

**Considerations for a Wildlife Underpass on Tamarack Road in the  
Stubbe Canyon Wildlife Movement Corridor, Coachella Valley,  
Palm Springs, California**

**Final Report**

by

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**TABLE OF CONTENTS**

1. Introduction.....7

2. General Recommendations .....12

    2.1. Strategic Framework Based on Population Viability Analyses ..... 12

    2.2. Collect Data in the Field..... 13

3. Specific Recommendations.....15

    3.1. Location..... 15

    3.2. Number..... 15

    3.3. Type..... 15

    3.4. Dimensions..... 15

    3.5. Habitat ..... 16

    3.6. Co-use by Humans ..... 17

    3.7. Fencing ..... 18

4. References.....19

**LIST OF TABLES**

Table 1.1: Regional ecologists selected 23 focal species for the San Bernardino – San Jacinto connection (Penrod et al., 2005). ..... 9

**LIST OF FIGURES**

Figure 1.1: The Stubbe Canyon corridor is a corridor between the San Bernardino Mountains and the San Jacinto Mountains, just west of Palm Springs, CA..... 7

Figure 1.2: The existing bridges (east and west set) under the freeway (I-10), railroad, and southern frontage road on the east side of the Stubbe Canyon corridor. The red oval indicates the location of one or more proposed structures under the northern frontage road (Tamarack Rd). The white arrows indicate possible animal movements through the eastern and western set of crossing structures..... 8

Figure 1.3: Proposed design of the wildlife crossing structure on Tamarack Rd (LSA, 2010). Reprinted with permission from LSA Associates, Inc. and County of Riverside. .... 10

Figure 3.1: A row of tree stumps provides cover for invertebrates, amphibians, reptiles, and small mammals inside a modified underpass originally build for traffic alone under a motorway (Copyright: Marcel Huijser). Note that vegetation grows where there is sufficient light and moisture, including in the median in between the two structures (one structure per travel direction)..... 17

## 1. INTRODUCTION

The Stubbe corridor is an existing and/or proposed corridor between the San Bernardino Mountains in the north, and the San Jacinto mountains in the south in the Coachella Valley, just west of Palm Springs, California (Figure 1.1). The corridor is intersected by several roads and a railroad (Figure 1.2). There are existing bridges, an eastern and a western set, underneath both directions of travel for I-10, the railroad, and the southern frontage road. Tamarack Rd, the northern frontage road, currently only has a set of three small diameter culverts opposite of the eastern structures. Tamarack Rd currently has no bridges. The existing bridges under the other roads and the railroad allow water from Stubbe Canyon (to the north) to flow southwards under the roads and railroad. In addition, utility companies (water, electricity) and off-road vehicles use the bridges to access areas south of the roads and railroad.

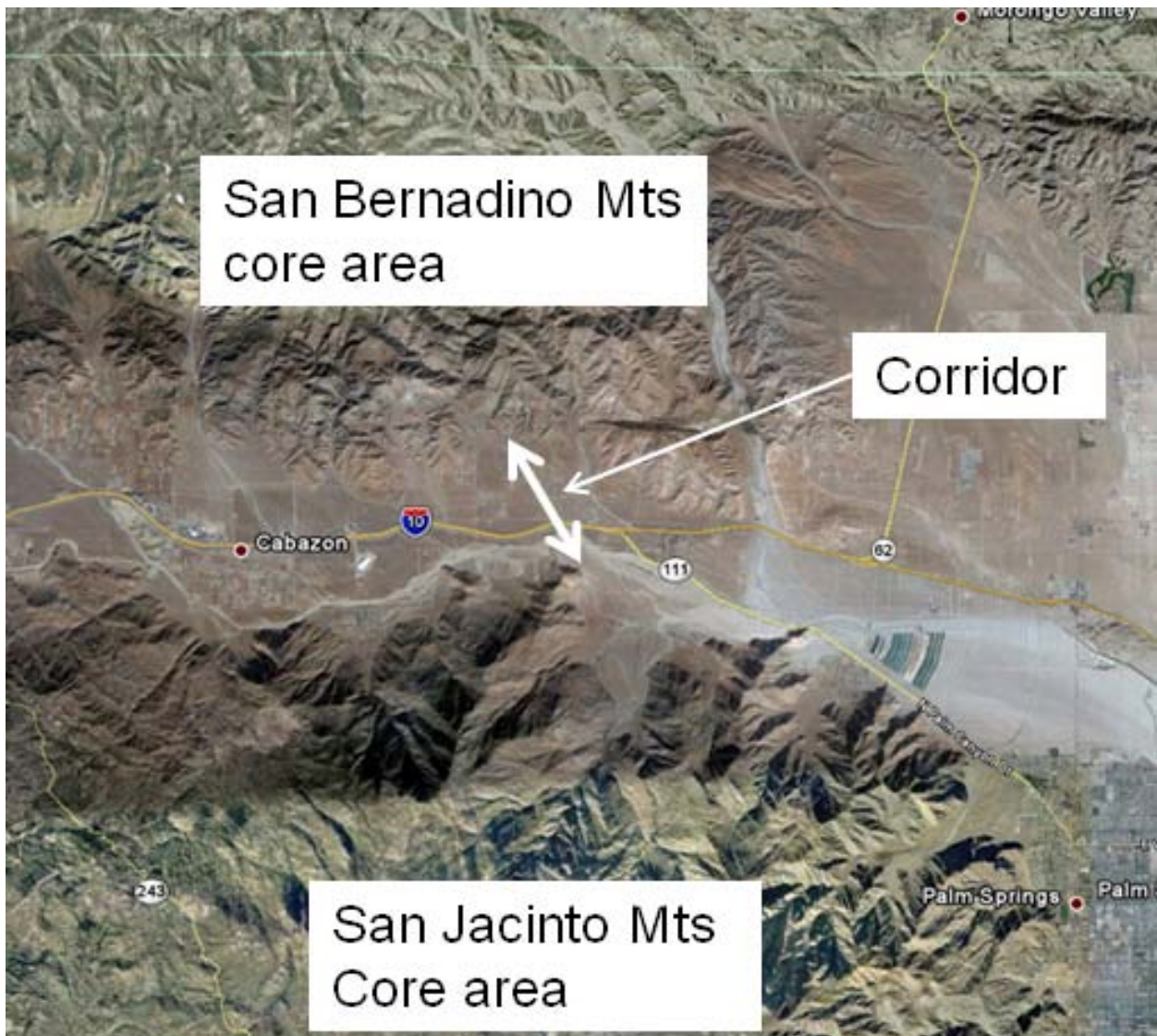


Figure 1.1: The Stubbe Canyon corridor is a corridor between the San Bernardino Mountains and the San Jacinto Mountains, just west of Palm Springs, CA.



Figure 1.2: The existing bridges (east and west set) under the freeway (I-10), railroad, and southern frontage road on the east side of the Stubbe Canyon corridor. The red oval indicates the location of one or more proposed structures under the northern frontage road (Tamarack Rd). The white arrows indicate possible animal movements through the eastern and western set of crossing structures.

Development is planned on the west side of Tamarack Rd. This is likely to result in a substantial increase in traffic volume on Tamarack Rd, and in the future Tamarack Rd may eventually be upgraded from two lanes to four lanes.

A range of plant and animal species have been identified for which the connectivity between the San Bernardino Mountains and the San Jacinto Mountains should be maintained or improved through corridors, including the Stubbe Canyon corridor (Table 1.1). Note that not all of the species listed in Table 1.1 are expected to use the Stubbe Canyon corridor. Also note that the Stubbe Canyon corridor is likely to be important for the desert tortoise (*Gopherus agassizii*) and bobcat (*Lynx rufus*), two species not listed in Table 1.1.



Table 1.1: Regional ecologists selected 23 focal species for the San Bernardino – San Jacinto connection (from Penrod et al., 2005).

<b>PLANTS</b>
<i>Dodecahema leptoceras</i> (slender-horned spineflower)
<i>Artemisia californica</i> (California sagebrush)
<i>Alnus rhombifolia</i> (white alder)
<b>INVERTEBRATES</b>
<i>Eleodes armata</i> (desert skunk beetle)**
<i>Apodemia mormo</i> (metalmark butterfly)
<i>Callophrys perplexa</i> (green hairstreak butterfly)
<i>Pepsis</i> spp. (tarantula hawk)
<b>AMPHIBIANS &amp; REPTILES</b>
<i>Hyla cadaverina</i> (California treefrog)
<i>Phrynosoma coronatum</i> (coast horned lizard)
<i>Masticophis lateralis</i> (California whipsnake)
<i>Crotalus mitchellii</i> (speckled rattlesnake)
<b>BIRDS</b>
<i>Salpinctes obsoletus</i> (rock wren)
<i>Chamaea fasciata</i> (wrentit)
<i>Sitta pygmaea</i> (pygmy nuthatch)
<i>Strix occidentalis</i> (California spotted owl)
<b>MAMMALS</b>
<i>Perognathus longimembris</i> (little pocket mouse)
<i>Dipodomys agilis</i> (Pacific kangaroo rat)
<i>Dipodomys merriami</i> (Merriam's kangaroo rat)
<i>Neotoma macrotis</i> (large-eared woodrat)
<i>Ammospermophilus leucurus</i> (Antelope ground squirrel)
<i>Odocoileus hemionus</i> (mule deer)
<i>Taxidea taxus</i> (American badger)
<i>Puma concolor</i> (mountain lion)
** Indicates insufficient data to model species.

Because of the anticipated increase in traffic volume, the county has proposed to build a wildlife crossing structure on Tamarack Rd, opposite the existing eastern set of structures under I-10, railroad, and southern frontage Rd (Figure 1.3). The proposed structure is 24 ft (7.3 m) wide and 7 ft (2.1 m) high. The proposed length of the structure (road width) is 43 ft (13.1 m) which anticipates the potential future widening of Tamarack Rd from two to four lanes (about 10 ft (3.0 m) per lane).

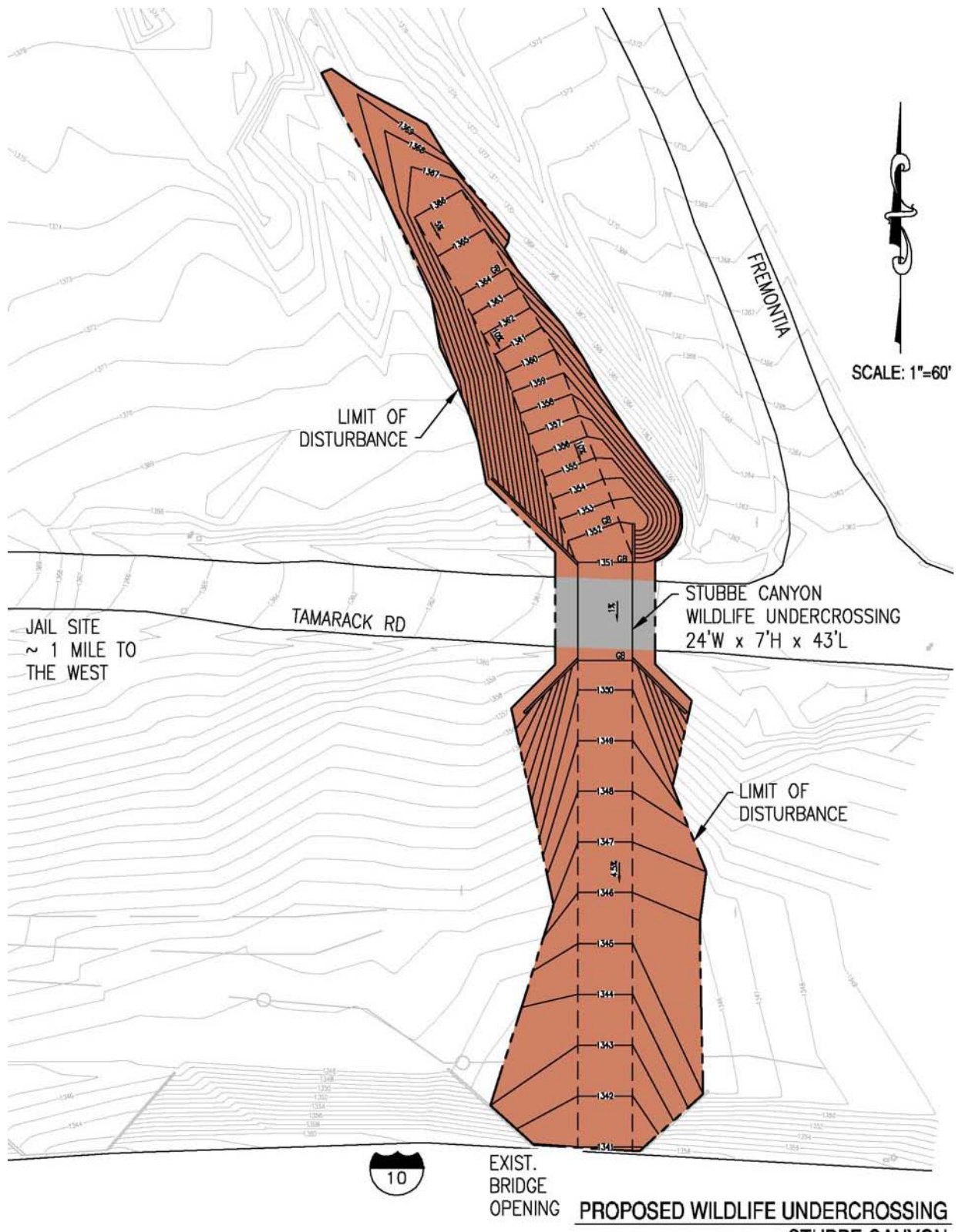


Figure 1.3: Proposed design of the wildlife crossing structure on Tamarack Rd (LSA, 2010). Reprinted with permission from LSA Associates, Inc. and County of Riverside.

Katie O'Connor (Friends of the Desert Mountains) and Bill Havert (Coachella Valley Mountains Conservancy) invited Dr. Marcel Huijser of the Western Transportation Institute at Montana State University to give a presentation at a workshop "Stubbe Wildlife Movement Corridor Stakeholders' Workshop" and provide advice on the proposed crossing structure on Tamarack Rd. The workshop took place on 27 October 2010 and was sponsored by Friends of the Desert Mountains, with grant funding from Southern California Edison. This report provides advice with regard to potential wildlife mitigation associated with transportation infrastructure in the Coachella Valley in general and the Stubbe corridor in specific.

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## 2. GENERAL RECOMMENDATIONS

### 2.1. Strategic Framework Based on Population Viability Analyses

There are three general approaches to maintaining or restoring viable populations (of selected species) in the valley and surrounding mountain ranges:

1. **Strategic:** you know where core areas and corridors need to be improved, maintained, or established and by how much. You go about these improvements in a logical manner, conducting the work in a certain order so that it always results in the greatest possible benefits. For example, improvement A may have much greater benefit than improvement B, or improvement B only makes sense once improvement A has been implemented also, thus you implement improvement A before improvement B. This approach requires the ability to fully control the efforts aimed at maintaining or restoring viable populations; i.e. a specific program with associated funding needs to be in place and needs to be administered strategically.
2. **Opportunistic within a strategic framework:** You know where core areas and corridors need to be improved, maintained, or established and by how much. However, the order in which the improvements are implemented depends largely on external conditions. For example, while improvement A may have much greater benefit than improvement B, or while improvement B only makes sense once improvement A has been implemented also, you may still implement improvement B when the opportunity presents itself, regardless of whether improvement A has been implemented already.
3. **Opportunistic without a strategic framework:** You do not know where core areas and corridors need to be improved, maintained, or established or by how much. The order in which the improvements are implemented depends largely on external conditions. You implement improvements whenever an opportunity presents itself, but you do not know if and how much the improvements will ever really contribute to maintaining or restoring viable populations.

The strategic framework could be the result of a series of population viability analyses for selected species. If we restrict ourselves to reducing the negative impacts of roads, railroads, and traffic on wildlife populations, we need to know how many safe crossing opportunities should be provided for, at what locations, what type, and what dimensions, and whether and where they should be combined with wildlife fencing. Population viability analyses can help answer these questions. For example, one can compare different scenarios (different levels of mitigation) and compare their effect on the population viability of selected species. Possible scenarios are:

1. The current situation, without mitigation;
2. The projected future situation with increased roads, road widths, and traffic volume, without mitigation;
3. A theoretical scenario where roads and traffic are absent (compared to the first two scenarios this then demonstrates the effect of roads and traffic), and;

4. Different scenarios for the current and/or projected situation with different levels of mitigation (vary the number, location, type, and dimensions of the safe crossing opportunities and associated mitigation measures). One can then compare the effectiveness of the scenarios with different levels of mitigation to a management goal. A management goal could be to have 95% probability that a population of a certain species will persist over the next 500 years. In areas that are of particular importance, for example a network that includes a national park, one may be less tolerant to potential extinction events; e.g. one may have a goal to have 99% probability that a population of a certain species will persist over the next 1,000 years. Again, the purpose of the analyses is to be able to compare the relative benefit of different combinations of mitigation measures in terms of their contribution to maintaining or restoring viable populations of selected species. The outcome of the analyses directly relate to management goals for the selected species, and one can change the level of mitigation, or adjust the management goals in an iterative process until one obtains an acceptable management goal with a realistic mitigation plan. For example, one can adjust the level of mitigation until the outcome of the population viability analyses meets the management goals. On the other hand, if one knows what set of mitigation measures can be realistically achieved, one can adjust the management goals accordingly, but then it is also clear what that means with regard to accepting certain probabilities of local or regional extinction for selected species. In summary, population viability analyses can help you decide on the number, location, type, and dimensions of the mitigation measures and should be considered a decision support tool that provides a strategic framework.

## 2.2. Collect Data in the Field

Specific consulting is required to decide on what species the population viability should be conducted for and if the required data are available (e.g. data on population size, demographics etc.). Regardless of what data may or may not be needed and available, and whether population viability analyses can be conducted, the following types of data can help you decide on specific locations for mitigation measures:

- a. Road mortality data: These data show what species are killed on the road(s) or railroads, in what numbers, and where. They show you where the animals cross the road(s) or railroad(s) unsuccessfully and where collisions occur. This type of data directly relates to human safety and is often collected by transportation agencies or other road management entities (carcass removal data for large mammals) and highway patrol (crash reports). However, the public can also contribute data on road killed animals, including through web based reporting systems.
- b. Observations of animals seen alive on or near roads and railroads: These data show where animals may want to cross road(s) or railroad(s) or where they cross them successfully. Note that these locations may be different from locations based on road mortality data. This type of data has a more direct relation to habitat connectivity and conservation goals and is typically not collected by transportation agencies. However, the public, especially

local residents or commuters) can help collect this type of information using a range of methods, including submitting observations through a website into a centralized database.

It is important to include observations of animals seen alive on or near road(s) and railroads in any decision process as one should avoid blocking animal movements (e.g. through wildlife fencing) on locations where animals may cross the road(s) or railroad(s) successfully with no or little road mortality.

Once safe crossing opportunities are in place (e.g. wildlife underpasses), one may monitor which animal species use the structures in what number. Traditional methods (e.g. tracking, photo cameras) typically cannot distinguish between individuals. For example, 10 passages can result from 10 individuals each passing once, or one individual passing 10 times. If genetic samples can be obtained (e.g. hair follicle samples through barbed wire or tape), one can tell the individuals apart and it also shows the gender of the individuals involved (not the age though). Note that wildlife use of the safe crossing opportunities is likely to increase in the first few years after construction as the animals may need time to learn about their location and get comfortable using them.

If one collects data on the presence and abundance of different species in the areas adjacent to safe crossing opportunities, one can compare the presence and abundance (or passage rate) to that of the safe crossing opportunities to place the use of the crossing opportunities in perspective. If genetic samples are obtained from both sides of a road or railroad, one can measure whether the presumed barrier effect of the transportation infrastructure has resulted in genetic differences. The larger the genetic differences, the more likely it is that the transportation infrastructure is a substantial barrier to the movements of that species. Note that there may be a delayed effect. It takes multiple generations of genetic isolation to develop genetic differences. In other words, a recently built road may be an absolute barrier, but insufficient time may have passed to have that barrier effect result in genetic differences between the animals on either side of the road. Note that genetic differences are not necessarily detrimental, at least not on the short term. Genetic diversity is generally good as it may allow a population of a species to better cope with changing circumstances (e.g. resistance against a disease) and be more fertile (lack of genetic diversity can sometimes affect fertility). However, the presence of genetic differences is not necessarily the same as a lack of genetic diversity, and lack of genetic diversity is not necessarily an immediate threat to the viability of a population. The viability of a population is largely dependent on its effective population size. Most species face local or regional extinction because of small and isolated populations rather than a lack of genetic diversity. Thus data on the potential genetic differences of individuals that live on either side of the road are mostly a useful tool to show the presence and degree of potential isolation.

### 3. SPECIFIC RECOMMENDATIONS

#### 3.1. Location

The barrier effect of Tamarack Rd is likely to increase as a result of growing traffic volume and perhaps eventual widening from two to four lanes. In that context, animal movements through the existing structures may be affected, increasing the overall barrier effect of the roads and railroad on that location. The proposed structure on Tamarack Rd can help reduce the barrier effect of Tamarack Rd. However, it is important to be aware of the fact that this is an opportunistic approach, taking advantage of the existing structures under I-10, the railroad, and the southern frontage road, anticipated changes in traffic volume and road width of Tamarack Rd, and a wish to mitigate for this anticipated increase in barrier effect. It is not based on a strategic approach that would ensure the minimum number, location, type, and dimensions for safe crossing opportunities in the Stubbe Canyon corridor. In this case the location is determined by the presence of the existing structures and the wash (hydrology) rather than current or potential animal movements. With regard to the location, one may consider the following parameters:

1. Place the proposed structure opposite of the eastern structures as they have greater dimensions than the western structures. However, note that based on preliminary data, the western structures currently receive greater wildlife use than the eastern structures (Personal comment Michelle Murphey, graduate student researcher, Center for Conservation Biology, University of California, Riverside), perhaps because of human disturbance (see later).
2. Place the proposed structure so that the animals that approach the structure can see through the structure or set of structures.
3. Place the proposed structure so that water is likely to flow through the structure in case of (relatively rare) flooding events (i.e. place it in an existing channel of Stubbe Canyon wash).

#### 3.2. Number

If possible, consider placing a second structure for Tamarack Rd opposite of the western structures. This will help allow the existing wildlife use of the western structures to continue.

#### 3.3. Type

Considering the nature of the terrain and the occasional flooding event, an underpass seems more appropriate than an overpass. Animal detection systems can be considered for at grade crossings for large species on a low volume road, but these systems do not benefit small species or species that avoid open areas or unnatural substrate (e.g. asphalt). In addition, animal detection systems should still be considered experimental.

#### 3.4. Dimensions

The proposed structure is 24 ft (7.3 m) wide and 7 ft (2.1 m) high (measured from the animal's perspective). The proposed length of the structure (width of the road) is 43 ft (13.1 m) which anticipates the potential future widening of Tamarack Rd from two to four lanes (about 10 ft

(3.0 m) per lane). The openness of the structure is  $(W*H)/L = (7.3 * 2.1)/13.1 = 1.17$ . The target species (see Table 1.1) that is most demanding with regard to the dimensions of a wildlife underpass is mule deer. The recommendations for the minimum dimensions of an underpass for mule deer are:

- a. 14 ft (4.3 m) wide, 14 ft (4.3 m) high, openness ratio  $\geq 0.6$  (Reed et al., 1975).
- b. 8 ft (2.4 m) tall and 20 ft (6.1 m) wide, openness ratio  $\geq 0.8$  (Gordon & Anderson, 2003).
- c. 20-40 ft (7–12 m) wide, 10-15 ft (4.0–4.5 m) high (Clevenger & Huijser, 2009).

When we compare the proposed dimensions of the structure to the recommended minimum dimensions for mule deer, it appears that the height of the proposed underpass is too low. A minimum height of 8 ft (2.4 m) is recommended, but as the length (road width) of an underpass increases, one may consider increasing the height (and width) of the underpass further. Note that an underpass with a height of 7 ft (2.1 m) may still be used by a variety of the target species, including mule deer, but that the dimensions, especially the height, are smaller than what is recommended for a wildlife underpass that includes mule deer as a target species. Another approach may be to make the structure the same dimension as the largest existing structure under I-10, the railroad and the southern frontage road. The result of this approach would then be that the structure on Tamarack Rd would not be the limiting factor for animals trying to cross the roads and the railroad at this location.

### 3.5. Habitat

It is not sufficient to build enough safe crossing opportunities at the right locations with the right dimensions. The habitat leading up to and inside the crossing structures should also encourage the target species to use the structure. The following is an example of how one could approach this considering the target species. For the target plant species one may consider the dispersal methods for the species (e.g. seed transport through wind, water, specific animal species). This may provide clues for the desired habitat leading up to and inside the crossing structure. Invertebrates, amphibians, reptiles, and small mammals generally require cover and transition zones between cover and more open habitat. Cover can be provided in the form of rows of rocks, tree stumps, litter or branches (depending on what natural cover may be present in the surrounding area) (Figure 3.1). In this specific situation where there may be occasional high water flow through the structure, consider making the cover robust enough so that it does not wash away after the first flooding event. On the other hand the cover should not block the waterflow either as that can threaten the integrity of the road bed. Also consider providing attractive habitat for the target species in the other (existing) structures and in the areas between the structures to improve the overall passage rate of the animals under the roads and railroad. Amphibians require water, at least seasonally, and providing water may even result in breeding opportunities inside or near the structure.





Figure 3.1: A row of tree stumps provides cover for invertebrates, amphibians, reptiles, and small mammals inside a modified underpass originally build for traffic alone under a motorway (Copyright: Marcel Huijser). Note that vegetation grows where there is sufficient light and moisture, including in the median in between the two structures (one structure per travel direction).

### 3.6. Co-use by Humans

In general, human co-use is negatively associated with wildlife use of crossing structures. Therefore, if possible, it is preferable to not have human use of wildlife crossing structures. On the other hand, relatively few crossing structures have been built that are exclusively for wildlife, and it may be wise to look for other partners in society that also need to cross major infrastructure, especially for partners that promote non-motorized travel (pedestrians, bicycles, horses, livestock). In general, if we are dealing with a multifunctional landscape with considerable human disturbance present in area, and a target species that is not very sensitive to human disturbance, and perhaps even thrives with a certain level of human disturbance, shared use may be considered. Separate structures for wildlife and human co-use are advised when dealing with important or sensitive ecological areas and target species that are sensitive to human disturbance. If human use is combined with wildlife use, it is advisable to locate the path for humans (and their potential vehicles) on one side of a structure rather than in the middle. This minimizes the disturbance associated with the human use.

### **3.7. Fencing**

While fencing alone can substantially reduce wildlife road mortality, it is generally considered bad practice to increase the barrier effect of roads and traffic without also providing for sufficient safe crossing opportunities. The use of fences alone, without safe crossing opportunities, is especially discouraged when the population size of a species is stable or increasing or if it is known that the animals need access to resources on both sides of the road decline (Jaeger & Fahrig, 2004). On the other hand, fences are recommended when the traffic volume is so high that animals almost never succeed in their attempts to cross the road, or when the population of the species of concern is declining and high traffic mortality is known to contribute to the decline (Jaeger & Fahrig, 2004). When fences are combined with a sufficient number of safe crossing opportunities (not too far apart), of the right type, in the right locations, and of the right dimensions, fences not only help reduce direct road mortality, but they can also help guide the animals towards the safe crossing opportunities. When fencing over shorter or greater length is considered, treat the roads and railroad as a transportation corridor rather than individual roads or railroads. In other words, fence the north side of Tamarack Rd, and the south side of the southern frontage road, and make sure the animals fully cross all the western or eastern structures and do not end up in the median of I-10, or in the space between the roads and railroad.

#### 4. REFERENCES

- Clevenger, A.P. & M.P. Huijser. 2009. Handbook for Design and Evaluation of Wildlife Crossing Structures in North America. Department of Transportation, Federal Highway Administration, Washington D.C., USA. Available from the internet: [http://www.westerntransportationinstitute.org/documents/reports/425259\\_Final\\_Report.pdf](http://www.westerntransportationinstitute.org/documents/reports/425259_Final_Report.pdf)
- Gordon, K.M. & S.H. Anderson. 2004. Mule deer use of underpasses in Western and Southeastern Wyoming. In: Proceedings of the 2003 International Conference on Ecology and Transportation, Eds. C.L. Irwin, P. Garrett & K.P. McDermott. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC: pp. 309-318.
- Jaeger, J.A.G. & L. Fahrig. 2004. Effects of road fencing on population persistence. *Conservation Biology* 18 (6): 1651–1657.
- LSA. 2010 Biological resource assessment and CVMSHCP consistency analysis with focused survey for the desert tortoise and burrowing owl and jurisdictional delineation. Stubbe Canyon wildlife undercrossing Riverside County Regional Detention center Project. County of Riverside, California. LSA Associates, Inc., Palm Springs, USA. Available from the internet: <http://saferstreets.countyofriverside.us/docs/nop2010/Stubbe%20Canyon%20Biological%20Resources%20Assessment.pdf>
- Penrod, K., C. Cabanero, P. Beier, C. Luke, W. Spencer & E. Rubin. 2005. South coast missing linkages project: A linkage design for the San Bernardino-San Jacinto connection. South Coast Wildlands, Idyllwild, CA, USA. Available from the internet: [www.scwildlands.org](http://www.scwildlands.org)
- Reed, D.F., T.N. Woodard & T.M. Pojar. 1975. Behavioral response of mule deer to a highway underpass. *Journal of Wildlife Management* 39 (2): 361-367.