California Amphibian and Reptile Crossing Preliminary Investigation

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July 17, 2013

Executive Summary

Background

The efficacy of highway crossings for herptiles (the term that encompasses both reptiles and amphibians) is not as well documented as the efficacy of highway crossings for other species, such as mammals and fish. This is due, in part, to the lack of documentation and reliable data on herptile crossings. In 2012, a Preliminary Investigation was conducted entitled *Highway Crossings for Herptiles (Reptiles and Amphibians)*.[1] It summarized the key issues relevant to the design and best practices of herptile crossings. This Preliminary Investigation builds upon that report, focusing on 18 herptile species of particular interest in California.

The effectiveness of a herptile crossing depends on the life histories and environment of the animals who will use it. Crossings should be only one component of mitigation efforts designed to minimize the effects of the "Road Zone" -- the altered area in and around roadways. Research has shown that animal reproduction is affected, not only by isolation, but by the changed environment created by the "Road Zone." Ditches, culverts, and tire grooves can create unsuitable breeding grounds that stifle offspring yield.[2]

Summary of Findings

Detailed habitat documentation and life histories are available for some of California's endangered and threatened herptile species. This investigation begins the process of grouping potential crossing strategies, based on species life histories. But to conclusively measure the efficacy of a crossing treatment for a given population, actual experimentation and data collection is necessary.

Researchers from New York State conducted such tests for the state's 67 herptile species, and used the resulting data to develop models to identify potential crossing "hot spots" -- places

[1] *Highway Crossings for Herptiles (Reptiles and Amphibians)*; Caltrans Preliminary Investigation; November 2012; http://www.dot.ca.gov/newtech/researchreports/preliminary_investigations/docs/herptile_highway_crossings_pi2012-11-2.pdf

[2] "Ecological Effects of Roads Infrastructure on Herpetofauna: Understanding Biology and Increasing Communication"; Andrews, K.M. and Jochimsen, D.M.; *Recent Work*, Road Ecology Center, John Muir Institute of the Environment, UC Davis; May 2007

[2] http://escholarship.org/uc/item/8d73q0mj

herptiles were most likely to use as a crossing.[3] The team focused on minimizing road mortality at crossings. (While crossing location can play role, it was beyond the scope of the study.) While the effect of road mortality can significantly impact a species population, isolation is a larger concern for roads that bisect local herptile populations. Landscape fragmentation occurs when roads separate a group from its breeding grounds, hibernation locations, or adult habitats.[4] The roads themselves may not directly cause mortality, but the disruption in habitat has an impact on the ability of populations to survive and reproduce.

Herptile species often utilize general crossing treatments, such as viaducts or overpasses intended for mammals and other species. Amphibian/reptile tunnels have been recommended in locations where relatively high volumes of herptile crossings and a specific need already exist. Recommendations for herptile crossings from FHWA's *Handbook for Design and Evaluation of Wildlife Crossing Structures in North America*[5], and work from the Idaho Department of Fish and Game[6] describe the key characteristics of crossing structures. While every crossing is context sensitive, it is possible to make generalizations for herptiles specific to their unique locomotion modes.

Treatment	Features/Reasons
Tunnel	Allows periodic migration for breeding without crossing a roadway. Natural substrate is often critical for herptiles, making it more likely they would use the tunnel (as opposed to bare concrete or metal). Wider tunnels allow for more natural light and airflow.
Stream Crossing	Amphibians often need water and moisture to successfully cross, just as in the natural environment.
Drift Fence	Acts as a barrier to prevent critters from crossing a roadway. Guides them to the designated crossing structure.
Natural Light	Some herptiles cross during the day or by moonlight; natural light is an important factor of their migration. Wide tunnels that allow some natural light and grating overhead are critical to maintain that environment.
Area Closure	Closes the area from use by humans to allow herptiles to migrate seasonally without threat from people.

[3] *Effects on New York State Roadways on Amphibians and Reptiles: A Research and Adaptive Mitigation Project*; Gibbs, J.P *et al*; State University of New York College of Environmental Science and Forestry Department of Environmental and Forest Biology; March 2011; http://www.utrc2.org/sites/default/files/pubs/effects-nys-roadways-reptiles-final_0.pdf

[4] "Effects of Habitat Fragmentation and Road Density on the Distribution Pattern of the Moor Frog Rana arvalis"; Vos, C.C. and Chardon, J.P.; *Journal of Applied Ecology*; no. 35, 1998; http://www.jstor.org/stable/2405186

[5] *Wildlife Crossing Structure Handbook: Design and Evaluation in North America*; Clevenger, A.P. and Huijser, M.P.; FHWA; March 2011;

[5]http://www.cflhd.gov/programs/techdevelopment/wildlife/documents/01_Wildlife_Crossing_Structures_Handbook.pdf

[6] *A Literature Review of the Effects of Roads on Amphibians and Reptiles and the Measures Used to Minimize Those Effects*; Jochminsen, D.M. *et al*; Idaho Department of Fish and Game; 2004; http://fishandgame.idaho.gov/public/wildlife/collisionAmphibRep.pdf

The following matrix shows recommended crossing strategies for the 18 herptile species of interest. Potential strategies were identified from the *Handbook for Design and Evaluation of Wildlife Crossing Structures in North America*. Specific strategies recommended for each species are a result of research on the individual life histories and habitats of the herptiles of interest, based on information found in environmental documentation from the U.S. Fish and Wildlife Service's Recovery Plans (via the Environmental Conservation Online System[7]), the California Department of Fish and Wildlife's "Threatened and Endangered Species" portal,[8] and life sciences research databases, such as BIOSIS and PLOS One.

Crossing Strategies for California Herptile Species of Interest

Species	Tunnel	Stream Crossing	Drift Fence	Natural Light	Area Closure
Arroyo Toad	●	●	●		
Yosemite Toad	●	●	●		
Western Spadefoot	●	●	●	●	
California Red-Legged Frog		◯			●
Southern Mountain Yellow-Legged Frog					●
Sierra Nevada Yellow-Legged Frog					●
Western Pond Turtle	●		●		
Southern Rubber Boa					
Rosy Boa					
California Tiger Salamander	●	●	●		
Santa Cruz Long-Toed Salamander	◯		●		
Coast Range Newt	●	●		◯	
Western Skink					
San Joaquin Coachwhip					
Alameda Whipsnake					
California Mountain Kingsnake					
Ring-Necked Snake	◯				
Giant Garter Snake	◯				

● - Recommended/Optimum Solution ◯ - Possibly effective, if tailored for local environment

[7] "Environmental Conservation Online System"; U.S. Fish and Wildlife Service; http://ecos.fws.gov/

[8] "Threatened and Endangered Species"; California Department of Fish and Wildlife http://www.dfg.ca.gov/wildlife/nongame/t_e_spp/

The most recommended crossing strategy is tunnels or stream crossings with a natural substrate. Guide fencing is frequently recommended to complement these treatments and ensure that the tunnels and stream crossings are used by the herptiles. Fencing must be made of an opaque, smooth fabric, constructed at a minimum height of 1.25 ft. so herptiles cannot climb over it.[9]

For some species of reptiles, paved roads can be attractive areas for basking. For others, paved roads disrupt the thermal environment and lead to population fragmentation. Some species, such as the Arroyo Toad[10], find dirt roads enticing to cross[11] or suitable for burrowing,

Based on the survey of California herptiles of interest, it is apparent that roads and highways are just one type of development threatening herptile populations. Encroaching land development, such as housing subdivisions, and recreational areas, particularly those used for off-highway vehicles or camping, are also problematic. In addition, considerable damage has been done to herptile populations as a result of environmental pollution, including mercury contamination from abandoned mines.[12] In these scenarios, the most direct mitigation strategy is to simply close down the area to human use during the migratory periods.

For species, such as the Southern Mountain Yellow-Legged Frog and the Sierra Nevada Yellow-Legged Frog, the spread of disease within the population is an even greater threat to their survival than roads or subdivisions.[13] Fungal infections and pesticides also adversely affect herptile populations. In addition, the threat of introduced fish and wildlife species that prey on or compete with native herptile species is another pressing issue. California Red-Legged Frogs are being threatened by introduced species, such as bullfrogs, trout, and crayfish, all of which are well suited to the habitat. These foreign species introduce new diseases to the local habitat.[14] The introduction of the American Bullfrog (*Rana catesbeiana*) to the Sierra foothills has resulted in increased competition for food and resources with Yellow-Legged frogs, which are native to the area. American Bullfrogs are well suited to man-made environs, such as artificial streams[15], and are therefore thriving in that habitat.

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[9] *Wildlife Crossing Structure Handbook: Design and Evaluation in North America*; Clevenger, A.P. and Huijser, M.P.; FHWA; March 2011; http://www.cflhd.gov/programs/techdevelopment/wildlife/documents/01_Wildlife_Crossing_Structures_Handbook.pdf

[10] *Arroyo Toad 5-Year Review: Summary and Evaluation*; U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office; August 2009 http://www.biologicaldiversity.org/species/amphibians/arroyo_toad/pdfs/5_year_review_5-21-10.pdf

[11] *Responses of Small Terrestrial Vertebrates to Roads in a Coastal Sage Scrub Ecosystem*; Brehme, C.S.l San Diego State University; 2003; http://roadecology.ucdavis.edu/pdflib/TTP_289/W08/Roads_Thesis_CSB_Final.pdf

[12] "Mercury contamination in three species of anuran amphibians from the Cache Creek Watershed, California, USA"; Hothem, R.L, Jennings, M.R. and Crayon, J.J.; *Environmental Monitoring and Assessment*; April 2010, v. 163, no. 1-4, pp 433-448; http://dx.doi.org/10.1007/s10661-009-0847-3

[13] "Dynamics of an Emerging Disease Drive Large-Scale Amphibian Population Extinctions"; Vrendenburg, V.T. *et al*; *PNAS*, v.107 no.21, 2010; http://www.pnas.org/content/107/21/9689.short

[14] http://www.epa.gov/espp/litstatus/effects/redleg-frog/attachment1.pdf

[15] "Linking the Distribution of an Invasive Amphibian (*Rana catesbeiana*) to Habitat Conditions in a Managed River System in Northern California"; Fuller, T.E. et al; *Restoration Ecology*, v. 19, no. 201, pp 204–213, March 2011; http://dx.doi.org/10.1111/j.1526-100X.2010.00708.x

Gaps in Findings

To date, very little research exists describing the direct impact of roads on the 18 California species of interest. While a handful of articles reference the current state of these herptile populations with some conjecture about the effects of roads and population fragmentation, they did not offer viable solutions or mitigation strategies.

Not all the species examined are officially labeled as endangered, and therefore are not protected under existing U.S. Fish and Wildlife Service recovery plans. In addition, because very little information exists about the life histories and habitats of some of these herptile species, it is difficult to deduce the actual impact of human development upon them. While some of the examined species have such local and contained habitats, it might be relatively straightforward to minimize and mitigate impact upon them. Other species that have forage in wider ranges and therefore are more likely to come in contact with man-made development will require more consideration.

Next Steps

When implementing new herptile crossings, documenting and collecting data to assess the efficacy of the crossings is important. This data can be used to develop models to better predict crossing hot spots and future survival strategies. For species where little or no information is available that documents their life histories and habitats, collecting that data would be a good initial step.

Herptile Life Histories

The 18 California herptile species of interest identified by Caltrans for this Preliminary Investigation are the following:

Arroyo Toad (*Anaxyrus californicus*)	Yosemite Toad (*Anaxyrus canorus*)	Western Spadefoot (*Spea hammondii*)	Southern Mountain Yellow-Legged Frog (*Rana muscosa*)
Sierra Nevada Yellow-Legged Frog (*Rana sierrae*)	California Red-Legged Frog (*Rana draytonii*)	Western Pond Turtle (*Actinemys marmorata*)	Western Skink (*Plestiodon skiltonianus*)
Southern Rubber Boa (*Charina umbratica*)	Rosy Boa (*Lichanura trivirgata*)	California Tiger Salamander (*Ambystoma californiense)*	Santa Cruz Long-toed Salamander (*Ambystoma macrodactylum croceum*)
Coast Range Newt (*Taricha torosa*)	San Joaquin Coachwhip (*Masticophis flagellum ruddocki*)	Alameda Whipsnake (*Masticophis lateralis euryxanthu*s)	Ring-Necked Snake (*Diadophis punctatus*)
California Mountain Kingsnake (*Lampropeltis zonata*)	Giant Garter Snake (*Thamnophis gigas*)		

The life histories and habitats of the concerned species were collected to make grouping and classification of effective crossings more apparent. None of the species of interest have been formally studied with regard to the effect of road zones on their populations. For species designated as endangered or threatened by the U.S. Department of Fish and Wildlife, the recovery plan was examined to see if it included any recommendations related to roads or vehicles. Species still under review do not yet have recovery plans and are not as well documented as those currently classified as Not Listed. Documented road interactions are also mentioned, as well as any noted mitigation strategies. These life histories help inform possible crossing strategies for specific herptile populations.

Arroyo Toad (*Anaxyrus californicus*)[16]

Status	Endangered (Federal) Special Concern (California)
Location	Los Angeles, Monterey, Orange County, Riverside, San Bernardino, San Diego, Santa Barbara, Ventura Counties.
Road Interactions	Threats from human development and off-road vehicles. Nighttime crossing and foraging on paved roads (particularly on rainy nights) leads to high mortality. Burrowing in dirt roads is a problem as they are crushed by traveling vehicles.
Crossings/Mitigation	Replacing culverts with stream crossings, adding roadside fences, and seasonal closing of campgrounds have led to greater breeding success.
Breeding	February to July in streams with persistent water. Slow moving, shallow streams and riparian habitats. Streams must be large enough for channel scouring.
Eggs/Tadpoles/Metamorphosis	Hatching occurs in 4-5 days. Substrate is sand or silt. Immobile for another 5-6 days, then disperse into shallow water for 10 weeks. Feed on loose organic material (algae).
Young Adult	Hangs out on the gravel on outsides until ponds dry out. Feeds on ants (and maybe beetles).
Adult	Feeds on insects and arthropods. Live in upland areas during non-breeding seasons; burrows in sand.

[16] *Arroyo Toad 5-Year Review: Summary and Evaluation*; U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office; August 2009 http://www.biologicaldiversity.org/species/amphibians/arroyo_toad/pdfs/5_year_review_5-21-10.pdf

[16] *Recovery Plan for the Arroyo Southwestern Toad*; U.S. Fish and Wildlife Service; 1999; http://ecos.fws.gov/docs/recovery_plan/990724.pdf

Yosemite Toad (*Anaxyrus canorus*)[17]

Status	Proposed Threatened (Federal) Special Concern (California)
Location	El Dorado, Fresno, Inyo, Madera, Mono, Tulare Counties.
Road Interactions	*No information.*
Crossings/Mitigation	Culverts, stream crossings, and fencing in some areas.
Breeding	Mating is polygynous, mid-April to mid-July, depending on local conditions. Eggs laid in shallow, quiet pools, in wet meadows, or shallow tarns surrounded by forest.
Eggs/Tadpoles/Metamorphosis	Laid in shallow pools or tarns. Compete for space with *Hyla regilla*, *Rana muscosa*, and *B. boreas*. Feed on bottom detritus, suspended plant material, or planktonic animals.
Adult	Diurnal. Lives in moist microclimates. Migration can be extensive. Hibernation in meadow sod or vegetation. Quiet pools in alpine meadows is optimal habitat. Diet includes beetles, ants, mosquitoes, dragonfly nymphs, centipedes, and spiders.

[17] "Yosemite Toad" A033; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; 2000; https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=18167
[17] *Arroyo Toad (Anaxyrus californicus) Life History, Population Status, Population*
[17] *Threats, and Habitat Assessment of Conditions at Fort Hunter Liggett, Monterey*
[17] *County, California*; Hancock, J.P.; California Polytechnic State University, San Luis Obispo; 2009;
[17] http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1222&context=theses
[17] "Habitat Use by Yosemite Toads: Life History Traits and Implications for Conservation"; Morton, M.L. and Pereyra, M.E; *Herpetological Conservation and Biology* v. 5 no. 3; September 2010;
[17] http://www.herpconbio.org/Volume_5/Issue_3/Morton_Pereyra_2010.pdf
[17] "El Dorado County Integrated Natural Resources Management Plan-Phase I"; Sierra Ecosystem Associates; *Wildlife Movement and Corridors Report*; November 2010;
https://www.edcgov.us/Government/Planning/INRMP/A_-_Final_Draft_Wildlife_Rpt.aspx

Western Spadefoot (*Spea hammondii*)[18]

Status	Under Review (Federal) Special Concern (California)
Location	Throughout Central Valley, Coast Ranges, and coastal lowlands from San Francisco Bay toward Mexico.
Road Interactions	Sometimes they cross roads at night during migration periods. The balance between urban development and open spaces greatly affects them.
Crossings/Mitigation	Undercrossings and stream crossings that have natural substrate and ambient light. Fencing for guidance and as a barrier.
Breeding	Breed January to May in temporary pools, drainage from spring rains. Water must be between 48-86 degrees F. Oviposition does not occur until the water is 48 degrees F. Eggs are deposited on twigs or detritus in pools.
Eggs/Tadpoles/Metamorphosis	Eggs hatch in 0.6-6 days depending on the water temperature. Half the eggs often fail to develop, perhaps due to fungus in the water. Feed on planktonic animals and algae.
Young Adult	Once they leave the natal pool, their habits are similar to that of adults.
Adult	Feeds on variety of insects, worms, and invertebrates. Active nocturnally during period of rain or high humidity. Remains in burrows during much of the year, but surface during first rains. Movement is restricted, at most several meters on rainy nights.

[18] "Western Spadefoot" A028; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; 2000; https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=18116
[18] *Appendix O Road Design Guidelines;* South Sacramento Habitat Conservation Plan; July 2010;
[18] http://www.per.saccounty.net/PlansandProjectsIn-Progress/Documents/SSHCPTOC/Appendix-O_Road%20Design%20Guidelines_final-mn.pdf

California Red-Legged Frog (*Rana draytonii*)[19]

Status	Threatened (Federal) Special Concern (California)
Location	Found in the Coast Ranges from Mendocino County southward and in portions of the Sierra Nevada and Cascade Ranges.
Road Interactions	Found on roads at night during winter and spring rains, which results in a high rate of mortality. Population fragmentation is also disruptive.
Crossings/Mitigation	Undercrossings and stream crossing may be appropriate. Recovery plans largely focus on preserving breeding grounds through area closures during breeding and migration seasons.
Breeding	Eggs laid in permanent pools with emergent vegetation. Breeding occurs January to July in the south; March to July in the north.
Eggs/Tadpoles/Metamorphosis	Tadpoles need 11-20 weeks to reach metamorphosis, typically between May and September.
Young Adult	Juveniles feed day and night.
Adult	Active year round on the coast. More inland populations are inactive during fall and winter. Prefers shorelines with vegetation, and water with depths of 3ft. or more for escape. Primarily nocturnal. There is little movement from the streamside habitats.

[19] "California Red-Legged Frog" A071; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; 2008 https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=17603

[19]"California Red-Legged Frog: *Rana aurora draytonii*"; Administrative Draft, Solano HCP; Solano County Water Agency; April 2009; http://www.scwa2.com/documents/hcp/Final%20Admin%20Draft/Appendix%20B/Inner%20Coast%20Range/California%20Red-legged%20Frog.pdf

[19]"Status and Life History of California Red-Legged Frog"; Environmental Protection Agency; 2007

[19]http://www.epa.gov/espp/litstatus/effects/redleg-frog/attachment1.pdf

Southern Mountain Yellow-Legged Frog (*Rana muscosa*)[20]

Status	Endangered
Location	Inyo, Los Angeles, Riverside, San Bernardino, San Diego, Tulare, Ventura Counties.
Road Interactions	Disturbance to the habitat during road construction is a threat. Pollution contaminating streams disrupts reproduction.
Crossings/Mitigation	Management and close monitoring of recreational trail crossings through the stream.
Breeding	Occurs from April or June/July and continues approximately 1 month. Egg masses vary in number from 15 to 350.
Eggs/Tadpoles/Metamorphosis	Laid in globular clumps, often flattened somewhat. Hatching time ranges from 18-20 days. Egg mass volume can average 198 cm. when close to hatching. Eggs have three firm jelly-like transparent envelopes surrounding a black vitelline capsule. Tadpoles are generally mottled brown in dorsal coloration with a golden tint/faintly-yellow underside. Tadpole lengths reach 72 mm. Diet includes benthic detritus and algae along rocky bottoms in streams. Metamorphosis variable and dependent on temperature. In low elevations it can occur in a single season; in higher elevations, it can take up to 3 years.
Young Adult	Reproductive maturity is reached when frogs are approximately 4 years old. Principally insectivorous, young adults feed on beetles, ants, bees, wasps, flies, true bugs, and dragonflies.
Adult	Principally insectivorous, but prefers terrestrial insects and adult stages of aquatic insects. Can be cannibalistic and consume the Pacific treefrog, tadpoles, and conspecific (?meaning eggs of multiple species?) eggs.

[20] *Mountain Yellow-Legged Frog 5-Year Review: Summary and Evaluation*; U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office; July 2013; http://ecos.fws.gov/docs/five_year_review/doc4001.pdf

Sierra Nevada Yellow-Legged Frog (*Rana sierrae*)[21]

Status	Endangered
Location	San Gabriel, San Bernardino, San Jacinto Mountains, Mount Palomar in San Diego.
Road Interactions	*No information.*
Crossings/Mitigation	Closing habitat to recreation may increase survival.
Breeding	Lasts from March to May. Males defend territory and make "advertising vocalizations" to females. Small egg masses of 15-300 eggs are deposited underwater where they attach to rocks, gravel, vegetation, or under banks.
Eggs/Tadpoles/Metamorphosis	Eggs hatch approximately 3 weeks after being laid. Tadpoles can reach lengths of 2.8 inches and are generally mottled brown with a golden tint and a "faintly yellow" ventral coloration. Feed on algae and diatoms along rocky bottom in shallows. Growth phase can last up to 4 years.
Young Adult	Sexual maturity is thought to be reached 3 years after metamorphosis.
Adult	Ranges in size from 1.5 to 3.25 inches. Belly and ventral surface of hind limbs are yellow to orange. Feeds on aquatic and terrestrial invertebrates, favoring terrestrial insects; also feeds on tadpoles.

[21] "Sierra Madre Yellow-Legged Frog" A044; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; 2008; https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=18017

[21] *California/Nevada Amphibian Population Task Force Presentation Abstracts;* California/Nevada Amphibian Population Task Force; January 2012; http://www.canvamphibs.com/APTF2012/APTF_2012_Final_Abstracts.pdf

Western Pond Turtle (*Actinemys marmorata*)[22]

Status	Under Review (Federal) Special Concern (California)
Location	Throughout California, west of the Sierra-Cascade crest; not found in desert regions (except in the Mojave Desert along the Mojave River).
Road Interactions	Urban development disrupts habitat, particularly nesting and basking areas.
Crossings/Mitigation	Undercrossings, along with fencing to guide them through the crossing, can help. Signage and education for drivers should also be considered.
Breeding	3-11 eggs are laid from March to August depending on local conditions.
Eggs/Hatchlings	Eggs are deposited in nests constructed in sandy banks along slow-moving streams. Nests are found in sandy to hard soil, usually 10 cm. deep. Nests must have high internal humidity for eggs to develop. Hatchlings may be subject to rapid death by desiccation if exposed to hot, dry conditions.
Young Adult	Sexual maturity is thought to be attained in about eight years.
Adult	Active all year where climates are warm; hibernate during cold season. Considered omnivorous with a diet that consists of pond lilies, beetles, fishes, frogs, and sometimes carrion.

[22] "Western Pond Turtle" R004; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; 2000; https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=18106

[22]"Survival of the Western Pond Turtle (*Emys marmorata*) in an urban California Environment"; Crayon, J.J., Pauly, G.B., Shaffer, H. B., and Spinks, P.Q.; *Biological Conservation* 113; 2003; http://digitalcommons.unl.edu/usgsstaffpub/526/

[22]*Conservation Assessment of the Western Pond Turtle in Oregon*; Barnes, S., Gervais, J., Holts, L., Horn, R., Rosenberg, D., Swift, R., Todd, L, Vesely, D., and Yee C.; November 2009;

[22]http://www.fs.fed.us/r6/sfpnw/issssp/documents/planning-docs/ca-hr-actinemys-marmorata-2009-11.pdf

[22] "Western pond turtle: biology, sampling techniques, inventory and monitoring, conservation and management. "; Bury, R. B., *et* al*; Northwest Fauna*; no. 7, 2012; Society for NorthwesternVertebrate Biology, Olympia, WA.

Southern Rubber Boa (*Charina bottae umbratica*)[23]

Status	Under Review (Federal) Threatened (California)
Location	Along Coast Ranges south to (nearly) Point Conception, Ventura; some species isolated in San Bernardino and San Jacinto Mountains.
Road Interactions	Majority of habitat in National Forest, and largely protected. Disruption due to human development, largely recreation, and off-highway vehicles. No real road interaction.
Crossings/Mitigation	*No information.*
Breeding	Breeding occurs from April to June.
Young	Live-born from late summer to late autumn. Number from 2 to 8. Are born in loose, well aerated soil, under surface objects, or within rotting logs.
Adult	Crepuscular during warm periods of spring, summer and autumn, with some nocturnal and diurnal activity. No activity during colder times. Diet consists of small mammals, lizards, and sometimes smaller snakes.

[23] "Rubber Boa" R046; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; 2002; https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=17981

[23]"Species Accounts- Reptiles", Threatened and Endangered Species; California Department of Fish and Wildlife; 2003; http://www.dfg.ca.gov/wildlife/nongame/t_e_spp/docs/2004/t_ereptiles.pdf

Rosy Boa (*Charina trivirgata*)[24]

Status	Not Listed (Federal) Special Concern (California)
Location	Throughout southern California, south of Los Angeles, from the coast of the Mojave Desert, along coastal areas.
Road Interactions	Roads interrupt their habitat, particularly for migration, though they typically stay in rocky areas away from roads.
Crossings/Mitigation	*No information.*
Breeding	Young are live-born with 6-10 in a brood.
Eggs/Young	Live-born; a quiet protected area is required.
Young Adult	Early in the season some may be crepuscular, but most are nocturnal.
Adult	Eats small rodents and birds (maybe lizards).

[24] "Rosy Boa" R047; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=17976

[24]"Highway Mortality of Snakes in the Sonoran Desert of Southern Arizona"; Lowe, C.H., and Rosen, P.C.; *Biological Conservation* v.68 no.2; 1994; "http://www.sciencedirect.com/science/article/pii/000632079490345X

California Tiger Salamander *(Ambystoma californiense)*[25]

Status	Endangered and Threatened (Federal) Threatened (California)
Location	From Sonoma County through the Central Valley (Yolo and Sacramento Counties) down to Tulare County. From the San Francisco Bay Area south to Santa Barbara.
Road Interactions	Roads have been linked to anthropogenic mortality. Low-road density is considered to be better suited for habitability, particularly if there is also sufficient ground cover. Divided highways are shown to cause high mortality.
Crossings/Mitigation	Proposed systems of guide fences, and undercrossings can reduce mortality. Viaducts and culverts (without rip rap) can be used as undercrossings.
Breeding	Eggs laid in vernal pools and other temporary rainwater pools in November to February. Some diurnal activity during breeding season only.
Eggs	Eggs are a laid on submerged or emergent vegetation or debris in shallow water. Larvae compete with other amphibian larvae, and are often the prey for wading birds (herons and egrets) and garter snakes. Larvae transform in late spring or early summer, usually by the first week of July.
Young Adult	Post-metamorphic juveniles disperse from breeding sites at night. They spend a few hours each day submerged in mud cracks or tunnels of soft soil, and then retreat to small-mammal burrows.
Adult	Adults live in subterranean refugia and occasionally in man-made structures most of the year. They emerge at night.

[25] "California Tiger Salamander" A001; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; 2005 https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=17607

[25]"Assessing Suitability for Conservation Action: Prioritizing Interpond Linkages for the California Tiger Salamander"; Pyke, C.R.; *Conservation Biology*, v.19, no. 2, pp. 492-503; http://dx.doi.org/10.1111/j.1523-1739.2005.00018.x

[25]"Highway Undercrossing Design for the California tiger salamander Highway Undercrossing Design for the California tiger salamander (*Ambystoma californiense*) in Santa Barbara County, California"; Kirkland, S. and Strohl, V.; 2011 International Conference on Ecology & Transportation, Seattle; 2011; http://www.icoet.net/ICOET_2011/documents/posters/CNT-P16-SKirkland-Poster-ICOET2011.pdf

Santa Cruz Long-Toed Salamander (*Ambystoma macrodactylum croceum*)[26]

Status	Endangered (Federal) Endangered (California)
Location	Monterey, Santa Cruz.
Road Interactions	Development disrupts habitat; roads break up migratory patterns and cause population fragmentation.
Crossings/Mitigation	Salamander tunnels have been used but are considered ineffective. Guide fencing might make the tunnels more effective.
Breeding	Breed in shallow freshwater ponds. Arrive in breeding ponds from November through March (mostly in January and February). A range of 215-411 eggs is laid.
Eggs/Larvae/Metamorphosis	Eggs are unattended by adults. Hatch 15-30 days into the aquatic larval stage. Larvae are unattended by adults. Feed on aquatic invertebrates, such as mosquito larvae, worms and larval amphibians (Pacific treefrogs and salamander larvae). Remain in pond until they reach 26 48 mm. in length. Extends from early May to late August but all larvae may metamorphose in a relatively short period of time if pond environment becomes unsuitable.
Adult	Length varies from 105-150 mm; weight, approximately 3-9.8 grams. Has dull orange or metallic yellow dorsal markings and a "sooty black" ventral surface. Forages on the soil surface for invertebrates, including isopods, beetles, slugs, and earthworms.

[26] "Santa Cruz Long-Toed Salamander Draft Revised Recovery Plan"; U.S. Fish and Wildlife Service; 1999
[26] http://ecos.fws.gov/docs/recovery_plan/990702.pdf

Coast Range Newt (*Taricha torosa*)[27]

Status	Not Listed (Federal) Special Concern (California)
Location	Coast ranges from central Mendocino County south to northern San Diego County, and from the peninsular ranges of San Diego to near Boulder Creek; some found near the Central Valley, Monterrey County and southward.
Road Interactions	Seen crossing roads during rainy weather.
Crossings/Mitigation	Modification of drainage tunnels can provide effective crossing cover.
Breeding	Occurs in intermittent streams, rivers, ponds, lakes and large reservoirs. Breeding and egg-laying from fall through late spring, depending on location. Migration to and from breeding occurs at night during, or just following, rains; sometimes on cloudy days.
Eggs/Younglings/Metamorphosis	Eggs laid in small clusters of emergent vegetation or underside of rocks in shallow water. Eats earthworms, snails, slugs, snowbugs, and insects. Larvae transform in summer or fall of their first year.
Young Adult	Inactive juveniles remain in moist areas.
Adult	Seeks cover under surface objects, such as rocks, logs, burrows, rock fissures, or man-made structures. Live in or near streams in foothill hardwood/hardwood-conifer habitats.

[27] "California Newt" A007; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; 2000; https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=1428

[27]"Supplement to The Project Information Sheet", Tehachapi Renewable Transmission Project (TRTP) Segment 6; California Water Boards; 2012; http://www.waterboards.ca.gov/water_issues/programs/cwa401/docs/certifications/edison/att_c.pdf

Western Skink (*Plestiodon skiltonianus*)[28]

Status	Not Listed (Federal) Special Concern (California)
Location	Tulare, Inyo, Kern Counties, throughout northern California, restricted to the Coast Ranges and southern mountains (excluding desert regions) in central and southern California.
Road Interactions	*No information.*
Crossings/Mitigation	*No information.*
Breeding	Nest chambers constructed in loose moist soil, several centimeters deep. Mating season varies by geography, usually in the spring after emergence.
Eggs/Younglings/Metamorphosis	In central California, eggs are deposited in July. Great Basin eggs are deposited in July and August. Clutch sizes range from 2-6.
Adult	Forages through leaf litter and dense vegetation. Feeds on insect eggs, adult and larval beetles, caterpillars, moths, spiders, grasshoppers, and other insects. Diurnal activity during warm season.

[28] "Western Skink" R036; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; 2000; https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=18114

San Joaquin Coachwhip (*Masticophis flagellum ruddocki*)[29]

Status	Not Listed (Federal) Special Concern (California)
Location	Southern half of Central Valley, eastern slopes of south Coast Range, isolated population in Sutter Buttes.
Road Interactions	*No information.*
Crossings/Mitigation	*No information.*
Breeding	Little known about nest sites - one recorded in highway drainage ditch approximately 1 foot from surface. Mating in April and May; eggs laid in June and July. Clutch range from 4-16 eggs.
Eggs/Younglings/Metamorphosis	Laid in June and July, young appearing in late August or early September.
Adult	Diet consists of rodents, lizards, snakes, birds, eggs, insects, and carrion. Seeks cover in rodent burrows, bushes, trees, and rock piles. Hibernates in soil or sand, approximately 1 foot below the surface. Diurnal. Active mid-morning to late afternoon from March through October.

[29] "Coachwhip" R052; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; 2000; https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=17640
[29]

Alameda Whipsnake (*Masticophis lateralis euryxanthus*)[30]

Status	Threatened (Federal) Threatened (California)
Location	Contra Costa, Alameda, San Joaquin, and Santa Clara Counties.
Road Interactions	Urban development has caused significant population fragmentation.
Crossings/MItigation	*No information.*
Breeding	Probably lays eggs in loose soil or under rocks or logs. Mates in early April. Clutch size 6-11 eggs.
Eggs/Younglings/Metamorphosis	
Adult	Feeds on variety of vertebrate prey. Forages on the surface, though occasionally climbs shrubs and small trees. Diurnal from March to November. Inactive rest of the year. Ectotherms, who bask for much of the day. They are non-migratory.

[30] "Striped Racer" R053; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; 1999; https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=17611

[30]"Endangered Species Facts: Alameda Whipsnake *Masticophius lateralis euryxanthus*"; Environmental Protection Agency; February 2010; http://www.epa.gov/espp/factsheets/alameda-whipsnake.pdf

[30]"Alameda Whipsnake (*Masticophis lateralis euryxanthus*)"; East Contra Costa County HCP/NCCP; 2006; http://www.co.contra-costa.ca.us/depart/cd/water/hcp/archive/final-hcp/pdfs/apps/AppD/08a_alawhipsnake_9-28-06_profile.pdf

Ring-necked Snake (*Diadophis punctatus*)[31]

Status	Not Listed (Federal) Special Concern (California)
Location	Widespread in California except in large portions of Central Valley, high mountains, desert areas, and regions east of Sierra-Cascade crest; found in Providence Mts. in San Bernardino.
Road Interactions	Observation has shown they are less likely to attempt road crossings than other species of snakes.
Crossings/Mitigation	*No information.*
Breeding	Eggs laid from April to July, depending on local conditions.
Eggs/Younglings/Metamorphosis	Laid in loose aerated soil, tailings, or rotted logs. Approximately 3 eggs at a time. Hatching occurs August to October.
Adult	Forages for earthworms, salamanders, newts, and treefrogs under rocks and other substrates. Diurnal, though day spent under surface objects. Common in open, relatively rocky areas within valley-foothill, mixed chaparral, and annual grass habitats.

[31] "Ringneck Snake" R048; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=17968

[31]"How Do Highways Influence Snake Movement? Behavioral Responses to Roads and Vehicles"; Andrews, K.M., and Gibbons, J. W.; *Copeia* v.4; 2005; http://www.naherpetology.org/pdf_files/456.pdf

California Mountain Kingsnake (*Lampropeltis zonata*)[32]

Status	Not Listed (Federal) Special Concern (California)
Location	Throughout the length of the Sierra and the Cascades, along Coast Range of California, in San Bernardino, San Gabriel, San Jacinto Mountains.
Road Interactions	*No information.*
Crossings/Mitigation	*No information.*
Breeding	Clutch sizes of 4-12 eggs.
Eggs/Younglings/Metamorphosis	Hatch late June to early October. No direct information where eggs are deposited; most likely aerated soil under rocks or in decaying trees.
Adult	Lives in or around rocks near stream beds or lake shores. Feeds on lizards, smaller snakes, nesting birds, birds' eggs, and small mammals. Mate March to May.

[32] "California Mountain Kingsnake" R059; California Wildlife Habitat Relationships System, California Department of Fish and Wildlife Service; 1990; https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentVersionID=17597
[32]

Giant Garter Snake (*Thamnophis gigas*)[33]

Status	Endangered (Federal) Threatened (California)
Location	Throughout the Central Valley.
Road Interactions	Habitat degradation resulting from the expansion of infrastructure at the expense of wetlands, including new roads and recreational facilities. Roads cause fragmentation of the population, particularly regarding mating. Increased road mortality from paved roads (compared to gravel or dirt) due to increased traffic and speeds.
Crossings/Mitigation	*No information.*
Breeding	Courtship and mating take place in early spring after hibernation. 10-46 live young are born from July to August.
Eggs/Younglings/Metamorphosis	Young immediately disperse and seek their own shelter.
Adult	Habitats contain permanent or seasonal water, particularly during their active season (early spring through mid-fall). Inactive during cooler months. Feeds on small fish, tadpoles, and small frogs (including the California Red-Legged Frog).

[33] "Giant Garter Snake (*Thamnophis gigas*)"; Yolo Natural Heritage Program Draft Species Account; Yolo County; April 2009; http://www.yoloconservationplan.org/yolo_pdfs/speciesaccounts/reptiles/giant-garter-snake.pdf

[33] *Why Did the Snake Cross the Road? Effects of Roads on Movement and Location of Mates by Garter Snakes"*; Langkilde, T., Lemaster, M., Mason, R., Shine, R., and Wall, M.; *Ecology and Society* v.9 no.1; 2004; http://www.ecologyandsociety.org/vol9/iss1/art9/

[33] "Thamnophis gigas (Giant Gartersnake). Movement"; Halstead et al.; *Herpetological Review*, v.44 no.1, pp 159-160; 2013

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