sheep and humans, and the presence of dogs all affect how bighorn sheep react to human disturbance (MacArthur et al. 1982, Papouchis et al. 2000, Miller et al. 2001). However, there is still uncertainty about the long-term effects of recreation disturbance on fitness, reproductive success, survivorship and recruitment dynamics of bighorn sheep.

Timing of recreation use relative to the life cycle of bighorn sheep is important. Bighorn ewes are most vulnerable to disturbance just prior to and during the lambing and rearing season (Geist 1971, Light and Weaver 1973, King and Workman 1986, Wagner and Peek 1999). In the desert, bighorn sheep may give birth virtually any month of the year; however, in the Peninsular Ranges, bighorn lambing predominantly and consistently occurs from January through early June. During a four-year study (1993-1996) conducted in the Peninsular Ranges south of the San Jacinto Mountains, the lambing season extended from February through August; 87% of the lambs were born from February to April and 55% of the lambs were born in March (Rubin et al. 2000)

DeForge et al. (1997) reported a similar onset of the lambing season in the San Jacinto Mountains. Ewes exhibit the most severe responses to disturbance a few weeks prior to parturition and for about 6 weeks after the lambs are born (Geist 1971). Bighorn ewes seek isolation in rugged terrain a few weeks before giving birth and remain there for a week to ten days after giving birth (Hansen 1980), after which they generally form large nursery groups of lambs, yearlings, and adult ewes.

Impacts to ewes that are pregnant or lactating can have deleterious effects (Geist 1971, Light and Weaver 1973, King and Workman 1986, Wagner and Peek 1999). Geist (1971) speculated that females with less exposure to disturbances such as predators or humans benefit from increased supplies of energy and nutrients beyond the requirements of daily living and the growing fetus. He further speculated that this leads to increased post-natal survival of lambs. Flight responses can be extreme when ewes are with young lambs. King and Workman (1986) and Wehausen (1980) documented a heightened awareness to human activity when lambs are present.

Ewes with lambs tend to remain close to escape terrain (McCarty and Bailey 1994) and reliable water sources (Leslie and Douglas 1980, McCarty and Bailey 1994) with density and proximity to water increasing during summer months (Blong 1967, Blong and Pollard 1968, Weaver and Mensch 1970, BLM 1980). Travel corridors between lambing areas and watering areas are also important, and high levels of recreation could impede access to important resources during critical times (Geist 1971, Ough and DeVos 1984, Van Dyke et al. 1983, Etchberger et al., 1989). Rams tend to exhibit less response to disturbance than ewes except in areas where hunting has been allowed or poaching is a problem (Geist 1971, King and Workman 1986, Papouchis et al. 2001).

Research has shown that bighorn sheep exhibit a stronger, adverse reaction to humans approaching from above them than to humans approaching from below (MacArthur et al. 1982, Hicks and Elder 1976, Geist 1971). Approaching from over a ridge may limit escape options for bighorn sheep. MacArthur et al. (1982) found that bighorn sheep withdrew when a human was approaching from over a ridge (> 50 meters away) 27.6% of the time but withdrew only 3.6 % of the time when approached from a road not above them. However, the effect depends on where sheep are located with respect to escape terrain and whether the humans are between them and their escape terrain (J. Wehausen, pers. comm.).

Response based on distance between the bighorn sheep and the source of disturbance has been generally documented. Both flight and cardiac responses seem to be stimulated between about 50 and 100 meters (Holl and Bleich 1983, MacArthur et al. 1982, Miller and Smith 1985). The exception is helicopter disturbance where the distance is above 400 meters (Bleich et al. 1994). The distance at which sheep become aware of the disturbance can also affect how far they move away from the disturbance (Miller and Smith 1985). Distance alone is a poor predictor of behavioral response to disturbance. Responses are variable and group size and gender compositions are also important factors (Miller and Smith 1985).

Bighorn sheep evolved with canine predators (Geist 1971) and thus react very strongly to domestic dogs. Disturbance of bighorn by dogs causes heart rate increases and flight response (MacArthur et al. 1979, MacArthur et al. 1982, Purdy and Shaw 1981). Sheep will remain nervous and alert for up to 30 minutes following a dog encounter, responding to subtle stimuli, which otherwise evoked no response (MacArthur et al. 1982). Goodson et al. (1999) noted that the elimination of camping and dogs in important sheep habitat resulted in a reduction in the effects of human disturbance to bighorn sheep.

Researchers have shown that bighorn sheep exhibit a response to hikers (e.g., Hicks and Elder 1979, Miller and Smith 1985, Papouchis et al. 2000). Miller and Smith (1985) found that sheep had a strong reaction (immediate flight response) to the presence of 1 or 2 humans on foot (38% and 49% of the total responses respectively). MacArthur et al. (1982) also found that bighorn sheep had a strong behavioral and cardiac response when approached from over a ridge by a human or a human with a dog. In addition, Hamilton et al. (1982) found that sheep avoided using areas while humans were present but were not permanently displaced by hikers. Bighorn sheep behavior was modified to avoid human interactions at salt licks or waterholes, visiting each earlier or later in the day when humans were not present (Campbell and Remington 1981, Hamilton et al. 1982).

The level of response seems to be affected by a number of factors such as direction of approach (i.e., from above, across a ridge, below, or level) or the presence or absence of a dog (MacArthur et al. 1982), levels of previous disturbance and the history of hunting (King and Workman 1986), composition of the bighorn sheep group (i.e., presence of ewes with lambs) (Wehausen 1980, Miller and Smith 1985, King and Workman 1986), and the size of the group of sheep (Berger 1978, Miller and Smith 1985). Papouchis (2000) found a more frequent flight response from hiking disturbance than from mountain biking or vehicles.

Conversely, Hamilton et al. (1982) did not detect any significant difference in bighorn distribution between heavily used and lightly used recreation areas. Hicks and Elder (1976) ~~and Wehausen (2000)~~ concluded that foot trails did not affect sheep movements in the Sierra Nevada Mountains. However, in the Bighorn Zoological Area of the Inyo National Forest, recreation activities have been strictly controlled since the 1970s. There are two main trails that access Mt. Williamson and Mt. Baxter in the Bighorn Zoological Area. These two trails are open from April 15 to May 15 and from December 15 to January 1 each year. Trail use quotas of 8 and 15 people per day are strictly adhered to through a wilderness permit system on the Georges Creek and the Sawmill Trails respectively (Adam McClorie, Inyo National Forest, Personal Communication April 26, 2003).

In addition to stringent trail use prescriptions, dogs are not permitted in the Bighorn Zoological Area. To date, research has not been conducted utilizing a research design that would establish a link between recreation and effects on individual fitness, reproductive success, survivorship, or recruitment of bighorn sheep.

Bighorn sheep typically range within 2 miles of free water (Geist 1971, Van Dyke et al. 1983) and are highly dependent upon reliable water sources especially during the hot season (BLM 1980). Where surface water is available, desert bighorn sheep drink regularly during the hot season (Turner and Weaver 1980, Krausman et al. 1999). Desert bighorn sheep frequently drink only every three days during the hot season and this ability has been studied physiologically (Turner 1973, 1979). Nevertheless, under some situations some sheep may visit water holes on consecutive days. The Peninsular Ranges of California experience hotter summer temperatures than many Mojave Desert ranges to the east; thus water appears to be particularly important to these sheep. Restricting access to trails near water sources during the hot season should minimize the frequency with which bighorn sheep delay drinking because of nearby humans. Bighorn sheep activity has been found to decrease on days when vehicle use interrupts access to water (Jorgensen 1974). Constant or frequent human use (e.g., cross country travel, camping, off-road vehicles) at or near water sources, particularly during the summer months, may adversely affect sheep and may cause them to abandon the water source in favor of less disturbed areas (Blong 1967, DeForge 1972, Cunningham 1982, Miller and Smith 1985). Leslie and Douglas (1980) recorded alterations in behavior and movement coincident with construction activity near a sheep water source.

Although there is considerable information known about the ecology of Peninsular Ranges bighorn sheep, there is uncertainty about the effects of recreation on bighorn sheep. It is acknowledged that bighorn sheep react to humans, but the level of effect is not well understood. Whether recreation related disturbances cause a population level effect on bighorn sheep cannot be ascertained in the context of this Trails Plan. Given the endangered status of this population of Peninsular bighorn sheep, the Trails Plan is designed to minimize potential disturbance to ewes and lambs during the spring to ensure that sheep have unimpeded access to water during the hot season. The observations of Campbell and Remington (1979), Leslie and Douglas (1980), Jorgensen (1974), Hamilton et al. (1982), and Blong (1967) justify limiting human activity at water sources. Otherwise, impacts of human activity upon bighorn sheep are difficult to predict (McCarty and Bailey 1994). Potential sources of stress should be limited in bighorn populations that are dangerously small (McCarty and Bailey 1994).

Human Disturbance. Bighorn sheep live in ecosystems that include predators. When predators are detected near them, sheep react in ways that minimize the probability of being caught. That reaction varies depending on the nature of the threat; flight is one such response. Humans are potential predators and bighorn sheep flee from them in some situations. Investigators have categorized and quantified flight responses of bighorn sheep in a variety of situations (Light and Weaver 1973; Wehausen 1980, 1983; Papouchis et al. 2001). Distances that trigger different flight responses can vary within populations as a function of sex, season, habitat characteristics, and types of disturbance (Wehausen 1980, Papouchis et al. 2001) as well as between populations (Wehausen 1980, 1983).

Flight responses of bighorn sheep vary from extreme flightiness at great distances under intensive hunting by humans (Thorne et al. 1978) to extreme habituation in which bighorn sheep show virtually no flight response (Horejsi 1976). Numerous habituated populations can be found in the Rocky Mountains from New Mexico to Canada. While habituated sheep are less common in desert environments, they do exist (Papouchis et al. 2001). A prime example has been in the northern Peninsular Ranges, where the sheep exhibited a high degree of habituation in the urban interface in the northern Santa Rosa Mountains – a predictable source of water and green forage for them. Because of this wide range in the reactions of bighorn sheep to humans, little can be extrapolated from one situation to another.

Human disturbance has been seen as a potentially negative influence on bighorn sheep populations where human use is frequent in bighorn sheep habitat (Dunaway 1971, Light and Weaver 1973). Wehausen (1980) analyzed this problem and pointed out that, like competition, human disturbance is of importance only if it has a demographic consequence, ultimately manifested as a lowering of carrying capacity, the density of sheep that the habitat can support.

Wehausen (1980) separated this problem into two aspects: a habitat effect and a physiological effect. The first occurs where sheep avoid otherwise favorable areas of habitat because of the frequency of human use, resulting in resources there becoming unavailable to the population. The physiological effect concerns influences of humans on the ability of bighorn sheep to utilize available forage. This potentially occurs through (1) the loss of energy in flight from humans and (2) reduced intake of nutrients when feeding patterns are disrupted by flight from humans. The demographic importance of this effect will depend on two variables: the frequency with which individual sheep alter their behavior patterns (e.g. flee) due to encounters with humans, and the nature of those episodes (e.g. how far they flee and how nutrient intake is affected). The more habituated bighorn sheep are to humans, the less often they will alter normal behavioral patterns due to humans near them and the less disruptive flight episodes will be (e.g. shorter flight distances).

The habitat effect leads to the simple prediction that bighorn sheep use of suitable habitat will be lacking or significantly reduced near areas of high human use (e.g. trails). Calculating the amount of habitat lost as a percentage of habitat available to the sheep population will provide a measure of the potential influence this might have on the sheep population (Papouchis et al. 2001). This can be refined by also considering differences in habitat quality. Data on bighorn sheep distribution relative to human use are therefore an important basis for any analysis of human disturbance as a potential factor influencing bighorn sheep population parameters. However, other variables that might affect sheep distribution must be considered as alternative hypotheses (Platt 1964, Quinn and Dunham 1983).

A prediction from the physiological effect is population decline to a lower size. Because multiple factors operate simultaneously on populations, it will rarely be possible to isolate human disturbance as the primary cause of a population decline. Scientific hypothesis testing involves an asymmetry. While hypotheses can be cleanly falsified, their corroboration in ecological settings will entail considerable uncertainty given the lack of ecological controls, thus lack of exclusivity among alternative hypotheses (Quinn and Dunham 1983, Wehausen 1980). However, a strong population increase will falsify the hypothesis that the prevailing human use patterns were an important negative physiological influence on the population (Wehausen 1980). An analysis of demographic data is consequently a second important aspect of objective analyses of human disturbance. Quantification of flight reactions of bighorn sheep to humans as a function of distance and other variables provides another basis that can be used to evaluate the potential for human disturbance to have a significant physiological effect. A high degree of habituation will suggest a low potential for this factor to be important. However, a high degree of flightiness could imply the same if the frequency with which individual sheep encounter humans is low. The frequency with which individual sheep encounter and react to humans is consequently useful information in evaluating the potential for human disturbance to have population effect.

The literature on human disturbance mostly includes: (1) general conjectures about the potential role of human disturbance in bighorn sheep population dynamics with no actual data on effects of humans (e.g. Wagner and Peek 1999); (2) observations of short term displacement of sheep by humans (Jorgensen 1974, Hamilton et al. 1982); (3) measurements of short term heart rate changes when humans and dogs are visible to sheep (MacArthur et al. 1979 and 1982), and (4) quantification of distances and other variables that influence different responses of sheep to humans (Wehausen 1980, 1983; Papouchis et al 2001). In only one situation did studies develop and synthesize data on long term displacement, variables affecting sheep flight responses, rates at which sheep encountered humans, and population dynamics (Wehausen et al. 1977, Hicks and Elder 1978, Wehausen 1980), and concluded for one population that human disturbance was not an important factor.

Relative to potential influences of human use of trails on bighorn sheep in the northern Peninsular Ranges, the following findings from the literature may have bearing: (1) females with small lambs are more flighty, thus more like to be influenced by people on or off trails (Wehausen 1980); (2) sheep are more flighty when people are between them and their escape terrain (Wehausen 1980); (3) dogs accompanying people may elicit greater responses from some classes of sheep in some seasons (MacArthur et al 1979, 1982; Wehausen 1979; Purdy and Shaw 1981); (4) sheep may delay drinking during the hot season if people are at their water sources (Jorgensen 1974) and (5) sheep are capable of habituating to human use that is geographically predictable and non-threatening (Campbell and Remington 1981, Hamilton et al. 1982).