Mitigation Translocation as a Management Strategy for Human-Snake Conflict in California

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Background

Urbanization & Climate Change. In recent years, a global increase in urbanization has caused an increase in the potential for human-wildlife conflict, with people experiencing unwanted wildlife visitors to their properties. This is problematic for wildlife because they face increased risks of injury or mortality due to the overlap of their habitat with human-occupied areas (Marchini & Crawshaw, 2015; Murray & St. Clair, 2015). This is becoming more evident in the case of human-snake conflict, as increased urbanization has been associated with an increase in the number of landowners encountering unwanted or "nuisance" snakes on their property, with a "nuisance" snake being defined as any snake perceived as a threat to human health or safety or is persistent and perceived as an annoyance (Table 1; ny.gov, n.d.; Pitts et al., 2017). Additionally, climate change is predicted to affect the distribution of many snake species, potentially causing further increase in the overlap of some species' distributions and human-occupied areas, increasing human-snake conflict even further (Nori et al., 2013). This is a concern for native snake populations, as snakes are at an especially high risk of mortality when they encounter humans due to the fear that many humans possess toward them (Pandey et al., 2016; Murray & Foote, 1979; Sasaki et al., 2012).

Human-Snake Conflict. When humans encounter an unwanted snake on their property, they have three options: wait for it to leave on its own, move it or have it moved by someone else (= translocation or relocation), or kill it. Euthanasia is typically considered the least ideal option because it is most often done inhumanely and can have adverse effects on local ecosystems and wildlife populations, especially in the case of endangered/threatened species or species of concern (Bluett, 2001; Julien et al., 2010; Henkel & Ziccardi, 2017; Warren, 2014). Additionally, the act of attempting to kill a wild animal, particularly a venomous snake, is often more dangerous to the human themself than either of the other two options, as the chances of being bitten are increased (Romo, 2018; Malhotra et al., 2021). For these reasons, the ideal option in the case of human-snake conflict is for the human to simply leave the snake alone and wait for it to leave the property on its own. However, many people are dissatisfied with this option and choose to have the snake removed from their property by specialized businesses or willing volunteers (Bateman et al., 2021; Pitts et al., 2017). People who are willing to translocate "nuisance" snakes–whether as part of a business, government agency, or as a volunteer–can often readily be found on the internet associated with business websites or through snake relocator directories (example: Facebook's Free Snake Relocation Directory, which as of Sept 2022 had over 50,000 members and featured 38 services in California to translocate snakes for free).

Mitigation Translocation. Mitigation translocation is the practice of moving individual animals away from human-occupied areas to mitigate human-wildlife conflict and is becoming an increasingly common method of managing human conflict with "nuisance" snakes (Bradley et al., 2021; Germano et al., 2015; Sullivan et al., 2015; Pitts et al., 2017). Mitigation translocation can be further broken down into two subcategories: short-distance translocation and long-distance translocation. This distinction is necessary as the distance that a snake is translocated can impact its behavior, mortality, and its likelihood of returning to human-occupied areas (Corbit & Hayes, 2022). While the purpose of mitigation translocation is to decrease snake mortality by removing it from a human-occupied area, several studies have shown that long distance translocations may cause abnormal movement and behavior, increase stress hormones, and increase mortality (Corbit & Hayes, 2022; Cornelis, 2021; Heiken et al., 2016), while other studies have indicated that snakes relocated to a short-distance are more likely to return to their original site of capture (Corbit & Hayes, 2022; Nowak et al., 2002). Although more research is needed on species-specific responses to different types of translocation, long-distance translocation more often results in poorer outcomes for the translocated snakes and has the potential to interfere with natural population ecology. Notably, while returning to the same spot is possible in short distance translocation, it is not common (e.g., Holding et al, 2014b) and the risk of return snakes is often overstated. Overall, short distance translocation is generally recommended.

Objectives. Mitigation translocation should ideally result in decreased snake mortality and decreased human-snake conflict, and the best way to ensure that both goals are achieved is to provide snake relocators with research-based education and/or training through a permitting process that is also designed to collect data so that management agencies know the extent of translocation occurring in their state. Well-informed snake translocations will likely not only decrease snake mortality and snakebite incidence but will hopefully bring awareness to the general importance of snake preservation because they allow relocators to interact with and educate residents. By making information on snake mitigation translocation more accessible to the public, we hope that more people who wish to translocate snakes for mitigation purposes will be able to do so and that more people will call upon said relocators to move unwanted snakes from their properties rather than turning to inhumane methods of euthanasia. Long term goals to aid in snake conservation efforts are to educate the public on the ecological benefits that snakes provide and improve their understanding of how to safely avoid interacting with venomous snakes so that people may develop a better appreciation for them and be more likely to advocate for their protection.

Table 1: Definitions of key terms used in this report

Term	Definition
Nuisance snake	a snake that is perceived as a threat to human health or safety, or is persistent and perceived as an annoyance (ny.gov, n.d.)
Relocation/ Translocation	human-mediated movement of living organisms from one area, with release in another (IUCN/SSC, 2013)
Conservation Translocation	the intentional movement and release of a living organism where the primary objective is a conservation benefit (IUCN/SSC, 2013)
Mitigation Translocation	movement of individuals to solve human–animal conflict, rather than to achieve a broader conservation purpose (Sullivan et al., 2015)
Short-distance Translocation (SDT)	translocation to a site within typical home range (variable among species but typically <½ mile)
Long-distance Translocation (LDT)	translocation to a site outside typical home range (variable among species but typically >½ mile)

Rattlesnake Ecology in California

At least **s**even rattlesnake species are currently recognized in California, where they occupy habitats ranging from grasslands to mountains, and can be found from beaches to inland deserts (Table 2). Members of the Western Rattlesnake complex (*Crotalus oreganus*, also known as the Southern Pacific Rattlesnake *C. o. helleri* or Northern Pacific Rattlesnake *C. o. oreganus*) is the species most likely to be found near human-occupied areas, but conflicts may also occur with the other species as well.

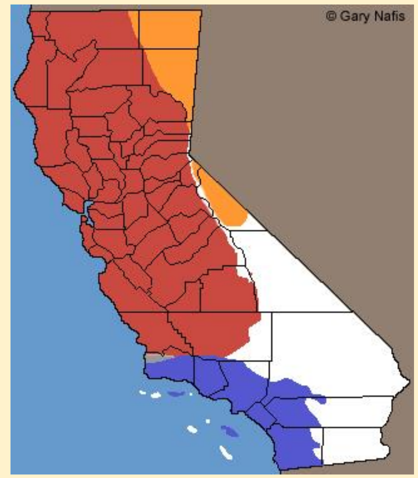
Ecology. Rattlesnakes are the only venomous snake native to California and play important roles in a variety of ecosystems and habitats by controlling small mammal populations, thus controlling diseases carried by small mammals, and acting as prey items themselves for mammals, birds, and other snake species. Rattlesnakes are cryptic species that spend most of their time hiding in mammalian burrows, tall grasses, or under the cover of rocks and logs.

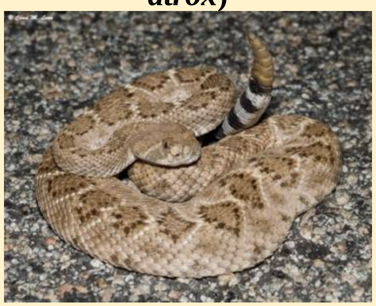
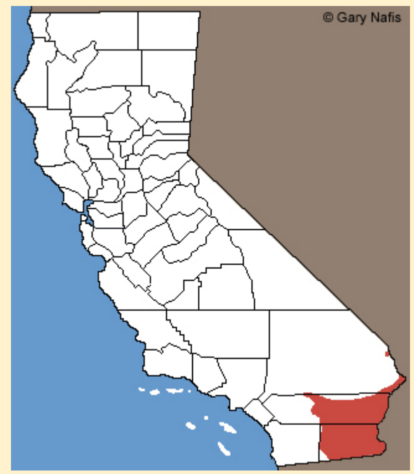
Behavior. Rattlesnakes are ambush predators, meaning that they sit and wait for prey to pass before striking and envenomating them. Once the prey is immobilized, rattlesnakes will swallow it whole. Rattlesnakes, like most animals, have an innate fear of humans and have no interest in striking us, and therefore will only do so in self-defense if they feel cornered or threatened. When encountered in the wild, it should be remembered that these organisms are peaceful by nature and are critical components of their ecosystems and should be given a respectful distance and left alone.

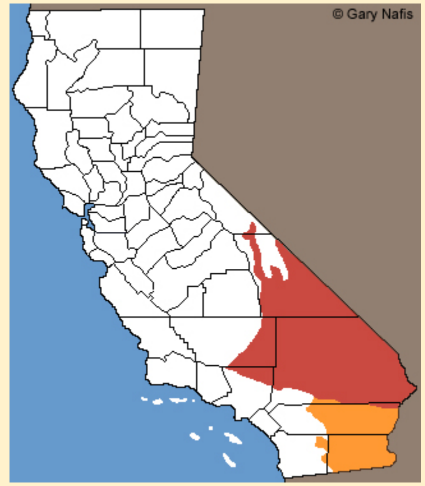
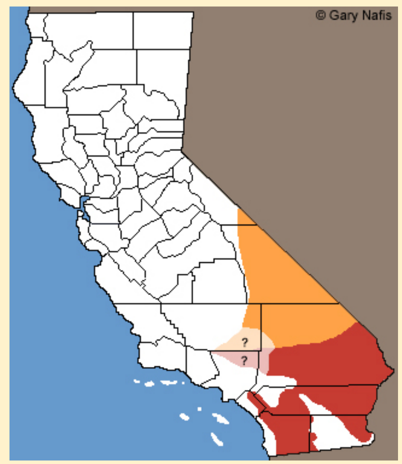
Human Interaction. As an increasing number of humans are living in and around rattlesnake habitat, rattlesnakes will occasionally find themselves in human-occupied areas such as yards and gardens, often in search for sources of water, shade, or shelter. These situations often warrant mitigation translocation when human or pet safety is compromised. Relocators may use safe methods to remove the snake from the human-occupied area and release it into its natural habitat nearby.

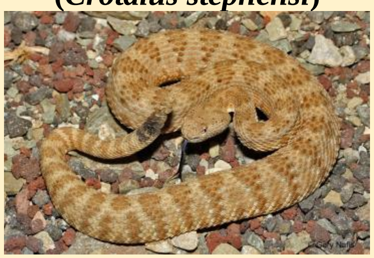
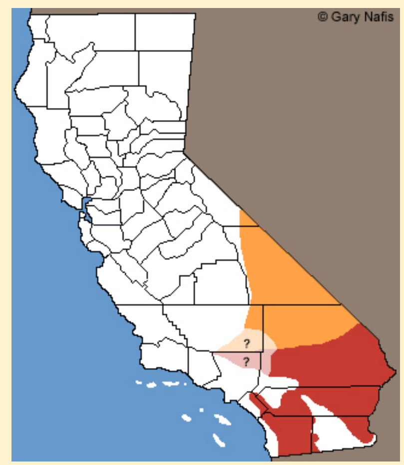
General Translocation Recommendations. Handling of venomous snakes such as rattlesnakes should only be done by trained individuals using snake tongs or a snake hook. The snake should be placed into a solid, sealable container, such as a bucket with a secured lid, and then released as soon as possible into suitable habitat (natural area with plenty of cover materials such as rocks, trees, and logs) preferably ¼-½ mile away, in areas away from manmade structures and roads.

Table 2: Natural History Information on Rattlesnakes of California. All information and photos in this table were obtained directly from www.CaliforniaHerps.com, courtesy of Gary Nafis. Photos by Gary Nafis unless otherwise specified.

Species	Physical Description	Distribution	Habitat
Western Rattlesnake (*Crotalus oreganus*) 	The ground color is variable: olive-green, gray, brown, golden, reddish brown, yellowish, or tan. Dark brown or black blotched markings, usually with dark edges and light borders, mark the back, with corresponding blotches on the sides. Dorsal blotches mark the front 2/3 of the body, change to dark bars on the body and dark and light rings on the tail which are well-defined and of uniform width. The underside is pale, sometimes weakly mottled. Usually has a light stripe extending diagonally from behind the eye to the corner of the mouth.	 Red = *C. o. oreganus* Blue = *C. o. helleri* Orange = *C. o. lutosus*	Inhabits rocky hillsides, talus slopes and rocky outcrops, rocky stream courses, rocky areas in grasslands, mixed woodlands, montane forests, pinyon juniper, sagebrush, seaside dunes, desert scrub, grassy plains, rocky hillsides, chaparral, open woodlands, agricultural areas

Red Diamond Rattlesnake (*Crotalus ruber*) 	Variable in ground color; pink, reddish-tan, reddish-brown or brick red. Diamond-shaped blotches, usually with light edges, mark the back. The underside is usually dull yellow and unmarked. Black and white rings, similar in width, or with the white rings slightly wider, circle a thick tail just before the rattle. The ring adjacent to the rattle is usually black.		Inhabits arid scrub, coastal chaparral, oak and pine woodlands, rocky grassland, cultivated areas. On the desert slopes of the mountains, it ranges into rocky desert flats.
Western Diamond-backed Rattlesnake (*Crotalus atrox*)  Photo: Chad Lane	The ground color and the intensity of the pattern are variable, often matching the habitat; gray, brown, olive, tan, or yellowish. Diamond-shaped blotches on the back are brown or black, with light edges. Markings are sometimes indefinite giving a dusty overall appearance. Broad black and white rings, fairly equal in width, circle a thick tail just before the rattle. The ring adjacent to the rattle is usually black. A light stripe extends from behind the eye diagonally to the upper lip in front of the end of the jaw crossing over the lip. (The light stripe behind the eye on the similar Northern Mojave Rattlesnake extends back beyond the end of the jaw and does not cross the lip.)		In California, inhabits only desert areas in the southern Mohave Desert and throughout most of the Sonoran Desert in California. May also be found in areas in the desert modified by urban development or agriculture. The species throughout its range inhabits arid and semiarid areas including plains and mountains, woodlands and pine forests, deserts, canyons, and rocky vegetated foothills.

Sidewinder (*Crotalus cerastes*) 	Pale cream, tan, brown, pink, or grayish back color usually closely matches the soil surface allowing the snake to blend in with the background. Around 40 darker blotches on the back. A dark stripe extends through each eye. The sidewinder has rough, keeled scales, which aid in its unique sidewinding locomotion. Its supraoculars (triangular projections over each eye) are pointed and upturned giving them a horn-like appearance.	 Red = *C. c. cerastes* Orange = *C. c. laterorepens*	Inhabits primarily areas of wind-blown sands, especially where sand hummocks are topped with vegetation. Also found in hardpan, open flats, rocky hillsides, and other desert areas, especially those grown with creosote bush, where the terrain is open, not obstructed by rocks or vegetation, allowing the broad sidewinding locomotion.
Speckled Rattlesnake (*Crotalus pyrrhus*) 	Shows a great variety of body coloration which usually allows the snake to blend into its environment: off-white, yellowish, gray, tan, pinkish, pale orange, or brown. Snakes from dark lava bed environments can be almost all black. The body is marked with a vague pattern consisting of dark speckled banded markings. Dark and light rings surround a thick tail. The tail rings are in considerable color contrast with the body color, with the terminal rings being black and with an ash-gray ground color on the tail often present.	 Red = *C. pyrrhus* Orange = *C. stephensi*	Associated mostly with arid areas strewn with rocks and boulders - alongside buttes, mesas, and desert outcroppings, but sometimes found on loose soil. Occurs in areas vegetated by sagebrush, creosote, thornscrub, chaparral, pinyon-juniper woodland, succulent desert.

Mojave Rattlesnake (*Crotalus scutulatus*) 	Ground color varies from greenish gray, yellow, tan, olive green, to brown. Irregular, dark, well-defined, diamond or near diamond-shaped dorsal markings. Black and white rings surround a thick tail. The black rings are narrower than the light rings, and often offset. A light stripe runs from behind the eye diagonally to the upper lip beyond the end of the jaw, but does not cross over the lip. (The posterior light stripe of the Western Diamond-backed Rattlesnake extends to the upper lip in front of the end of the jaw, crossing over the lip.)		Inhabits grassland, desert scrub, rocky slopes, creosote bush flats, open juniper woodland, and light chaparral.
Panamint Rattlesnake (*Crotalus stephensi*) 	Shows a great variety of body coloration which usually allows the snake to blend into its environment: tan, yellowish, orangish, gray, off-white, brown. The body is marked with a pattern consisting of dark speckled banded markings, which can be vague or distinct. A dark band or bands on the tail, but not usually alternating with light bands. The ground color of the tail is generally the same as the body color, not contrasting sharply with it. The last dark tail bands often seem to fuse together into one large black band just before the rattle.	 Red = *C. pyrrhus* Orange = *C. stephensi*	Associated mostly with habitats composed of rocky outcrops and boulders, but also found in creosote bush, cactus deserts, and open coniferous woodlands.

Future Research. As human-snake conflict is likely to persist and potentially increase in coming years, it is important that mitigation translocation is well-understood and considered as a management strategy, particularly for venomous rattlesnakes. As shown in Table 3, several translocation studies on California rattlesnakes have been done, but more research is required to confidently translocate nuisance snakes in a manner that is least detrimental to their ecology and physiology while simultaneously minimizing the chances of the snake's return to its capture site. It is apparent that translocation of the Western Rattlesnake, *Crotalus oreganus,* is the most well-studied among California-native rattlesnakes, primarily due to its wide distribution and greater overlap with human development that causes it to occur in human-occupied places more frequently than other species. Despite the results of existing studies on *C. oreganus*, more translocation studies on this species would be beneficial as it is likely to persist as the main protagonist in human-snake conflict in the future. Likewise, species such as *C. ruber* and *C. atrox* also frequently inhabit human-occupied areas and would also benefit from further translocation research, along with other understudied species such as *C. pyrrhus, C. cerastes, C. scutulatus,* and *C. stephensi.* Funding for this type of research is likely to benefit conservation of native rattlesnake species by reducing human-caused snake mortality as well as the wellbeing of humans by reducing snakebite risk.

Recommendations. Based on the results of the studies provided above, the current recommendations for mitigation snake translocation favor short-distance translocation. Short-distance translocation is variable among species based on their typical home-range size, but in general should be no more than a ½ mile away from point of capture. Additionally, we encourage the development of a specific permitting process in California for mitigation translocation of snakes so that relocators are educated on optimal translocation practices for both the snakes and humans involved. Additionally, we encourage a system for reporting all snake translocations to California Department of Fish and Wildlife to ensure proper translocations procedures are being followed and to use the data in future translocation research. Since many snake species may be sensitive to the effects of climate change and urbanization in the foreseeable future, these measures are necessary to monitor snake populations and advocate for their conservation in the face of human-snake conflict. By encouraging mitigation translocation as opposed to euthanasia, people may develop a greater respect and appreciation for snakes and may be more willing to coexist with them peacefully.

Table 3: Translocation Case Studies on California Rattlesnakes. This table summarizes all published results of studies on translocation of rattlesnake species that occur in California. To our knowledge, no studies have been performed on translocation of other species of Californian rattlesnakes anywhere in their range (even outside of California).

Species	Methods	Conclusions	Reference
Western Rattlesnake (*Crotalus oreganus*)	Tracked movement, body condition, and mortality of 14 adult males after 500m SDT	SDT does not have a negative impact on snakes, but they may return to point of capture.	(Brown et al., 2009)
	Compared volumes of medial, lateral, and dorsal cortices as well as numbers of 5-bromo-2'-deoxyuridine (BrdU) -labeled cells in the MC and DC in translocated versus control snakes	SDT causes greater navigational demands than control snakes, impacted size of brain region involved in navigation	(Holding et al., 2012)
	Hourly body temp was tracked following weekly SDTs (225 m) of 22 adult male snakes	No long-term effect of SDT on body temperature.	(Holding et al., 2014a)
	Tracked activity range size, hormonal stress response, body condition and behavior of 22 adult males after 225m SDT	SDT affected activity range size but not physiology. SDT not stressful to snakes. Males returned to capture site only when they had been removed from a female snake.	(Holding et al., 2014b)
	Measured corticosterone and testosterone levels of 14 adult males following 30 km LDT	Snakes have acute stress response to LDT, and testosterone levels rise.	(Heiken et al., 2016)

Red Diamond Rattlesnake (*Crotalus ruber*)	Compared movement patterns and survivorship of "resident", SDT (97-340 m), and LDT (856-1090 m) *C. ruber* individuals	Similar survivorship in relocated and resident snakes. LDT snakes less likely to return to point of capture. Authors recommend SDT for mitigation and LDT for possible future repatriation.	(Brown et al., 2008)
	Compared movement patterns and survivorship of SDT (50-400m) and LDT (>716m) *C. ruber* individuals	LDT snakes less likely to return to capture site. No difference in mortality between SDT and LDT snakes. Authors suggest that LDT may be viable option.	(Corbit & Hayes, 2022)
Western Diamond-backed Rattlesnake (*Crotalus atrox*)	Observed movement patterns and survivorship of adult *C. atrox* individuals following LDT (0.6 km-2 km) (Note: research conducted in Arizona)	LDT snakes had high mortality and made significant effort to return to point of capture	(Nowak et al., 2002)

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Note embedded hyperlinks to doi

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